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Environmental Sustainability Index for Indian States 2009

Informing Environmental Action

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CHAPTER 1

INTRODUCTION

1.1 The Concept and Rationale of State Level Environmental Sustainability Index

Environmental Sustainability Index (ESI) is a comparative analysis of environmental achievements, challenges and priorities among Indian states. It indicates a state's general environmental conditions, including both the state's innate resources and the achievements of its policies, by aggregating indicators that track a wide range of sectors such as water, air, land, forest, as well as measures of the impact of environment on human health and ecosystem, policy response and society's efforts to preserve the environment. It maps the various dimensions of each state's environmental policies and provides insights into priority areas for states to act towards protecting their environment in the coming years.

Since a state's long term sustainability is a combination of the stock (resources that a state is historically endowed with) and flow (environmental services and resource extraction leading to depreciation of the stock), ESI is constructed as a composite index from 40 key environmental indicators selected based on the Driving Force-Pressure-State-Impact-Response (DPSIR) framework. These 40 indicators capture the present state of the environment (State), depletion and pollution (Pressure), resulting impact on ecosystem and human health (Impact), policy and societal efforts to reduce such impacts and protecting the ecosystem (Response) and the driving forces that affect the environment (Drivers). The 40 indicators can also be grouped into nine thematic sub-indices for interpretation from a policy perspective. The nine sub-indices are: Air Quality and Pollution, Water Quality and Availability, Land Use and Agriculture, Forest and Biodiversity, Waste Management, Energy Management, Health Impact, Population Pressure, and Environmental Budget. Data are compiled from published government sources for all indicators across 28 states and are converted to a comparable scale through a series of statistical operations so that they can be aggregated into a single point index. As discussed later in this chapter, the indicators are first normalized to be on a comparable scale and then grouped into the policy-related sub-indices, which are then added to form the aggregate ESI. The DPSIR categorization is used to select a comprehensive set of variables and as a framework for comparative analysis of states' challenges and priorities, but it does not play a role in the calculations to aggregate the data.

The ESI ranking is designed to compare Indian states with their peers rather than indicate an absolute level of achievement. Although there are no clear normative benchmarks or thresholds for "good" performance on many of the indicators, the scores on each indicator can be ordered from "better" to "worse." Based on the aggregate ESI, states are categorized into five groups: most sustainable (top 20 percentile), more sustainable (within 60-80 percentile), medium sustainable (within 40-60 percentile), less sustainable (within 20-40 percentile) and least sustainable (bottom 20 percentile). A higher ESI for any given state indicates that the state has the benefit of better environmental quality at present and that the state has been able to create the potential to maintain its environment over the long run. A low ESI for a state is a sign of greater pressure on the ecosystem, higher pollution and degradation, vulnerability to environmental predicaments and/or non-responsive institutions and government.

While the overall ESI score is a quick summary of state performance, the sub-indices are far more informative about states' achievements and priority areas for attention, and the environmental status as measured by these can vary widely. A section in Chapter 2 of the report focuses on comparing ESI disaggregated in to sub-indices and components.

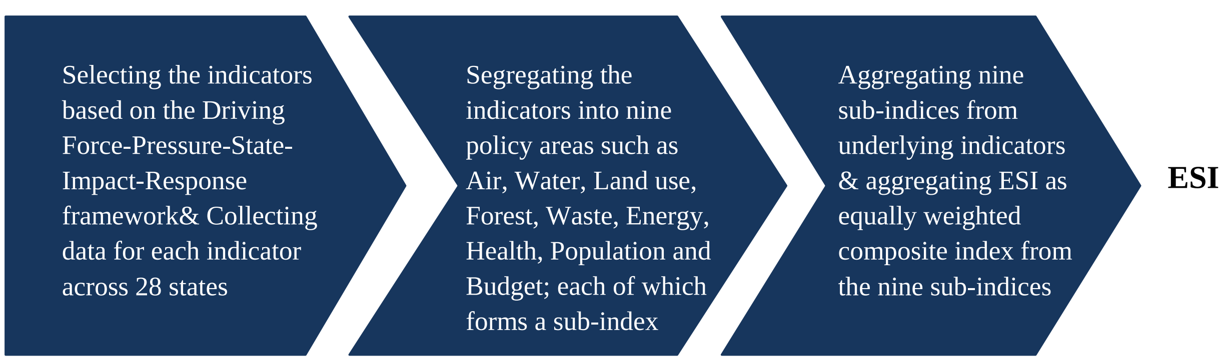
A state's overall ESI can be high due to better scores from favorable prevalent historical conditions or present actions. When a state's ESI is further disaggregated into DPSIR components, it better explains the drivers of sustainability in a state, the aspects that can be easily improved and factors that are difficult to control.

State level ESI is primarily a diagnostic tool for informing and empowering the government and policy makers, concerned citizens, researchers and activists. It is developed with the objectives of (i) promoting information and evidence based policy making, (ii) prioritization among different environment concerns within the state and identifying issues that require more attention in policy and budget allocation, (iii) encouraging states to realize their potential as drivers of India's overall environmental sustainability, and (iv) measuring and monitoring sustainable development at the state level.

1.2 Constructing ESI: The Framework

The Index is prepared in three steps: 1) Selecting the indicators based on DPSIR framework and collecting data on each indicator, 2) Grouping of indicators into nine policy areas/sub-indices, and 3) adding the equally weighted nine sub-indices to form a composite index.

Figure 1.1: How ESI is Constructed

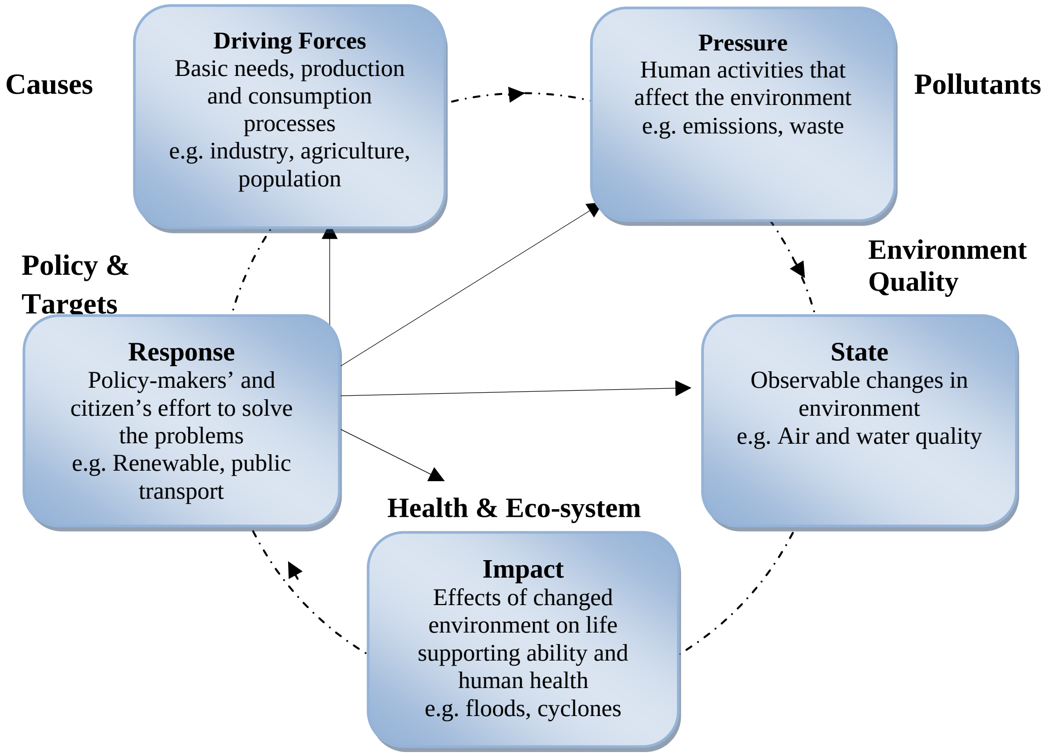


The multiple dimensions of environmental sustainability demands a framework that can appropriately cover all or most of the dimensions in a way that is logical and comprehensive. There is a particular stock of environmental assets such as forest and wildlife, fertile land, water, clean air, mineral reserves, coastline etc. that each state is endowed with. Over a period of time the stock gets depleted due to resource extraction and environmental services derived unless replenished adequately. Additionally, pollution accumulates in the ecosystem. Therefore, each state needs to manage the flow of environmental services and minimize the depreciation of the stock to remain sustainable in the long run. Some states have higher initial endowment, which places them in an advantageous position and reduces the pressure on policymakers to respond, but it does not eliminate the need for environmental stewardship. For example, a state with more water resources might have a higher capacity to become sustainable, but it will remain sustainable over a period of time only if a balance is maintained between the extraction and replenishment rates. If the pressure on ecosystem is not managed and reduced, it will lead to higher rates of extraction and resource use that depletes the historical endowment. Moreover higher population pressure aggravates the problem of stress on environment by generating more pollution and waste than what the ecosystem can absorb, which adversely affects the ecosystem's capacity to regenerate itself.

How human life and health are affected as a result of changes in the environment is another necessary dimension of measuring sustainability, as human-environment interaction is more important from a policy point of view as compared to investigating only the physical components. Similarly, human response to observed and anticipated changes in environment and efforts to mitigate negative environmental impacts and to maintain and improve present environmental conditions play the most important role in determining sustainability over a longer period.

In constructing the ESI, these criteria have been considered as the critical aspects in determining the building blocks of the index by adopting the Driving Force-Pressure-State-Impact-Response (DPSIR) framework. *Driving forces* are the basic need, human activities and production-consumption processes that affect the natural environment. Examples of driving force are agriculture, industry, transport, population etc. The driving forces lead to human activities such as food production, industrial processes and so on that exert pressure on the environment by depleting the natural resources, changing land use pattern, and emitting pollutants in air, water or land.

Figure 1.2: Driving Force-Pressure-State-Impact-Response Framework



The *pressure* exerted by society's patterns of production and consumption affects a variety of natural processes that may result in observable changes in the *state* of natural environment. *Impact* captures the environmental and economic impacts on ecological and natural systems, human health, and the economic and social welfare of a society, arising from changes in the state of the environment. The *response* component measures a society's effort to prevent, mitigate, ameliorate or adapt to changes to the environment. Response of the citizens and policymakers can improve the overall environment through triggering changes in any of the other four components. For example, policy to restrict emissions, mandate waste treatment plants, foster renewable energy use and initiatives on reforestation, and encourage energy conservation and habitat protection can trigger changes in multiple sectors by penalizing polluters and incentivizing green practices. Citizens demanding organic foods lead to less pesticide and fertilizer usage, reduced use of paper can save trees, and switching to public transport can improve the air quality, for example.

Therefore, a model for measuring sustainability should ideally contain indicators encompassing the chain of causal links starting with 'Driving Forces' through 'Pressures' to 'States' and 'Impacts' on ecosystems and human health, eventually leading to policy 'Responses'. The five components provide the basis of selecting the indicators. A total of 40 environmental indicators[1] were selected along these five components; the list of indicators, the five components and their role in gauging sustainability are given in Table1.

[1] Initially a list of 75 indicators was prepared exhaustively covering different environmental issues and potential drivers of sustainability. The list was reduced to 40, mostly due to data constraints. The list of 75 indicators is provided in Annexure

Table 1: Framework for Selecting Indicator of ESI

Components of ESI	Rationale	Indicators
1. Population pressure (D)	A state's sustainability is more likely to increase with lower anthropogenic pressure - a major driver of many subsequent activities that extract from and pollute the ecosystem. Since ecosystems have finite carrying capacity, higher population pressure means rapid rate of resource use and resulting degradation.	• Population density • Population growth • Total fertility rate
2. Pressure on environment (P)	States that can manage the pressure on environment at a tolerable level and even successfully reduce the stress so that it does not further affect the environmental quality, are more likely to remain sustainable in the long run. If the pressure is not reduced, even states with very good initial conditions can degrade much faster than states that manage to preserve their environment.	• Density of motor vehicle usage • Annual groundwater extraction • Water usage in irrigation • Grazing land as % of total land • Fertilizer consumption intensity • Pesticide consumption intensity • % Change in forest area • % forest area encroached • Per capita municipal solid waste • Per capita Hazardous waste
3. Environmental Quality (S)	A State will be considered more sustainable if its initial endowment is good and ecosystem vitality is preserved, quality of critical environmental systems maintained at healthy levels and the system is able to regenerate and replenish the resources and absorb the pollution to the extent that it does not harm human beings.	• Annual average SO2 concentration • Annual average NO2 concentration • Annual average SPM concentration • Annual average RSPM concentration • Mean Biochemical Oxygen Demand • Mean total coliform count • Replenishable ground water • Access to piped drinking water • % land area under forest cover
4. Impact on human health & ecosystem vitality (I)	The degree to which a state can reduce the negative environmental impacts on basic human life and health, and protect from threats caused by environmental disturbances is more likely to govern the state's sustainability by offsetting alarming environmental quality and/or high stress on environment.	• Land affected by salinity, acidity and water logging • Land affected by Soil erosion • Incidence of acute respiratory diseases • Incidence of water borne diseases • Flood affected area to total area • Drought prone area to total area • Life loss due to disaster
5. Policy response (R)	A state's effort to prevent, mitigate or adapt to changes to the environment enhances its ability to maintain a sustainable environment. If a state has appropriate policies, resources and institutions in place to respond to environmental issues, it is in a better position to lead the sustainability curve in the long run.	• Protected area as % of total area • Compensatory reforestation • Wetland as % of total area • Area under Joint Forest Management • Gap in sewage treatment • % of household using non LPG fuel • Renewable energy installed • Energy used to produce 1 unit of GSDP • Budget for renewable energy development • Environmental budget as % of state GDP • Actual expenditure vs. agreed outlay in environmental budget

Each of these 40 indicators quantitatively measures a part of the environment; their aggregation into a composite index provides the overall picture of state-level sustainability. The environmental quality indicators highlight the level of pollution and deterioration highlighting areas in need of rapid response. The level of stress on environment indicates the possibility of further damage to the environment if environmental stressors are not controlled and managed properly. Indicators in the component 'Impact' reveal the extent to which environmental issues have affected human health and the natural ecosystem, again important information for prioritization. The 'Driving Forces' component highlights some of the most stubborn challenges states face. The 'Response' indicators show the effort made by government and society to protect, conserve and improve the environment.

While categorizing the indicators into the five components can help in understanding the inter-linkages between various indicators in the complex environmental systems as a whole; it is a generic classification from an action-oriented point of view. Therefore indicators were additionally grouped into sub-indices according to broad areas or sectors across which policies are formulated and state bureaucratic and administrative institutions are organized. For example, all land related indicators such as grazing, erosion and pesticide use were categorized as "Land use and Agriculture" sub index. Similarly all water related indicators were grouped together. Through this process nine sub-indices were formed across air, water, land, forest, waste, energy, health impact, population and government spending; the aggregate index is derived from these underlying nine sub-indices. The usefulness of ESI endeavor lies in these sub-indices, which are designed keeping in mind where information can guide policy planning and action for sustainable development. A detailed account of aggregation of all the indicators into nine sub-indices and corresponding DPSIR components is given in Table 2.

Table 2: The ESI Framework of Indicator Aggregation

	Driving Force	Pressure	State	Impact	Response
Air		• Motor vehicle density	• Concentration of SO2, NO2, SPM and RSPM		
Water		• Groundwater extraction • Water usage in irrigation	• BOD • Coliform count • Replenishable ground water • Drinking water		
Land use and Agriculture		• Grazing land • Fertilizer consumption • Pesticide consumption		• Land affected by salinity, acidity and waterlogging • Soil erosion	
Forest and Biodiversity		• Change in forest area • Encroachment	• % land area under forest cover		• Protected area • Wetland • Compensatory reforestation

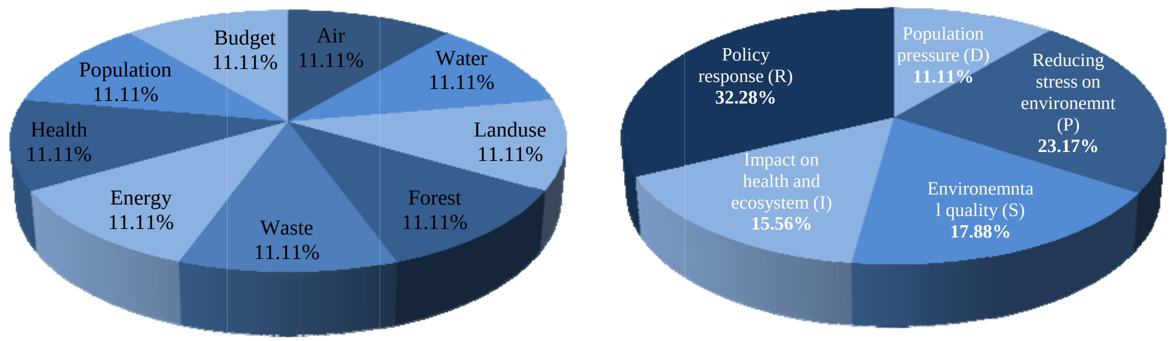
					• Joint Forest Management
Waste		• Municipal solid waste • Hazardous waste			• Gap in sewage treatment
Energy					• Usage of Non-LPG cooking fuel • Energy per unit of SGDP • Renewable energy installed
Health and Natural Disaster				• Incidence of respiratory and water borne diseases • Flood affected area • Drought prone area • Loss due to natural disasters	
Population Pressure	• Population density • Population growth • Fertility rate				
Environmental Budget					• Budget for Renewable energy • Environmental budget as % of SGDP • Actual expenditure vs. outlay

Overall ESI is the equally weighted average of the nine sub-indices.[2] The reason behind assuming equal weights is two-fold: 1) lack of systematic study and scientific evidence to hypothesize differentiated weights and as to why any one of these nine aspects of environment should be considered more important than the others, 2) from a policy perspective, actions in each of these nine areas will lead to better sustainability, therefore each assumes its own imperative. Similarly, each sub-index is an equally weighted average of the underlying indicators. Tracing backwards the aggregation of two stages (first indicators to sub-index and second, sub-indices to overall index), the differential weights of each indicator can be derived.[3] Consequently, when the disaggregated weights are summed up for each of the five components relating to DPSIR, it is evident that ESI attaches maximum emphasis on policy response (R) (32.28%) followed by pressure on ecosystem (P) (23.17%), state/quality of environment (S) (17.88%), impact (I) (15.56%) and the driving forces of population pressure (D) (11.11%). The distribution of weights is shown in Figure 1.3.

[2] An interactive spreadsheet is developed and available on the ESI website (www.greenindiastandards.com) that allows users to make changes in weights and see the corresponding changes in ESI scores.

[3] Details in annexure weight40

Figure 1.3: Distribution of Weights in ESI: By Sub-indices and By DPSIR Components



Weightage of Sub-indices

Weightage of DPSIR Components

1.3 Constructing ESI: Methodology in Brief

Data were collected from published government sources such as databases of census of India, government surveys (including the Forest Survey of India, National Family Health Survey, Economic Survey), state departmental websites (e.g. transport department, energy department, water resources department), central and state planning and budget documents, State of the Environment (SoE) reports, Central Pollution Control Board publications (National Ambient Air Quality Monitoring, Water Quality Monitoring, Waste Generation), and responses to parliamentary questions.

The first step in computing the ESI was to convert data to comparable scales. This involved several types of calculations. First, suitable denominators were chosen to transform data into measures suitable for comparing states of varying sizes. For example, data on forest cover was made comparable by taking total geographic area as the denominator, while data on incidence of respiratory disease was made comparable by taking total population as the denominator. This process ensured that no state was given undue advantage or disadvantage because of its geographical size or population. Also the percentage change of an indicator could capture the rate of flow of resources or the rate of accumulation of waste. In doing so, a state's relative performance over the years is gauged. This procedure further mitigates differences arising from area or population size. Missing values in the datasets were imputed using multiple imputation regression technique.

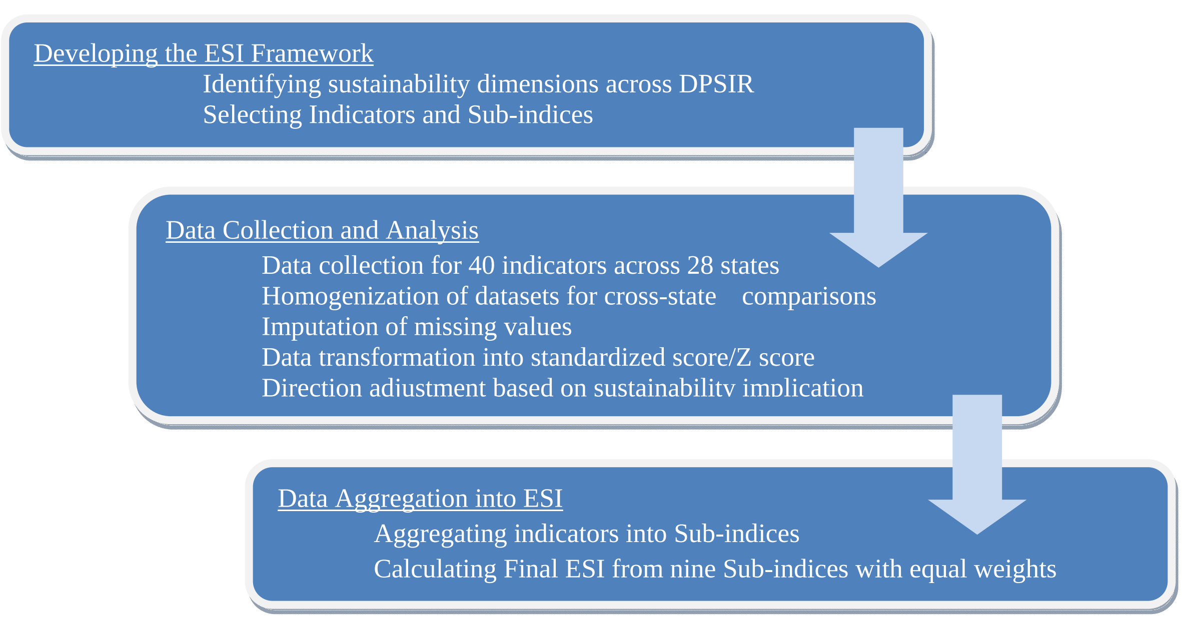
Since ESI uses a wide range of datasets to include different indicators, each of these indicators is measured in different units. For example, pesticide consumption is measured in ton/ha, particulate concentration in air is measured in µg/metre^3, forest cover as % of total geographical area and ground water in Cubic m/Sq km. Hence for processing into a composite index, these differences of measurement units needed to be overcome by converting each indicator into a uniform scale of measurement. Hence the data were transformed into Z-scores, which represent standardized deviations from the mean. Z-scores computed from datasets with different units can be directly compared since these numbers do not express the original unit of measurement.

Finally, high values for some of the indicators indicate positive sustainability whereas high values for others indicate lesser sustainability. For example, in case of the indicator % change in forest cover, a positive Z-score would highlight a change in a favorable direction and a negative Z-score would highlight a change in an unfavorable direction. However, in the case of the indicator population density, a more positive deviation from the mean (i.e., a higher Z-score) would mean a higher absolute value for a state. Thus a higher positive Z-Score would mean a high population density, which is not in a favorable direction for the ESI of that State. Thus, the directions for all z-scores were set so that higher scores mean "more sustainable," in other words all higher positive Z-scores for indicators that represent negative sustainability were converted into lower negative Z-scores and vice versa.

Each policy sub-index was calculated as average of underlying indicators and the final ESI was aggregated as equal weighted average of the nine sub-indices. Based on the aggregate ESI, states are categorized into five groups: 1. Most Sustainable (top 20 percentile), 2. More Sustainable (within 60-80 percentile), 3. Medium Sustainable (within 40-60 percentile), 4. Less Sustainable (within 20-40 percentile) and 5. Least Sustainable (bottom 20 percentile). While the aggregate index reveals the relative position of states among each other, the nine sub-indices elucidate each state's performance across different sectors in greater detail.

The entire process of constructing ESI as a composite index, starting from developing the framework of indicator selection to the process of aggregation is graphically demonstrated in Figure-1.4.

Figure 1.4: ESI Framework and Methodology



CHAPTER 2

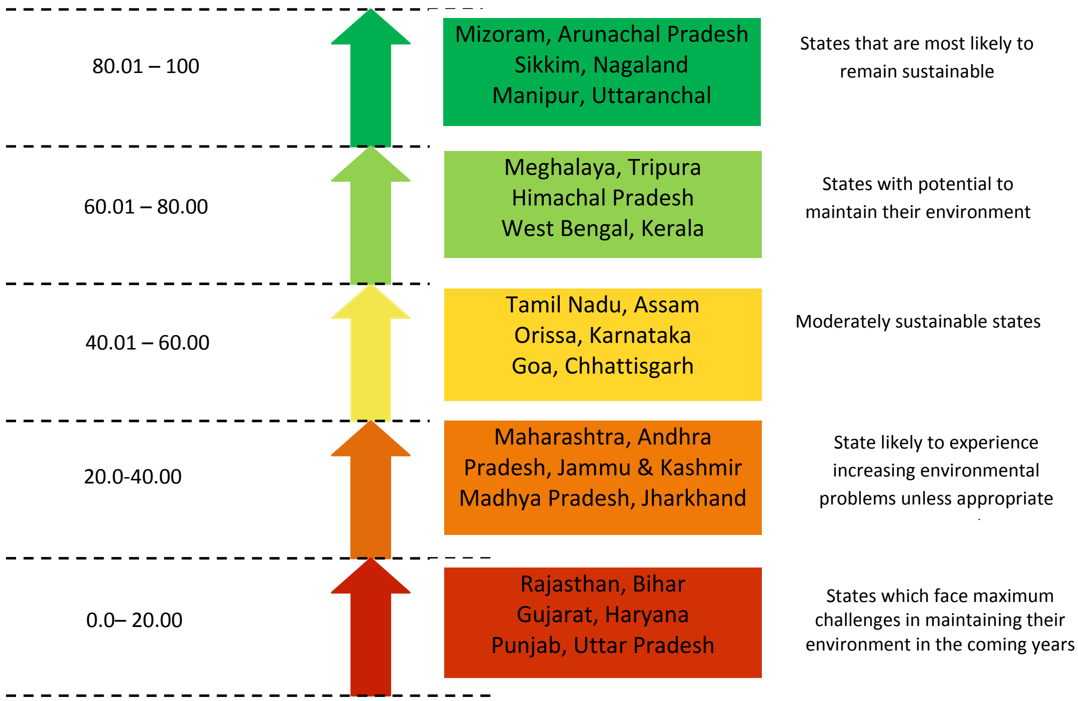
KEY FINDINGS AND ANALYSIS

2.1 Overall ESI Results

ESI is a relative measure of sustainability that compares all Indian states in order to predict the pressure each state will face in managing its environmental resources in the coming years. A higher ESI for a state means that the state currently faces fewer challenges than states with a lower ESI, but not necessarily that a state's present trajectory will preserve its current level of environmental quality. A higher ESI, therefore, should not lead to complacency amongst highly ranked states, nor should a low ESI be viewed as irreversible or necessarily an indication of lack of state effort.

Based on the aggregate ESI, states are categorized into five groups: 1) Most Sustainable (top 20 percentile), 2) More Sustainable (within 60-80 percentile), 3) Medium Sustainable (within 40-60 percentile), 4) Less Sustainable (within 20-40 percentile) and 5) Least Sustainable (bottom 20 percentile). The states that are most sustainable according to ESI 2009 are Mizoram, Arunachal Pradesh, Nagaland, Manipur, Sikkim and Uttaranchal. The least sustainable states are Rajasthan, Bihar, Gujarat, Haryana, Punjab and Uttar Pradesh. The various states in each of the five sustainability classes are shown in the figure below.

Fig 2.1 Sustainability percentile groups



The color-coded map of India (Figure 8) shows the states' sustainability according to ESI. While ESI results are largely consistent with the common perception regarding environmental conditions in the states of India, ESI also reveals some unexpected patterns of state-level sustainability. Most states with abundant natural resources – for example, the Himalayan states and Kerala, have scored high, yet other states with high endowments of natural resources, such as Orissa, Jharkhand, Chhattisgarh, Madhya Pradesh and Goa, come under the medium and less sustainable categories. Similarly, among the north-eastern states, Assam, Meghalaya and Tripura have not scored as high as the other four.

Figure 2.2: Environmental Sustainability Index of 28 States

Larger states like Gujarat, Punjab and Uttar Pradesh that have experienced intensive industrialization and/or agricultural activities have scored lower on the ESI. However, states like Tamil Nadu, West Bengal and Kerala have maintained environmental conditions in spite of the high intensity of economic activity and demographic pressure in these states.

Such revelations emphasize both the value and the weaknesses of the macro snapshot that the summary ESI offers. On the one hand, the ESI neatly aggregates the contributions of states' initial endowments as well as the rate of consumption and replenishment of its environmental assets with the help of the DPSIR analytical framework. On the other hand a high ESI score is hard to interpret as either a summary of state performance or a guide for policy. A state's high overall ESI score could be a result of its superior environmental quality, less stress on its environment, responsive civil society and government actions, or due to a combination of more than one of these factors.

A thorough examination of disaggregated ESI in terms of the five components of DPSIR reveals some interesting patterns of sustainability across states.

When all states were considered in relation to the 'reducing pressure on environment' component, it was evident that almost all the states which are endowed with higher natural resource and sparse population are also the ones that face less pressure on their environment (states on the right side of the Y-axis in Fig 2.3a). This is an advantage these states have in remaining sustainable. However, when overall ESI is considered, some of these states – Jharkhand, Madhya Pradesh, Orissa, Assam and Bihar fall in the yellow, orange and red categories because of their poor scores in other components. While Himachal, West Bengal and Kerala face high environment stress, they manage to fall in the green category by scoring high on other components.

Fig 2.3a: Reducing Pressure on environment

States on the right of y-axis are doing better than states on the left. For states on the right side, the longer the bars, the lesser pressure on its environment. For states on the left side, longer bars mean more pressure on environment. All values are in standardized scores.

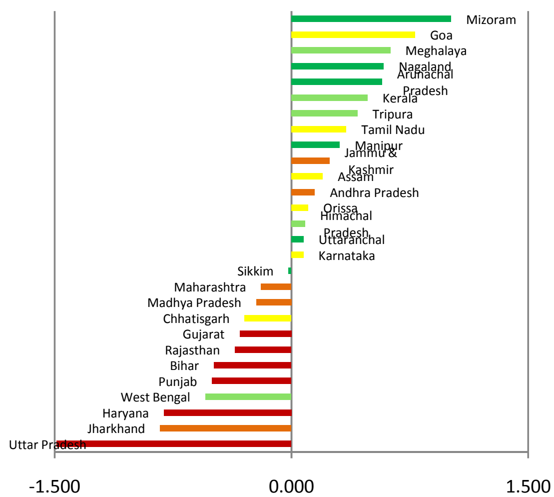


Fig 2.3b: Quality/State of Environment

States on the right of y-axis are doing better than states on the left. For states on the right side, the longer the bars, the better the quality of their environment. For states on the left side, longer bars indicate worse environmental quality. All values are in standardized scores.

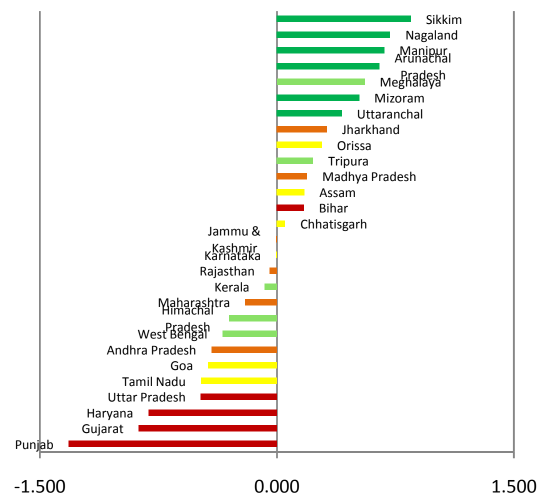


Fig 2.3b shows state-wise quality of environment, measured in terms of air and water quality, forest and water resources. States on the right side of the Y-axis (Mizoram, Goa, Meghalaya, Nagaland, etc.) are those with better quality of environment at present. States with poorer environmental quality (Uttar Pradesh, Jharkhand, Haryana, etc.) are shown on the left side of the Y-axis. Jharkhand, Orissa and Madhya Pradesh are good examples of states that show less pressure on their ecosystems, but the overall ESI for these states is lowered due to their lower-than-average performance in some other components. On the other hand, states with intensive economic activity reveal high pressure on their environment in the form [illegible] standardized scores.

Figure 2.3c shows the impact of environmental degradation and pollution on human health and ecosystem vitality. Some green states like Himachal, Kerala and Sikkim reveal a significant impact, while certain less sustainable states such as Uttar Pradesh, Madhya Pradesh and Jharkhand face a lower impact even though their overall sustainability is low. West Bengal's high score in this area boosts its ESI despite its lower scores in environmental quality and reducing pressure on ecosystem.

Figure 2.3c: Impact on Health & Ecosystem

States on the right of y-axis are doing better than states on the left. For states on the right side, the longer the bars, the lesser the impact on human health. For states on the left side, longer bars indicate more negative impacts due to

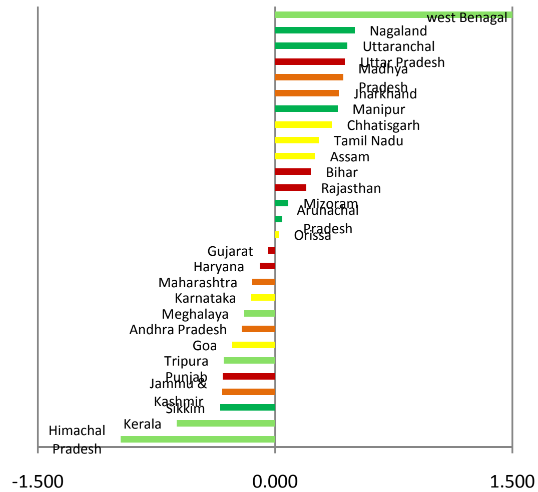
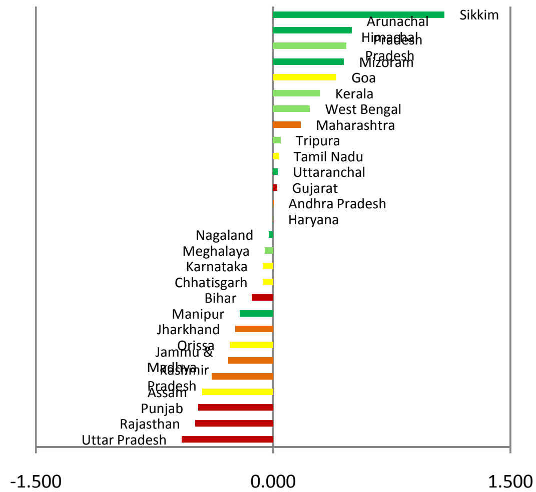


Figure 2.3d: Responses to maintain the environment

States on the right of y-axis are doing better than states on the left. For states on the right side, the longer the bar, the more responsive is the society to maintain its environment. For states on the left side, longer bar



"Responses to maintain the environment" (Fig 2.3d) is a measure of a state's efforts to maintain its environment in terms of forest and wetland conservation, waste and energy management practices and budgetary allocations towards environment sectors. This key factor in determining future sustainability reflects a state's efforts to become green irrespective of its endowments, and 'response' is therefore given maximum weight in the overall ESI. Almost all s this component also score high on the overall ESI. The results also illustra states are more responsive and capable of taking care of their environme low per capita income have shown very poor response/efforts to protect their environment; yet there are exceptions like Arunachal Pradesh, which has shown a stronger response despite being a lower-income state. In contrast, most high-income states demonstrate high responsiveness and efforts to preserve their environment. Punjab is one exception – a high income state that scores low on responsiveness due to less budgetary allocation towards environmental sectors and fewer efforts on waste management, reforestation and conserving wetlands. However, because a state's responsiveness is only one of several factors that determine sustainability, not all states with a high response have a high overall ESI, and vice versa.

Each of the 28 states' ESI disaggregated into these five components is discussed in detail in chapter 3 on State ESI Profiles. The state profiles also describe how each state has fared in the nine sub-indices which is another way of examining the areas of strength and weakness for the states. Some states like Himachal Pradesh, West Bengal and Kerala have highly varied performance across sub-indices, while other states like Karnataka, Rajasthan and Uttaranchal have shown more or less uniform scores across sub-indices. Therefore, looking at the sub-indices gives a more balanced picture and reveals the nuances that the overall index may mask.

2.2 Inter-State Comparisons across Sub-Indices

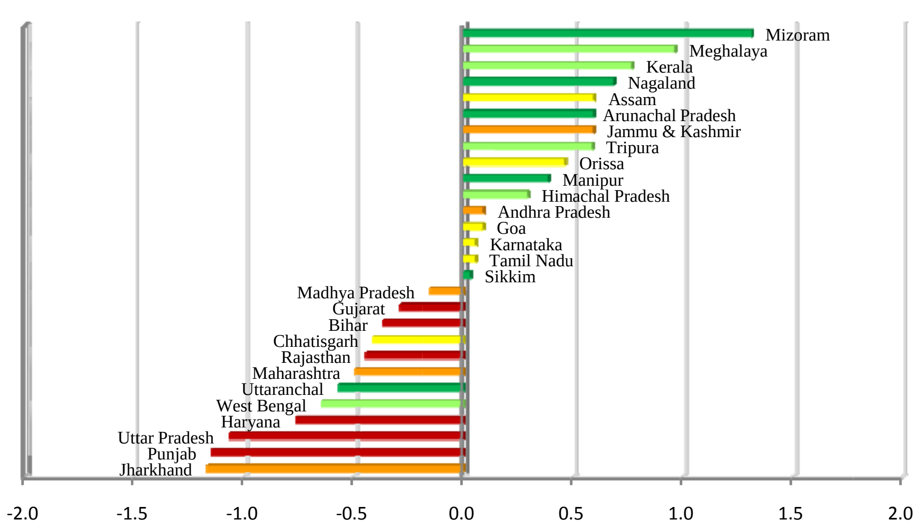
While the aggregate ESI indicates the overall sustainability trajectory for a state, the sub-indices provide insight into the particular drivers of sustainability with implications for policy and action. ESI is aggregated from various aspects of the environment such as water, forest, air quality and land use, in order to understand the larger picture of sustainability. Each of these dimensions is important for sustainability and states' conditions can vary widely across the components of the ESI. A state with an overall high ESI score might suffer from acute water stress, for example, while having good air quality; or it may have high scores on land use and civil society activity but do less well on water quality. Each of these profiles requires a different type of policy response – the steps necessary to improve water quality are very different from those necessary to preserve biodiversity and forests.

Analyzing the patterns across the nine underlying sub-indices reveals that states with similar overall ESI may vary greatly when it comes to specific sectors or dimensions of environmental sustainability. The bar charts demonstrate the states' performance on the nine sub-indices. Values on the x-axis are the standardized scores on the respective sub-indices, while the color codes (red/orange/yellow/green/dark green) of states indicate the overall ESI peer groups. All states with positive scores (right half of chart) have shown better performance than the ones with negative scores (left half of chart).

1. Air Quality

Most states that score high on ESI also score well on air quality. Uttaranchal and West Bengal happen to be outliers, as they are green states (more sustainable) but have low air quality. Likewise, Jammu & Kashmir, Orissa and Assam score low on ESI but score well in terms of air quality.

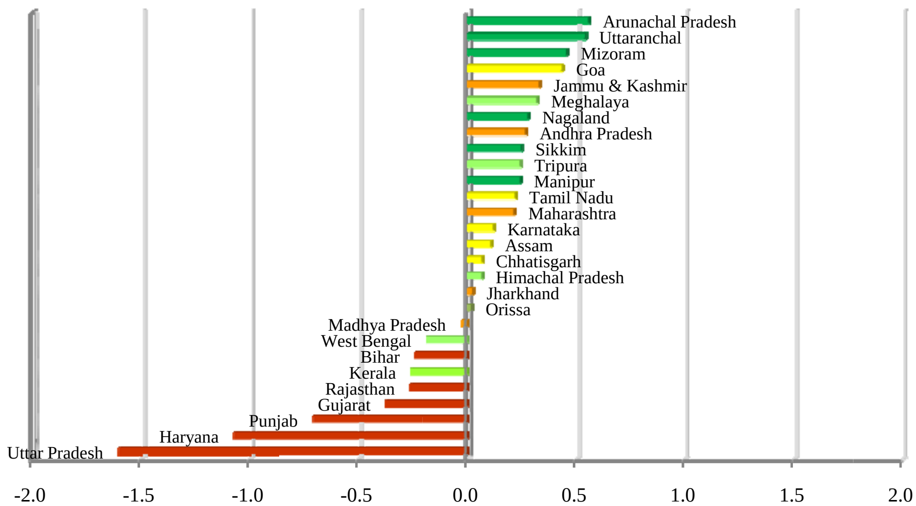
State-wise standardized scores on air quality and pollution



2. Water Quality and Availability

Unlike air quality, the patterns in the water quality sub-index are not similar to the overall ESI. None of the 'most sustainable' (dark green) states are negative in the sub-index 'water quality'. However, 'more sustainable' states of Kerala and West Bengal score low in this arena, while many states in yellow and even orange categories have shown high scores. The data show that Uttar Pradesh, Haryana, Punjab, Gujarat, Rajasthan, Kerala, Bihar and West Bengal face relatively greater water stress and pollution. Examining the underlying indicator data reveals that bacterial contamination is high in Uttar Pradesh, Punjab and West Bengal, whereas in Gujarat and Haryana, relatively high measured Biological Oxygen Demand indicates poor water quality.

State-wise standardized scores on water quality and availability

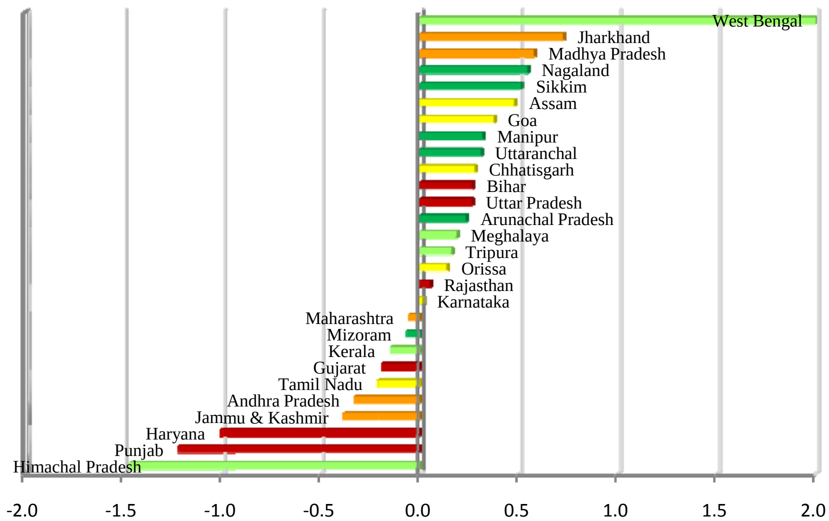


Low groundwater tables, overdraft of ground water without adequate replenishment and diversion of water for irrigation are leading to unsustainable rates of extraction in most states. For example, the ground water extraction rates in Punjab and Haryana are 145 percent and 109 percent respectively – more is being extracted than added.

3. Land Use and Agriculture

Similar to the water quality sub-index, the average in the 'land use' sub-index is driven by a few states with starkly negative scores, though most states are found on the other side with smaller positive values. In this sub-index, the variation of scores from the overall ESI is notable. Even states in the same ESI group vary widely; Himachal Pradesh, for example, has the lowest score whereas West Bengal has the highest, though they are both 'more sustainable' according to the ESI ranking. While Himachal has 27 percent of its land area under grazing, West Bengal has only 0.06 percent of the same. Himachal faces the highest soil erosion of all states, which together with its high percentage of land area under grazing indicates a pattern of unsustainable land use. Himachal is followed by Punjab and Haryana, which demonstrate less sustainable land use practices and also share a relatively low overall ESI score.

State-wise standardized scores on landuse and agriculture

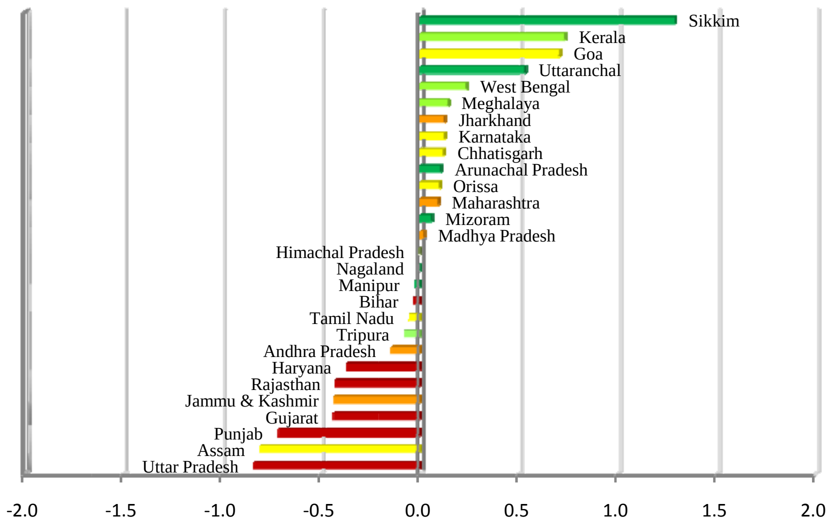


In Punjab and Haryana, usage of fertilizer and pesticide is higher than in other states, a fact that together with their high incidence of soil erosion results in their poor score in this sub-index. West Bengal, by contrast, scores high on this index as it has less erosion, fewer land problems from grazing, less salinity, less acidity and lower rates of pesticide usage.

4. Forest and Biodiversity

While high initial endowments as measured by forest cover and wetlands can improve a state's score; the flow indicators such as change in forest cover, protected area, reforestation and joint forest management also indicate the policy response to initial conditions. Therefore to assess the sustainability of forest and biodiversity, both stock and flow indicators have been considered. Hence Sikkim's highest score in this sub-index should be read as a combination of both endowment and conservation efforts. The state has 45.97% land under forest cover which is one of the highest in the country, at the same time there is 120% growth in forest cover. Uttar Pradesh has a very low initial endowment (5.86% land under forest), and adding to the problem is the reduction in forest cover of 51.54%. The state also has limited compensatory reforestation and joint forest management.

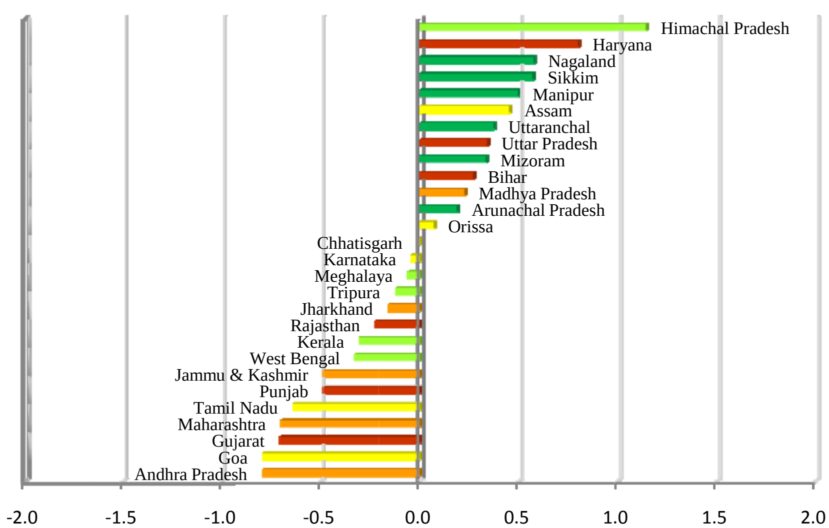
State-wise standardized scores on forest and biodiversity



5. Waste Management

Waste generation and treatment is important when one considers environmental sustainability since they show the lifestyle and consumption pattern of a society. More waste generated means higher ecosystem service extraction rate and thus less sustainability. Himachal Pradesh, where data record 100% sewage treatment facility and relatively little per capita solid waste generation (99.86kg/year), ranks the best in this sub-index.

State-wise standardized scores on waste management

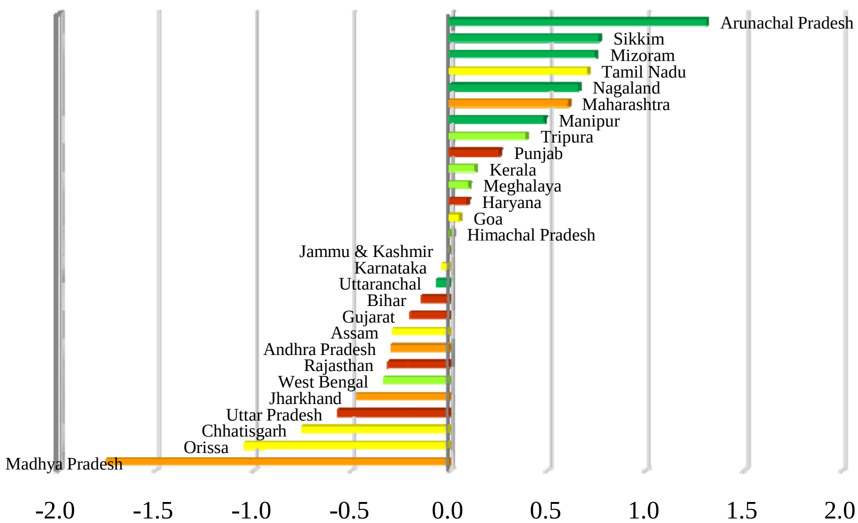


Bihar is one of the lowest per capita hazardous waste generating states (0.037kg/year) whereas Gujarat is the highest (31.782kg/year), which is reflected in the sub-index scores of these two states. In Tamil Nadu and Goa the solid waste generation is one of the highest in the country (226 kg and 198 kg respectively), which is one of the reasons why these two states are also at the bottom of the list.

6. Energy Management

Arunachal, Sikkim and Mizoram score the highest in energy management; these are also states with very high overall ESI. Except Tamil Nadu, Maharashtra and Punjab, most other states which show better energy management also have high ESI. In Orissa, renewable energy is a mere 0.19% of total installed capacity in contrast to Tamil Nadu's 28.87% and Arunachal Pradesh's 25.13%, two states scoring high on the energy sub-index. States with least scores in this sub-index are Madhya Pradesh, Orissa and Chhattisgarh. While Madhya Pradesh is the most energy intensive economy (43.92 kWh per 1000 Rs of GDP), it has very limited renewable energy (1.42% of total installed capacity) coupled with the fact that 83% of households use relatively inefficient fuel for cooking. All these factors contribute to Madhya Pradesh's score as the lowest among all states in the sub-index.

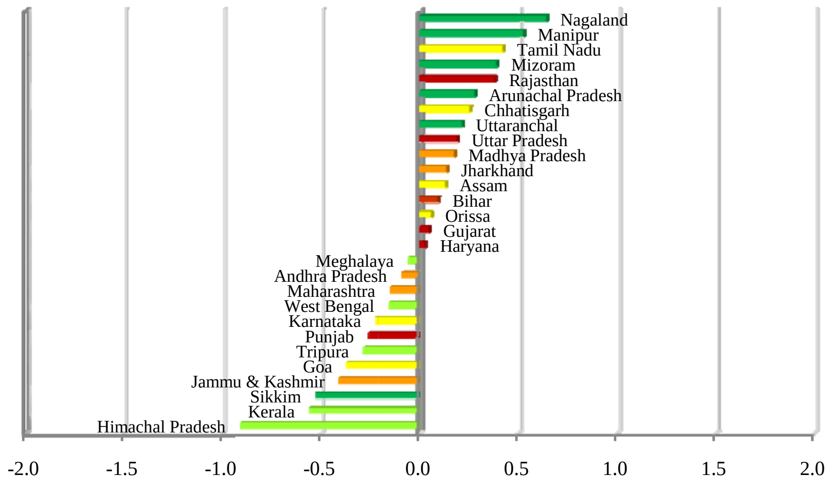
State wise standardized scores on energy management



7. Impact on Human Health and Ecosystem

Reducing health problems caused by environmental pollution is a priority recognized by every society. A clean environment enhances health and well being and can reduce the infant mortality rate, increases life expectancy and improves quality of life. Similarly, disaster management is important for sustainable habitat creation. Through measuring the incidence of respiratory and waterborne diseases, as well as the impact of natural disasters on human life and ecosystems, this sub-index demonstrates the environmental burden on human health and on the overall vitality and resilience of an ecosystem. Nagaland, Manipur and Mizoram are the states with the least environmental burden on human life and ecosystems. A few moderate and low ESI states like Tamil Nadu and Rajasthan also have done well in this sub-index.

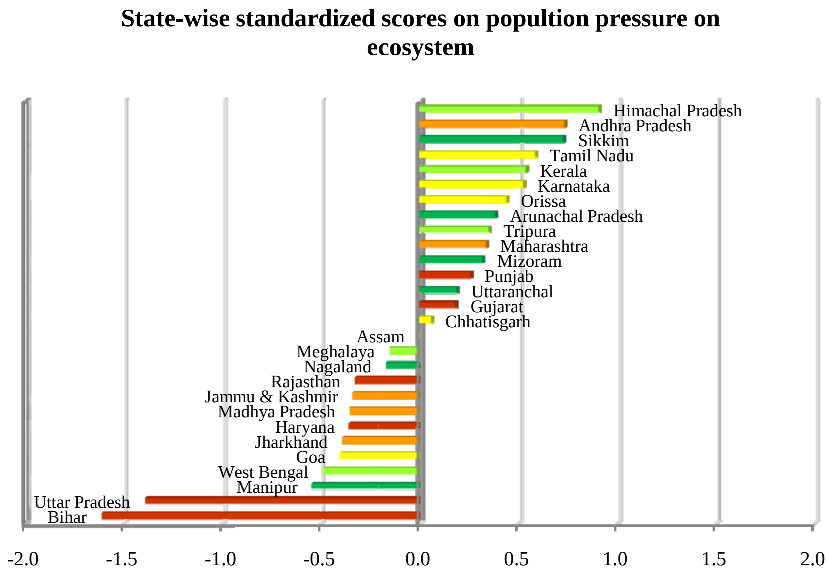
State-wise standardized scores on environment impact on human health and ecosystem



The poorest performances in this arena are by some of the greener states like Himachal Pradesh and Kerala with 22% and 24% of the population being prone to respiratory diseases respectively. Moreover, in Kerala, 37% of state's area is flood prone. This indicates that even if these states' overall environmental stewardship is high, they need to fortify their fragile ecological units, improve environmental quality and build resilience to extreme events. On the contrary, Tamil Nadu with a very miniscule measured disease incidence percentage (population prone to respiratory and water borne diseases being, 0.31% and 0.24% respectively) has a good score.

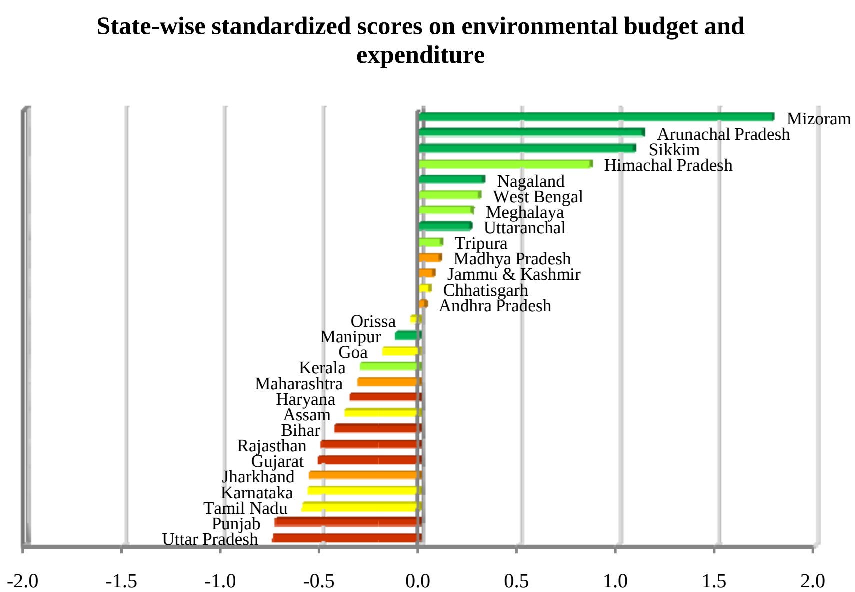
8. Population Pressure on Ecosystem

Though population density and growth is not a direct constituent of the natural environment, it affects the load on any ecosystem at present or in the future. Therefore, it is not surprising that states such as Uttar Pradesh and Bihar with very high population pressures fall in the red category. Given the fact that population-related variables are difficult to change in short term, a state can do its best to manage the other aspects of environment to compensate. While states like Himachal Pradesh and Andhra Pradesh have the advantage of less population pressure, Andhra Pradesh's overall ESI score is still lower than most other states that face pressure on ecosystems. Bihar and Uttar Pradesh, two states towards the bottom of the ESI list, face the maximum pressure on their environment, but a few states with high pressure have still managed to score well in the overall ESI, West Bengal being an example.



9. Environmental Budget

Except Manipur and Kerala, most states with higher ESI also show higher spending on the environment sectors. Pollution abatement, conservation, clean energy production and conservation spending all contribute to the "environmental budget" indicator. The comparative performance on this indicator also indicates an opportunity for states like Punjab and Gujarat which are facing high pollution loads to increase the budget allocation for environment and related sectors.



In the current ESI, Tamil Nadu and Karnataka have managed moderate positions even with their lower priority for environmental budgets (environment budget as only 0.056% and 0.004% of state GDP). Their scores can improve further with increased government attention to apportion funding for environmental sectors. Similarly, many of ESI's less sustainable and least sustainable states need to make provision for more budgetary resources for energy, environment and forest.

This reinforces the point that no state has fared very well or very poorly in every sub-index and that each state's environmental concerns are distinct from those of others. While it may not be possible for a state to change its initial natural endowment of land, forest and water; it can certainly make sustainable use of the resources and prevent degradation. Increased funding is one such direct way to promote positive changes in current practices of waste and energy management and pollution abatement. Efforts in this direction raise awareness and pave the way for greater integration of environmental concerns into mainstream development policy making.

2.3 Peer State Comparison

Due to the high degree of variations among the twenty eight states, more meaningful conclusions about environmental sustainability can be drawn by clustering similar states into peer groups and then comparing them against each other. For example, in any comparison of Goa with Uttar Pradesh, the differences of area, population, per capita income and socio-economic heterogeneity are important to consider. States[1] were grouped into 6 peer groups based on GDP per capita[2] and their contribution to India's GDP[3]. Our choice to use GDP-related data as grouping criteria is based upon the argument that income will influence and even determine many environmental policy choices that relate to the growth of the state. Inter-state differences in size (both in geographical area and size of the state economy) is another important consideration. While a state's size in terms of geographic area is unlikely to be a major determinant of environmental outcomes, it is essential to consider the anthropogenic pressure on the given area especially in terms of population density (population per square km area) and economic density (GDP/square km area). Since a state's contribution to national GDP is a combination of its natural resources, human resources and economic activities, it accounts for the inter-state differences and is taken as a criteria for peer grouping.

States vary largely in their contribution to India's overall GDP. For example, Maharashtra has a share of 15.17 percent of India's GDP, while Sikkim and Mizoram account for only 0.06 and 0.09 percent respectively. Therefore comparing Sikkim with Mizoram is more justified than comparing Sikkim with Maharashtra; whereas Maharashtra's ESI should be analyzed along with states with high GDP contribution such as Uttar Pradesh, Andhra Pradesh, Gujarat and Tamil Nadu. Seven states - Maharashtra, Uttar Pradesh, West Bengal, Andhra Pradesh, Gujarat, Tamil Nadu and Karnataka - together accounted for 61 percent of the country's GDP, with each of these states contributing 5 to 15 percent. These seven states were grouped as *high GDP contributors*. Similarly all states with a percentage share less than 5 percent and more than 1 percent were categorized as *medium GDP contributors* and states with less than 1 percent share were grouped as *low GDP contributors*. Details on state wise income, GDP contribution, population and economic density is provided in Annexure. Taking the mean per capita income as benchmark, states were divided into high or low per-capita income states. Combining these two criteria, six peer groups were formed as follows: 1) High income - High GDP%, 2) Low income - High GDP %, 3) High income - Medium

[1] The peer group is studied based on 27 states, Nagaland is not included due to non-availability of data
[2] State-wise Per Capita Income in Rupees/annum at current prices (2005-06)
[3] State-wise Gross State Domestic Product at current prices (2006-07) as % of India's overall GDP

GDP%, 4) Low income - Medium GDP%, 5) High income - Low GDP%, 6) Low income - Low GDP%. The 6 peer groups and states in each group are shown in Table 3.

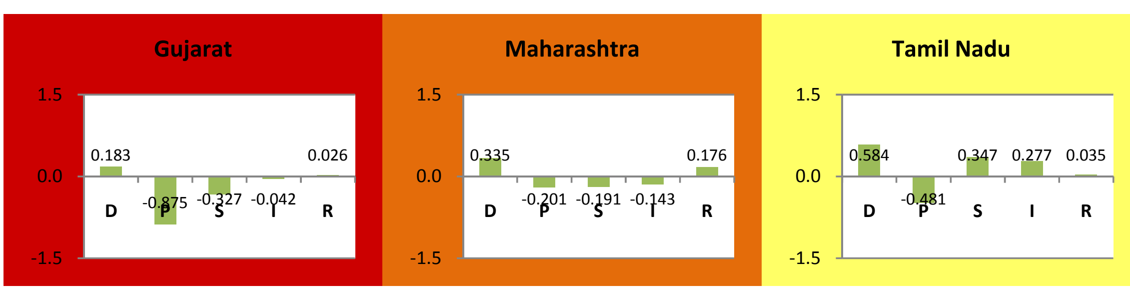
Table 3: Grouping of Peer States

	High % contribution to overall country's GDP	Medium % contribution to overall country's GDP	Low % contribution to overall country's GDP
High per capita Income	Maharashtra Gujarat Tamil Nadu	Kerala Punjab Haryana	Himachal Goa Sikkim
Low per capita Income	Uttar Pradesh West Bengal Andhra Pradesh	Karnataka Rajasthan Madhya Pradesh Bihar Orissa Jharkhand Chhattisgarh Jammu & Kashmir Assam Uttaranchal	Mizoram Manipur Meghalaya Tripura Arunachal

For each peer group, sustainability is measured along five components: driving force/population pressure (D), pressure on the ecosystem (P), state/quality of environment (S), impact on human health and ecology (I), and response from government and society (R). The color of the thumbnail of each state represents the overall ESI group the state belongs to (Red/Orange/Yellow/Green/Dark Green). All values are in standardized z-scores, positive values indicating better than average performance.

Peer Group 1- Gujarat, Maharashtra, Tamil Nadu (High income - High GDP%)

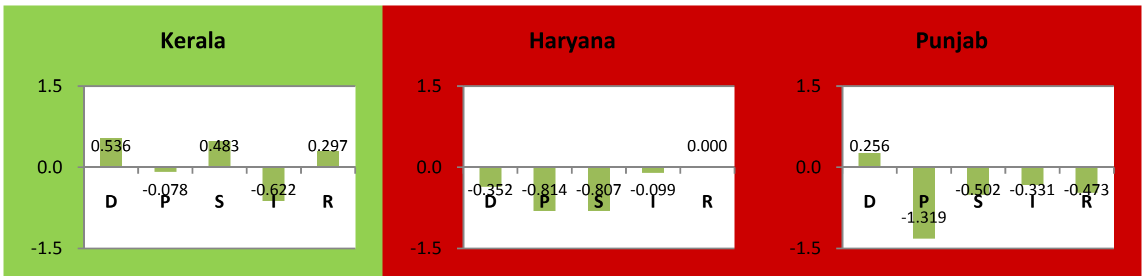
All the three states in this peer group face high negative pressure on their environment, an indication of risk of further degradation. Stress on ecosystem is high in all three states. For instance, the groundwater extraction rate in Tamil Nadu is as high as 85%, while in Gujarat the rate of ground water extraction is 76% even though the total replenishable ground water is one of the least among all states.



In Tamil Nadu, per capita municipal solid waste generation is 226 kg/year, one of the highest in the country, whereas Gujarat generates the highest amount of hazardous waste per person per year. While Gujarat and Tamil Nadu each have allocated 0.06% of their state GDP as environment budget, Maharashtra has a higher share of 0.9%. Gujarat and Maharashtra's population pressures are higher than Tamil Nadu, which is one of the factors contributing to better overall ESI of Tamil Nadu.

Peer Group 2 – Kerala, Haryana, Punjab (High income - Medium GDP%)

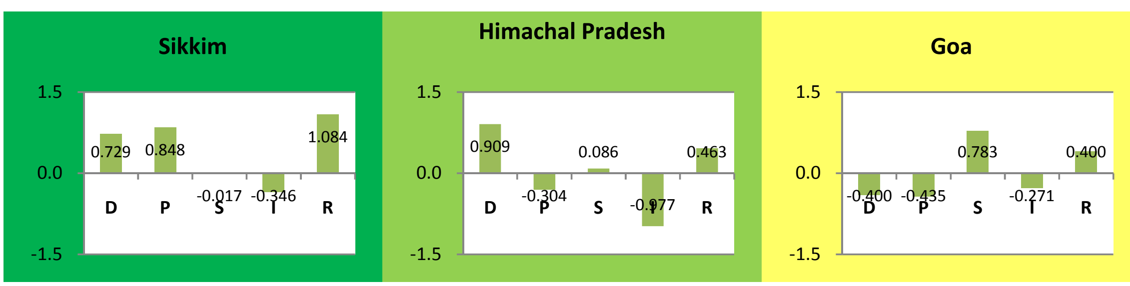
In this group, Kerala stands out with a high overall ESI score and also demonstrates better scores in the underlying components, particularly with regard to the present state of the environment and government efforts as compared to both Haryana and Punjab's negative scores in both these components.



The annual average concentration of respirable particulate matter in Kerala's atmosphere is 47.44 µg/m3 as compared to 179.6 µg/m3 and 208.43 µg/m3 in Punjab respectively. Biological Oxygen Demand, an indicator of water quality, was 28.53 µmhos/cm for Haryana as compared to 1.27 µmhos/cm in Kerala. The share of renewable energy in total installed energy in these three states are: 1.6% (Haryana), 2.87% (Kerala) and 2.35 (Punjab). Being high income states, all the three states have the resources to strengthen response components.

Peer Group 3 – Sikkim, Himachal Pradesh, Goa (High income – Low GDP%)

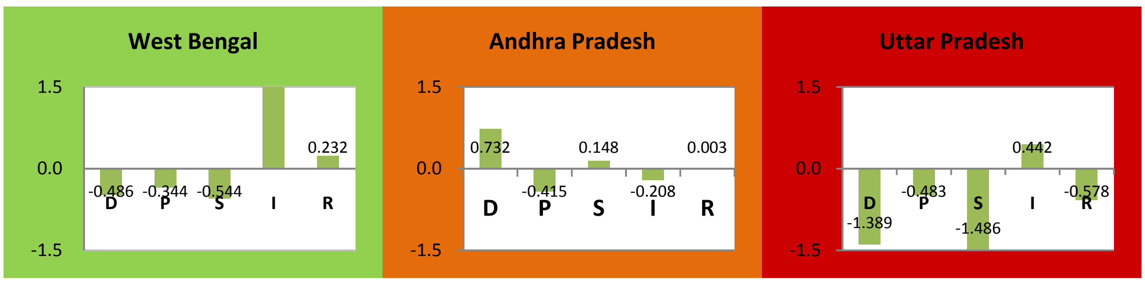
Sikkim, Himachal Pradesh and Goa have positive overall ESI scores, but intra-group differences exist with regards to ESI scores and some of the five components. All the three states are rich in natural endowment with considerable parts of their land area under forest (Goa - 58%, Sikkim - 46% and Himachal Pradesh - 26%).



In Himachal the ground water extraction rate is as high as 60% compared to its peers Sikkim (12.5%) and Goa (26%). Also Himachal Pradesh is facing high pressure on its environment due to a large part of its land under grazing land. Sikkim's data indicates that it is better than its peers in most indicators related to forest, energy and government spending on environment. While Himachal Pradesh and Goa score almost same in the response component, both states data at indicator level are quite different. For instance, in Himachal Pradesh, 100% of sewage is reportedly treated before discharge. Data on Goa indicate that only 25% is treated. On the other hand Goa has shown more efforts on wetland conservation and compensatory reforestation than Himachal Pradesh.

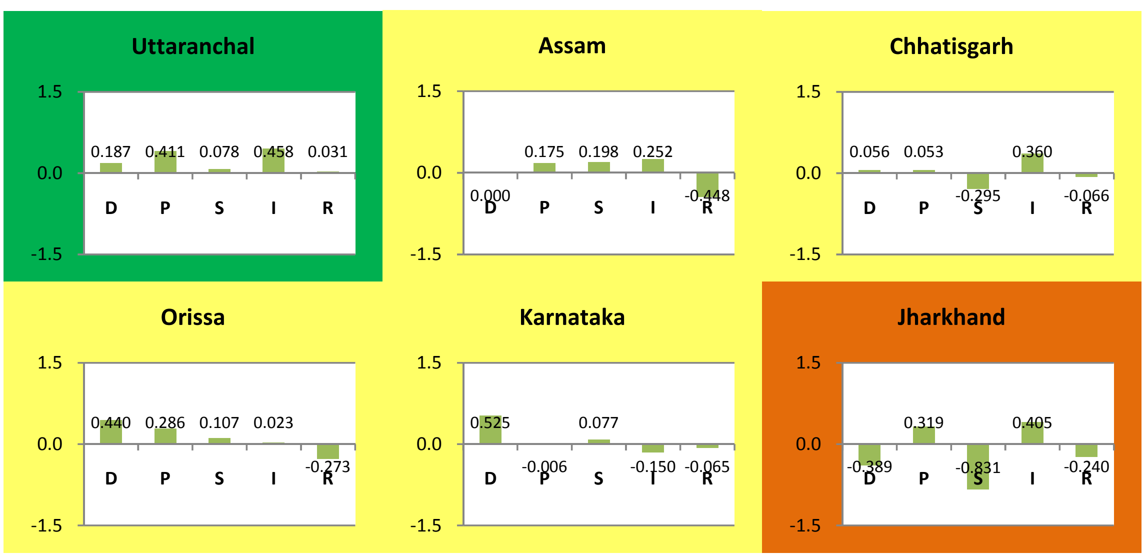
Peer Group 4 – Andhra Pradesh, Uttar Pradesh, West Bengal (Low income - High GDP %)

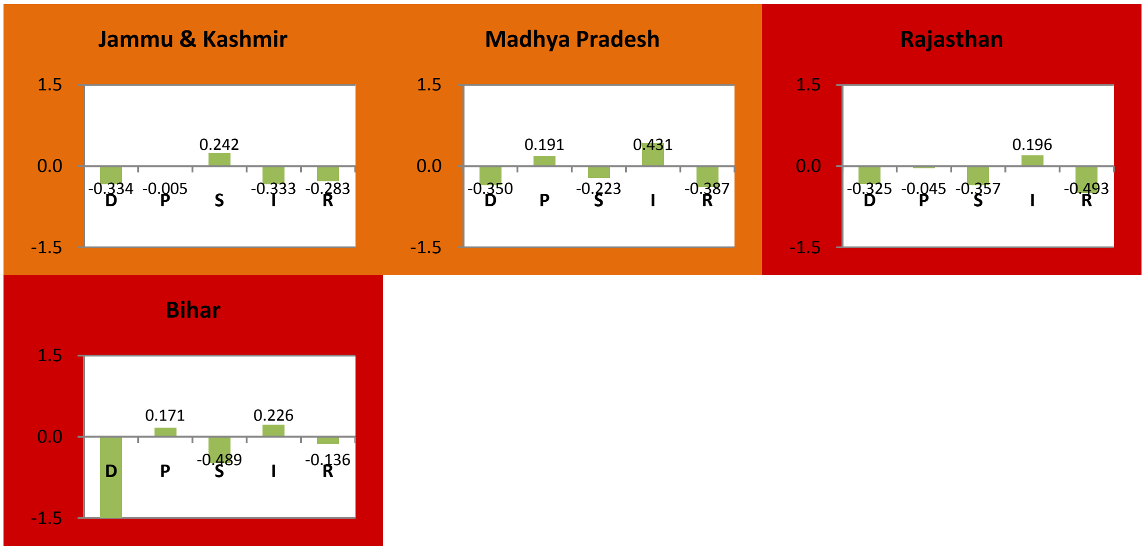
West Bengal's overall ESI is high; largely due to high scores on the impact on human health and ecology component and a moderate score on the response indicator. Scores on the other three components are negative. Uttar Pradesh scores less than it peers in all components. The only component in which it scores positive is the 'impact' component which comes largely from the lesser incidence of respiratory and water-borne diseases, and lesser flood and drought prone land as compared to West Bengal and Andhra Pradesh.



Peer Group 5 – Uttarakhand, Assam, Chhattisgarh, Orissa, Karnataka, Jharkhand, Jammu & Kashmir, Madhya Pradesh, Rajasthan & Bihar (Low income - Medium GDP %)

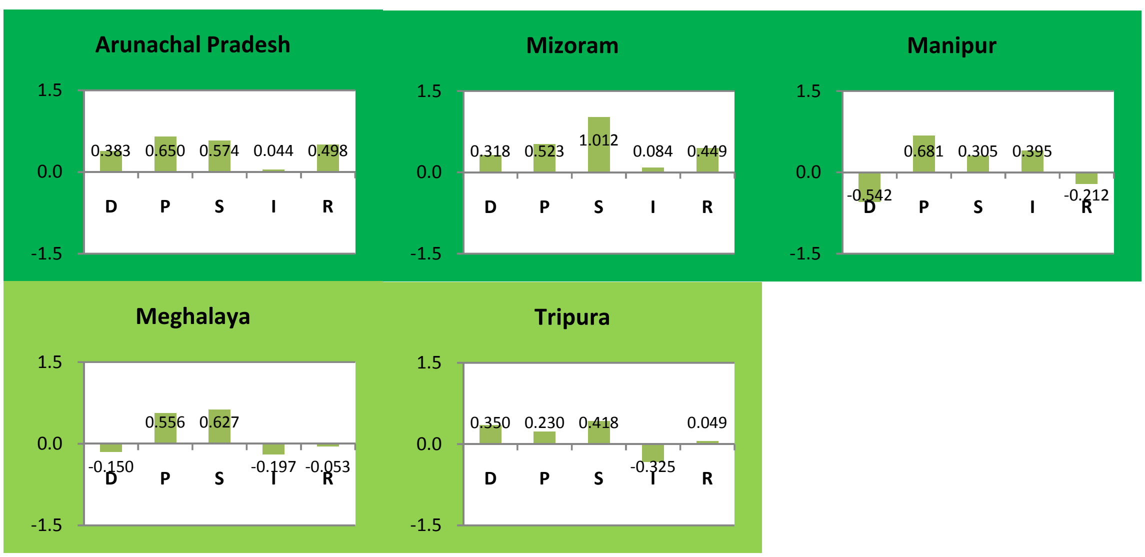
This is the biggest peer group with 10 low income states with moderate GDP contribution to national GDP. In this group while Uttarakhand is the only green state, there is large variation among the rest 9 states, both in overall ESI and in five underlying components.





Peer Group 6 – Arunachal Pradesh, Mizoram, Manipur, Meghalaya, Tripura (Low income - Low GDP %)

In this peer group of small states with lower per capita income, all the five states belong to the most and more sustainable category in overall ESI. In Meghalaya and Tripura, problem of salinity, acidity and waterlogging affected land is as high as 46 and 37 percent of total land. Moreover in Tripura, 31 percent land is flood affected whereas all other states in this group have no more than 5 percent of land under flood affected land.



All the five states have better water quality, less soil erosion and very good forest cover. Mizoram has 88.63 percent of its land under forest (as defined in official data), the maximum among the peers whereas Meghalaya has the minimum with 75.74 percent. Though there are some areas in which these states show variation, most of them score well in almost all components. For instance, Arunachal Pradesh has 25% of its total energy from renewable sources and Manipur has only 3.5%. Mizoram, Meghalaya and Tripura have 15%, 11% and 6.5% respectively. It is apparent that in all the five states the quality of environment is good with less pressure on the ecosystem.

In each of the six peer groups, there is considerable inter-group variation, both in overall ESI as well as the underlying components. The interstate variation within peer groups indicates the uniqueness of each state in terms of its historical endowment, prevalent environental quality and present actions that will shape its environment in the coming decades.

2.4 ESI 2009 and ESI 2008

Being a relative index, ESI measures state level sustainability by capturing the variation within 28 states at any given point of time. Hence each year's ESI is a standalone measure of sustainability that is not comparable in a time series format. However, some pattern of state level sustainability can be established by reviewing the grouping of states in 2008 & 2009 ESI. In both the years, states with abundant natural resources and less economic activity are the most sustainable states whereas the least sustainable are the ones where degree and intensity of economic activities, coupled with higher population and limited natural resources lead to unsustainable anthropogenic impacts on the environment. While this is the dominant observation, there is some reshuffling between states in the 5 sustainability groups. States that have moved up the sustainability ladder are: Uttaranchal, Goa, Himachal Pradesh, Kerala and Tamil Nadu. States which moved down by 1 group are: Orissa, Assam, Andhra Pradesh, Chhattisgarh, Jammu & Kashmir, Jharkhand and Tripura. While West Bengal's ESI improved by 2 groups, Bihar's ESI moved down by the same.

Table 4: State groups based on Overall ESI in 2008 and 2009

ESI Groups	States in ESI 2009	States in ESI 2008
Very High Sustainability **States between 80-100 percentile**	Arunachal Pradesh Manipur Mizoram Nagaland Sikkim Uttaranchal	Arunachal Pradesh Manipur Mizoram Nagaland Sikkim Tripura
High Sustainability **States between 60-80 percentile**	Himachal Pradesh Kerala Meghalaya Tripura West Bengal	Assam Chhattisgarh Meghalaya Orissa Uttaranchal
Moderate Sustainability **States between 40-60 percentile**	Assam Chhattisgarh Goa Karnataka Orissa Tamil Nadu	Bihar Jammu & Kashmir Jharkhand Karnataka Kerala Himachal Pradesh
Low Sustainability **States between 20-40 percentile**	Andhra Pradesh Jammu & Kashmir Jharkhand Madhya Pradesh Maharashtra	Goa Tamil Nadu West Bengal Madhya Pradesh Maharashtra
Very Low Sustainability **States between** **0-20 percentile**	Bihar Gujarat Haryana Punjab Rajasthan Uttar Pradesh	Andhra Pradesh Gujarat Haryana Punjab Rajasthan Uttar Pradesh

While the framework and methodology have remained constant, the difference in ESI 2008 and 2009 is a product of the changes in data and the manner and sequence in which indicators are aggregated. The amendments in ESI 2009 over the previous year are in three main areas: data upgradation, alteration in indicators, and changes in construction of sub-indices.

i. *Changes in the datasets for many indicators*

ESI 2009 uses more updated datasets than 2008 depending on newer data being made available by government and published sources. Air quality, hazardous waste, fertilizer usage, renewable energy and government expenditure are a few to name.

ii. *Changes in Indicators*

Some indicators used in ESI 2008 were dropped in 2009 study due to lack of recent data and large-scale occurrence of missing values. Some indicators were changed to improve measurement of key concepts. For example in water related indicators, electrical conductivity was replaced with coliform as a measure of water quality and in energy indicators, usage of biomass fuels was considered instead of per-capita energy consumption. Additional indicators on drinking water, compensatory reforestation and gap in sewage treatment, which adequately capture society's efforts were used in 2009 ESI.

iii. *Changes in Sub-indices*

The 2008 ESI was constructed from 15 sub-indices such as: Air quality, Air pollution, Water quality, Water pollution, Natural resource endowment, Natural resource depletion, Land use, Waste generation, Natural disasters, Human health impact, Energy management, Government's initiatives, People's initiatives and Greenhouse gas emission. While these sub-indices were formulated keeping in mind a particular set of environmental issues; the nine sub-indices of 2009 ESI are formed based on their policy relevance. Thus there have been some changes in assigning indicators into each sub-index thereby changing the extent to which each data point influences the overall ESI.

2.5 ESI and Other Development Indicators

In this section, ESI is compared with three macroeconomic indicators: per capita income, the Human Development Index and incidence of poverty. ESI's focus on environmental stewardship and its view toward the future make the index an extremely relevant complement to these traditional development indicators. The implications on resource use for supporting India's high growth rate must also be accounted for in order to signal the sustainability of the growth process. When per capita income and ESI of several major states[4]were plotted, no distinct patterns could be established. Since ESI is not a performance-oriented index that measures outcomes, its graph should not be interpreted as a picture of which states have performed better in preserving their environments. Rather the utility of this graph lies in identifying states with higher or lower obstacles to environmentally sustainable development. For example, Uttar Pradesh, Bihar, Madhya Pradesh and Rajasthan are all low ESI and low per capita income states, which implies that the growth policies for these states should be designed in such a way that prevents further

[4] Major states in terms of size and contribution to country's overall GDP

harm to the environment. Two other low-income states – Orissa and Assam – exhibit medium sustainability that might decline with increased intensity of developmental activities.

Figure 2.4: ESI and Per capita Income

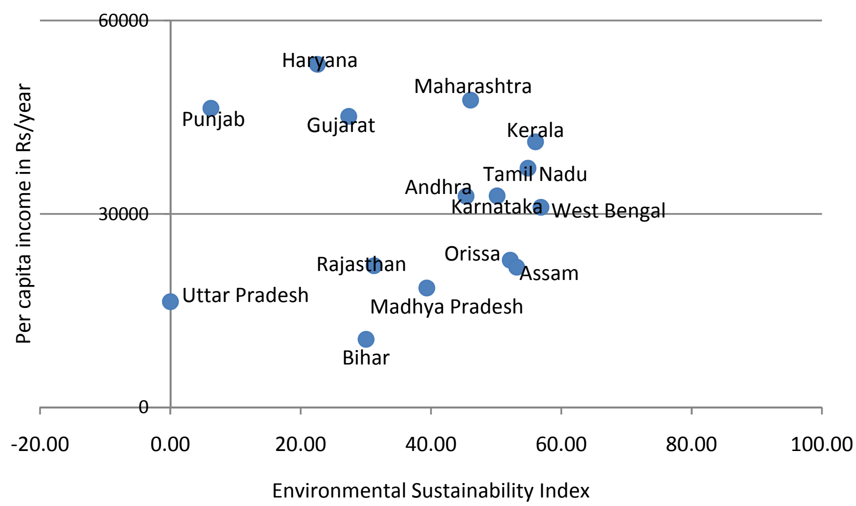
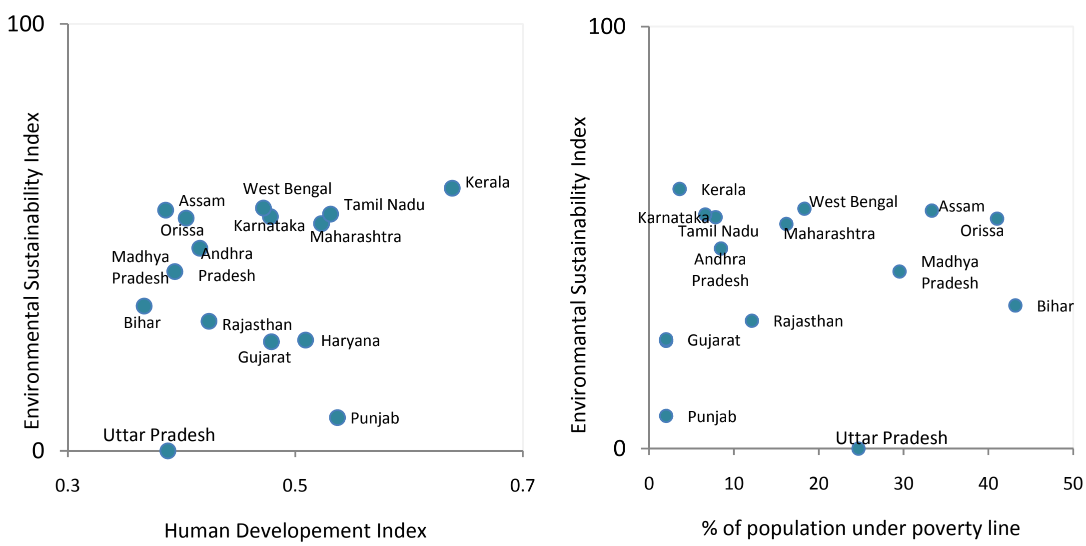


Figure 2.5: ESI and Human Development Index and Poverty



ESI does not seem to be correlated with Human Development Index or the poverty rate. States with similar HDI differ in terms of ESI; similarly ESI scores vary in states where the percentages of below poverty line (BPL) population are similar.

Nevertheless, the data do highlight the different challenges that states face. Bihar, Uttar Pradesh, Madhya Pradesh, Orissa and Assam are the five states with a high incidence of poverty and low per capita income. Among these states, a low ESI (as seen for Uttar Pradesh and Bihar)indicates that without specific interventions, the environment is likely to degrade faster than it will in states like Assam and Orissa, where a relatively higher ESI ranking suggests that these states are better equipped to grow sustainably.

These inter-relationships among the environment, the economy and society highlight the manifold challenges of planning and policy making for development that integrates income with social well-being, equity, quality of life and ecosystem vitality. To design development interventions for Uttar Pradesh, for example –a state with one of the lowest per capita incomes in India, a very low ranking on the human development index, a large part of its population under the poverty line and a low ESI – demands a very different approach than planning for Kerala, which scores high both on human development and environmental sustainability. Assam and Orissa both have low income, low human development and better-than-average environmental sustainability. Similarly, Tamil Nadu, Karnataka, Maharashtra and West Bengal are comparable in terms of socioeconomic and environmental conditions. There is clearly scope for states to exchange experiences of growth and benefit from mutual learning.

CHAPTER 3

STATE ESI PROFILES

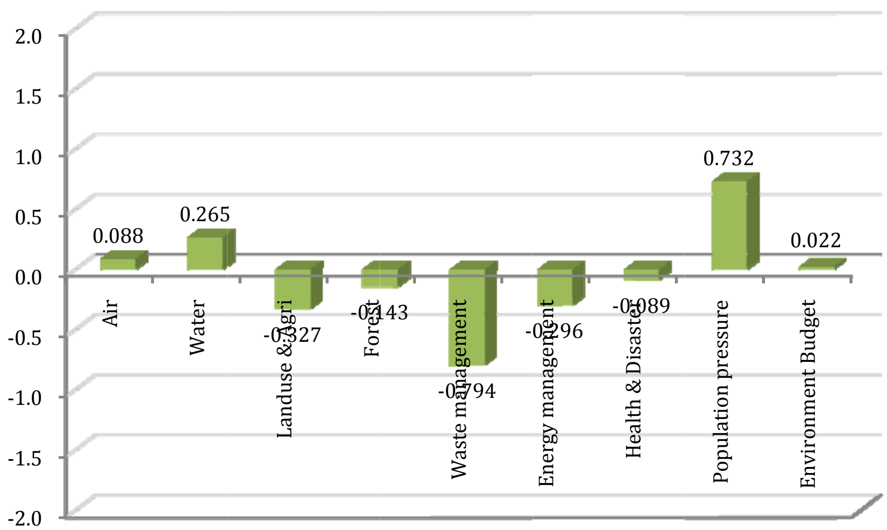
In this section, detailed ESI profile of each state is presented in alphabetical order. A state's ESI disaggregated into the relative performance across nine policy sub-indices helps prioritize policy attention by identifying the factors that contribute to the state's overall sustainability. The nine sub-indices are shown in the column chart in terms of standardized scores on a scale of -3 (least) to +3 (most); 0 means average. Most states' scores are in the range of -2 to +2. For any given sub-index, the upward going bar is a sign of better than average (of all 28 states) performance and the bars going downwards show less than the average performance(of all 28 states). The height of the upward going bar indicates how well a state has performed compared to others in that particular sub-index. Thus more the number of longer upward bars, better the state's sustainability in different aspects of environment. Theoretically, it is possible for a state to have all positive or all negative sub-indices. However the ESI results reveal that each state has both positive and negative scores, which signify that even states with overall less ESI have outperformed the higher ESI states in certain areas and each state has something to learn from other states. The graph with nine sub-indices also illustrates which area needs more urgent policy attention. The sub-indices with negative values are the ones that need urgent policy attention for any state. In case of states with most of the sub-indices having negative scores, the ones with higher negative scores are the ones that need more attention. States with most sub-indices as positive upward bars, the ones with smaller positive values as well as the negative ones, if any, need prioritization over others.

To understand the drivers of overall sustainability in a state, ESI is broken down into the DPSIR components that show the state's sustainability in terms of present environment conditions, historical endowment and resource depletion, effort of policymakers and society to maintain and improve the state's natural environment. The spider chart which shows the states sustainability in terms of DPSIR is also from the standardized scores in a scale of -3 (least) to +3 (most) with 0 as average. Values farther from the centre indicate better performance. Thus a state's higher positive scores in different components add up to higher green area in the spider indicating better performance by the state in all components.

ANDHRA PRADESH

ESI Group	Orange
Other states in same ESI group	Maharashtra, Jammu & Kashmir, Madhya Pradesh and Jharkhand
Contribution to overall India's GDP	8.02%
SGDP per capita/annum	Rs 32754
Population living below poverty line	8.49%
Population density per square km area	303

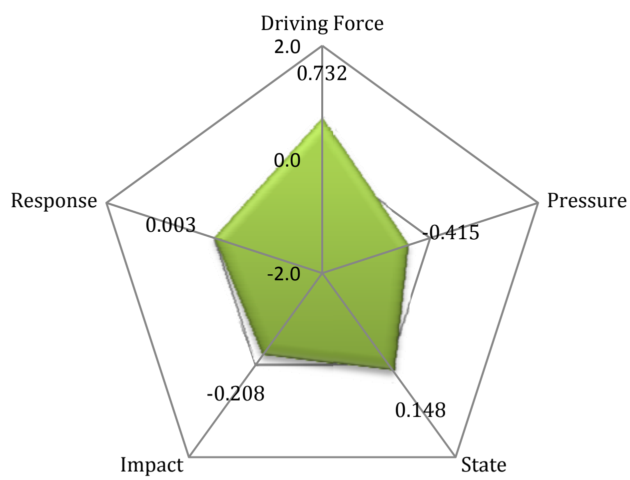
ESI in 9 Sub-indices



For any given sub-index, the upward going column is a sign of better than average (of all 28 states) performance and the columns going downwards show less than average performance(of all 28 states). The height of the upward going column indicates the degree to which a state has performed better than others in that particular sub-index. All values are in standardized scores. All sub-indices are adjusted in a way that higher values indicate better performance in that aspect of sustainability.

ESI in DPSIR

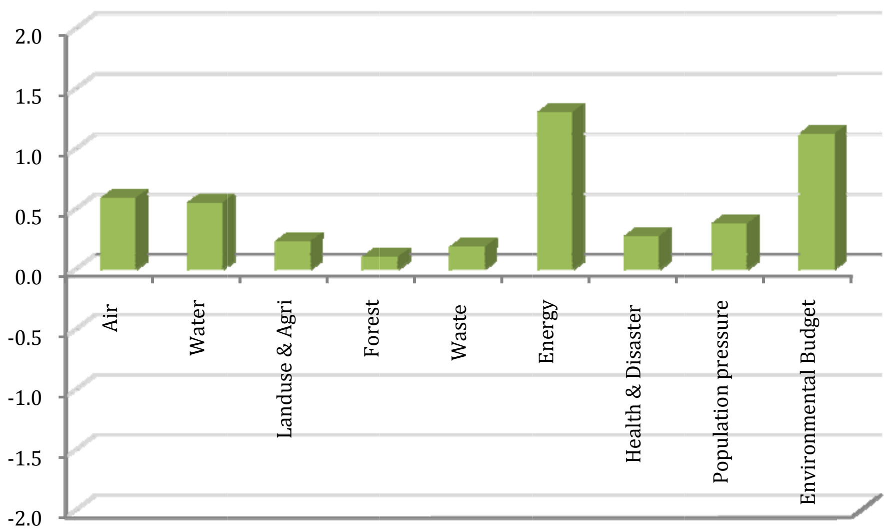
The spider chart shows the states sustainability in terms of DPSIR. All values are in standardized scores. Values farther from the centre indicate better performance. A state's higher positive scores in the 5 different components add up; and higher green area in the spider indicates better performance by the state in all components.



ARUNACHAL PRADESH

ESI Group	Dark Green
Other states in same ESI group	Mizoram, Sikkim, Nagaland, Manipur, Uttaranchal
Contribution to overall India's GDP	0.1%
SGDP per capita/annum	Rs 28533
Population living below poverty line	3.68%
Population density per square km area	15

ESI in 9 Sub-indices



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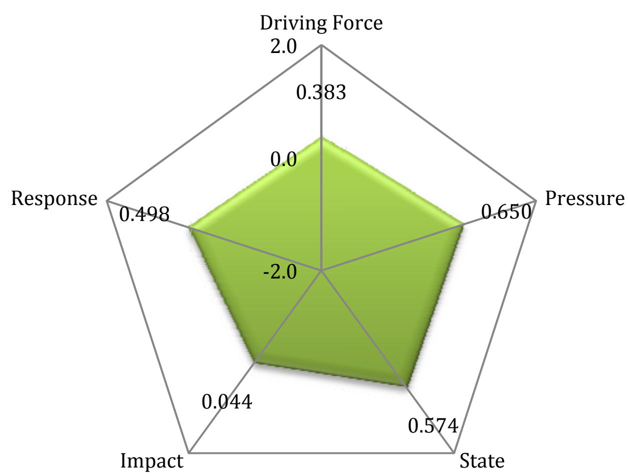
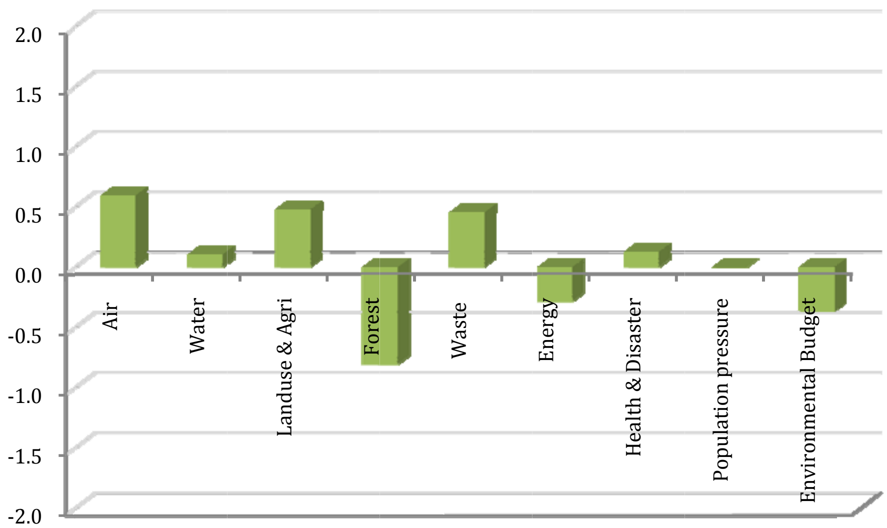


ASSAM

ESI Group	Yellow
Other States in same ESI group	Tamil Nadu, Orissa, Karnataka, Goa, Chhattisgarh
% Contribution to overall India's GDP	1.94
SGDP per capita/annum	21729
% of population living below poverty line	33.33
Population density per square km area	387

ESI in 9 Sub-indices



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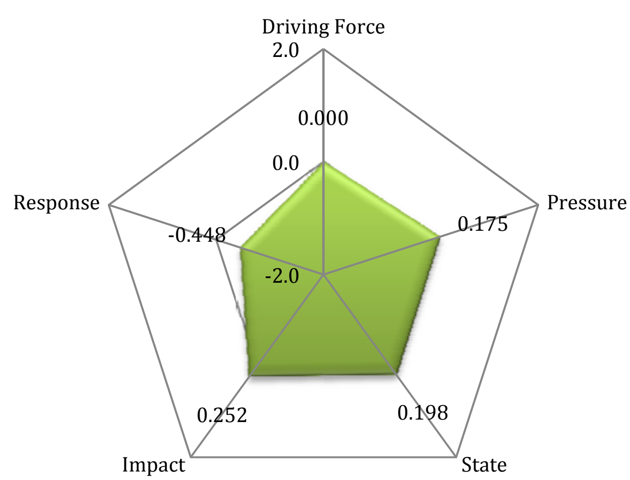
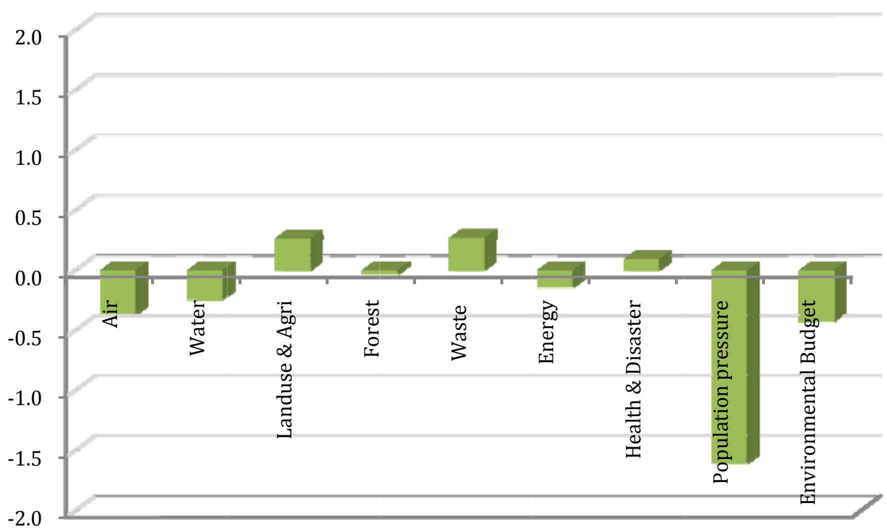


BIHAR

ESI Group	Red
Other States in same ESI group	Rajasthan, Gujarat, Haryana, Punjab, Uttar Pradesh
% Contribution to overall India's GDP	2.95
SGDP per capita/annum	10547
% of population living below poverty line	43.18
Population density per square km area	1010

ESI in 9 Sub-indices



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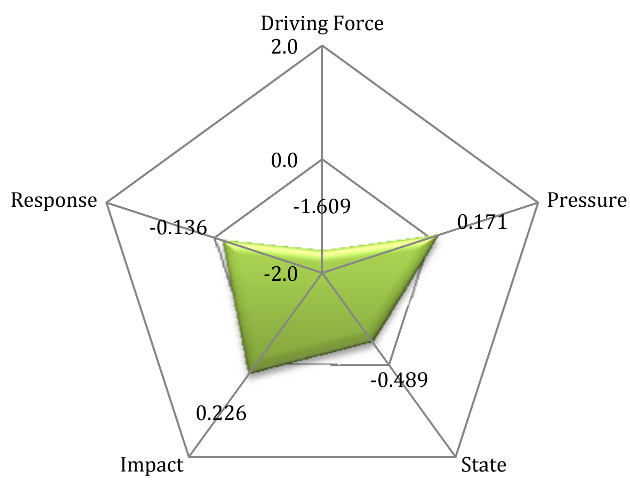
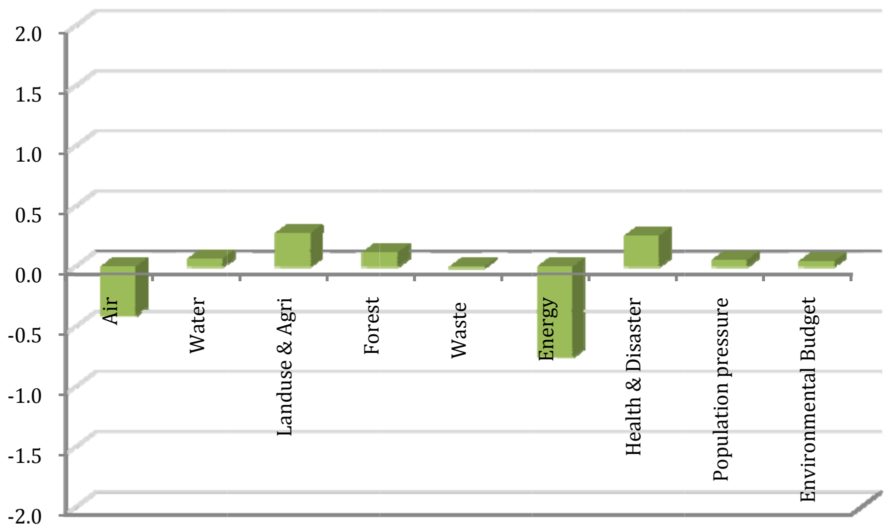


CHHATTISGARH

ESI Group	Yellow
Other States in same ESI group	Tamil Nadu, Orissa, Karnataka, Goa, Assam
% Contribution to overall India's GDP	1.91
SGDP per capita/annum	27168
% of population living below poverty line	
Population density per square km area	177

ESI in 9 Sub-indices



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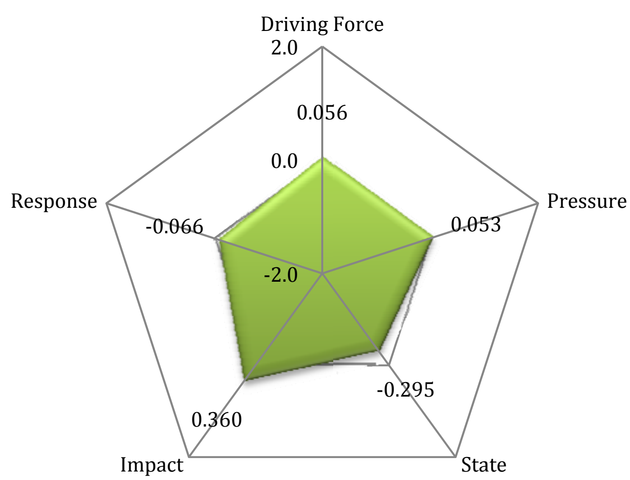
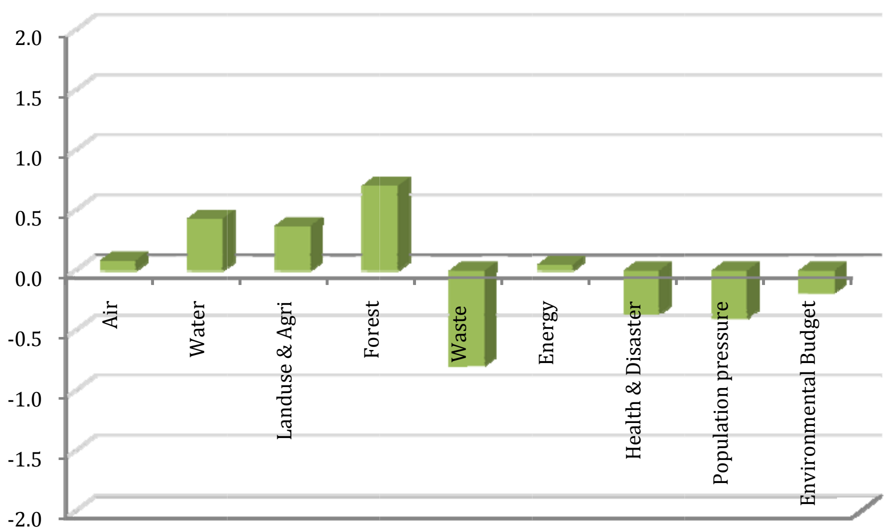


GOA

ESI Group	Yellow
Other States in same ESI group	Tamil Nadu, Orissa, Karnataka, Assam, Chhattisgarh
% Contribution to overall India's GDP	0.43
SGDP per capita/annum	89208
% of population living below poverty line	2
Population density per square km area	446

ESI in 9 Sub-indices



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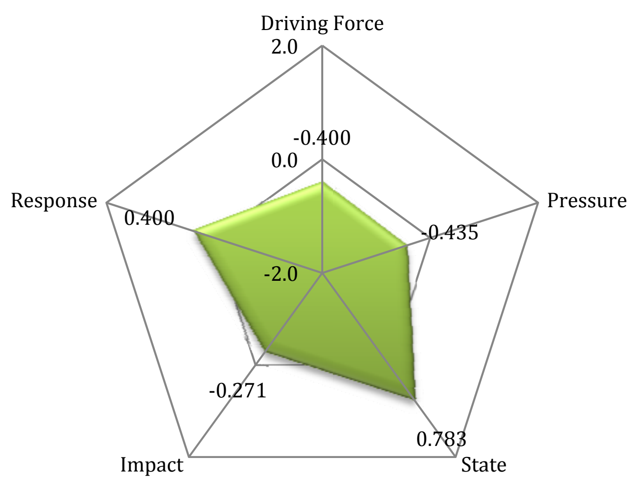
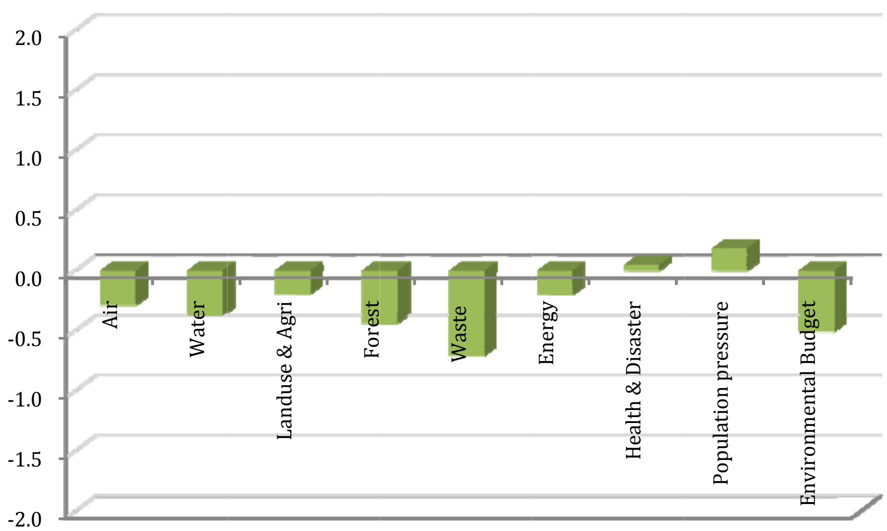


GUJARAT

ESI Group	Red
Other States in same ESI group	Bihar, Rajasthan, Haryana, Punjab, Uttar Pradesh
% Contribution to overall India's GDP	7.58
SGDP per capita/annum	45124
% of population living below poverty line	2
Population density per square km area	292

ESI in 9 Sub-indices



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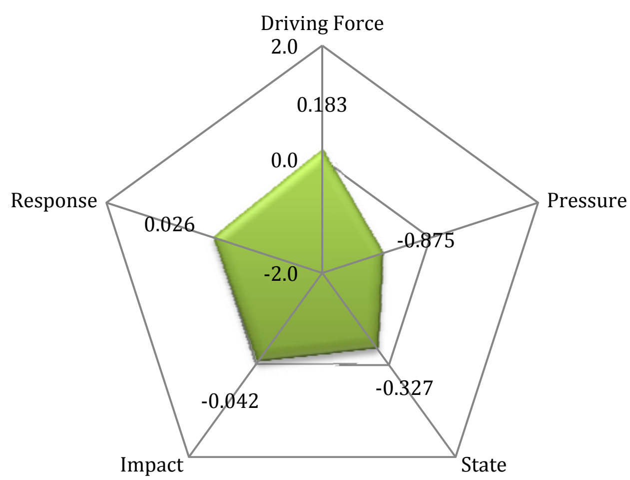
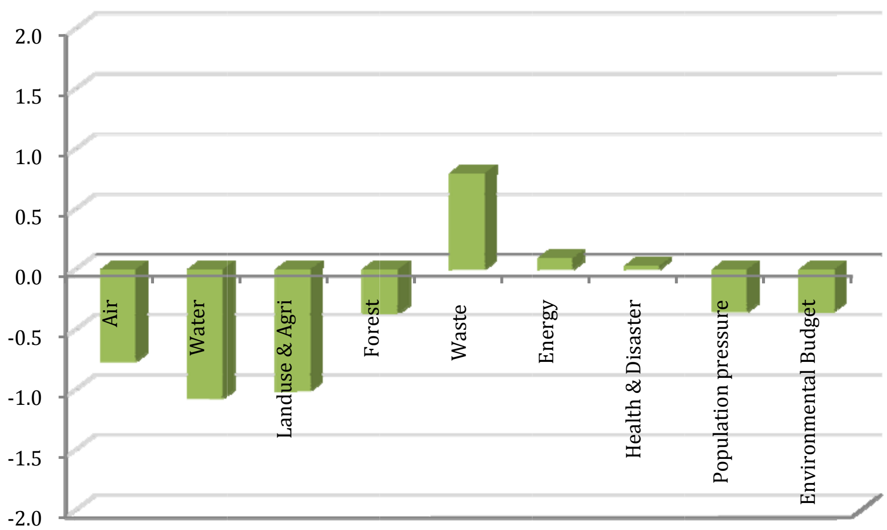


HARYANA

ESI Group	Red
Other States in same ESI group	Bihar, Rajasthan, Gujarat, Punjab, Uttar Pradesh
% Contribution to overall India's GDP	3.77
SGDP per capita/annum	53203
% of population living below poverty line	2
Population density per square km area	545

ESI in 9 Sub-indices



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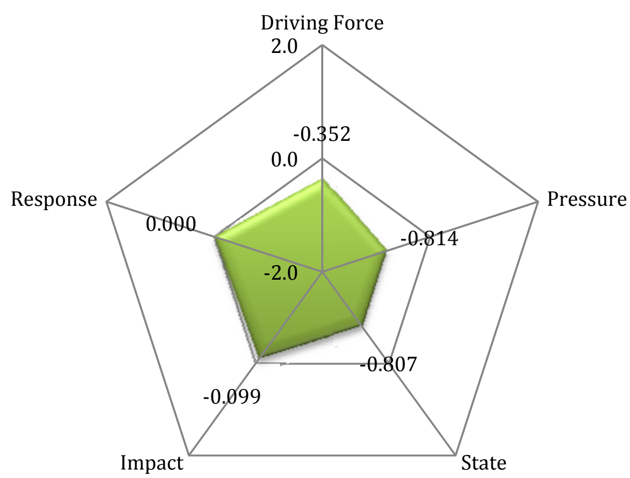
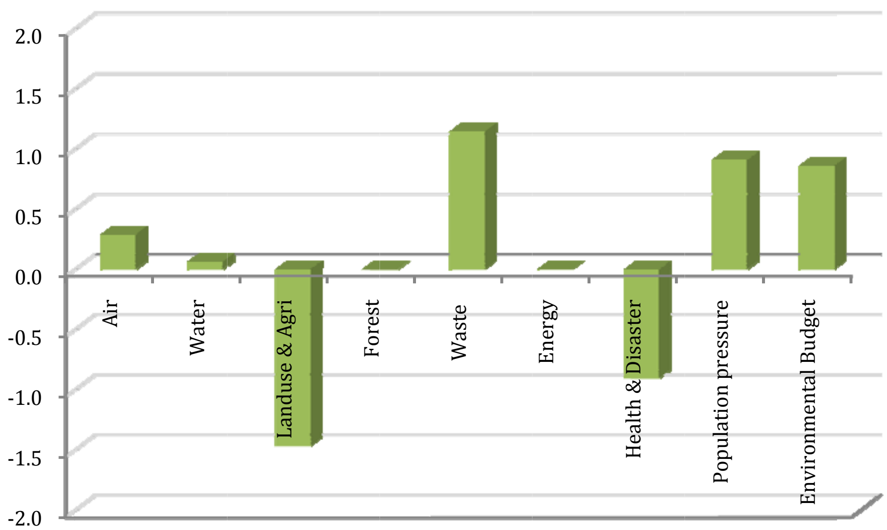


HIMACHAL PRADESH

ESI Group	Green
Other States in same ESI group	Meghalaya, Tripura, West Bengal, Kerala
% Contribution to overall India's GDP	0.84
SGDP per capita/annum	43295
% of population living below poverty line	2
Population density per square km area	119

ESI in 9 Sub-indices



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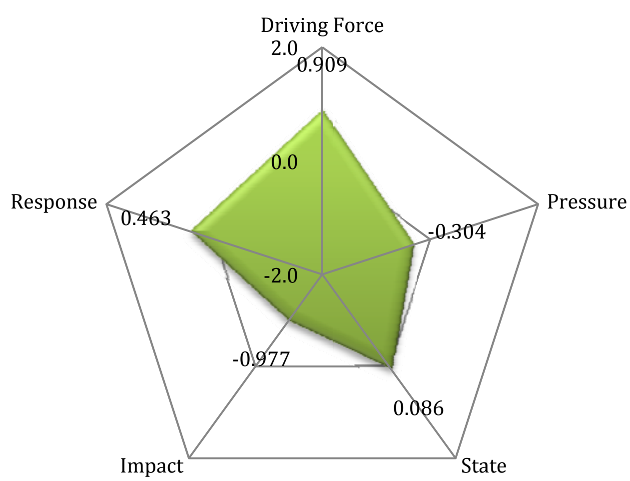
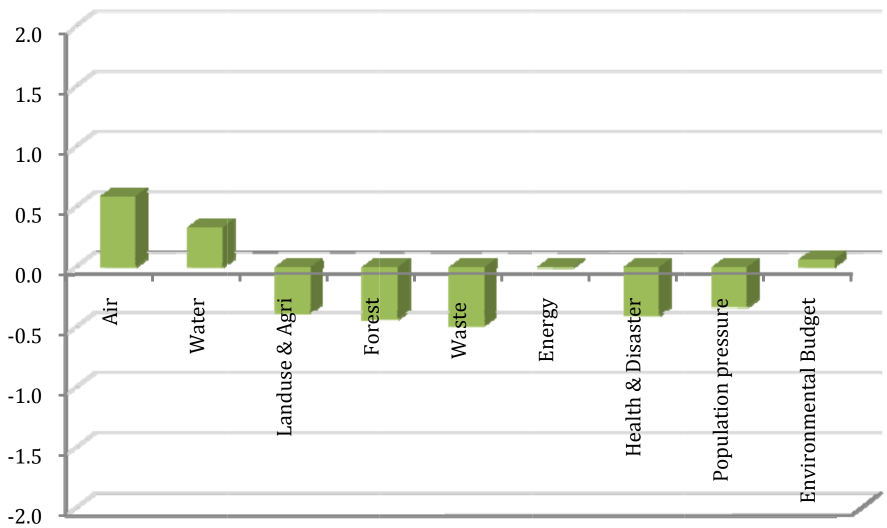


JAMMU & KASHMIR

ESI Group	Orange
Other States in same ESI group	Maharashtra, Andhra Pradesh, Madhya Pradesh, Jharkhand
% Contribution to overall India's GDP	0.86
SGDP per capita/annum	23476
% of population living below poverty line	
Population density per square km area	56

ESI in 9 Sub-indices



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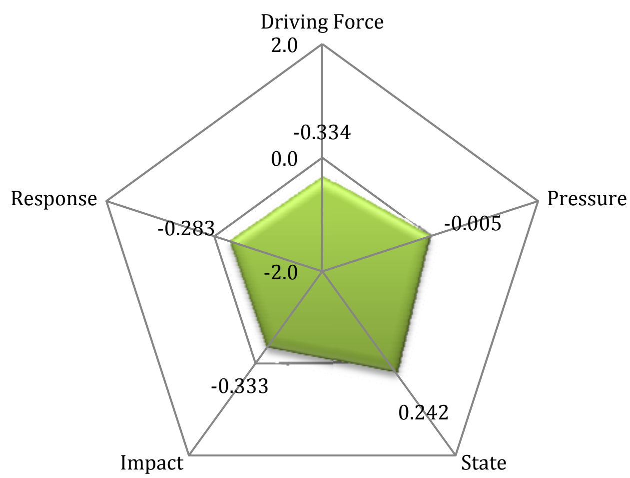
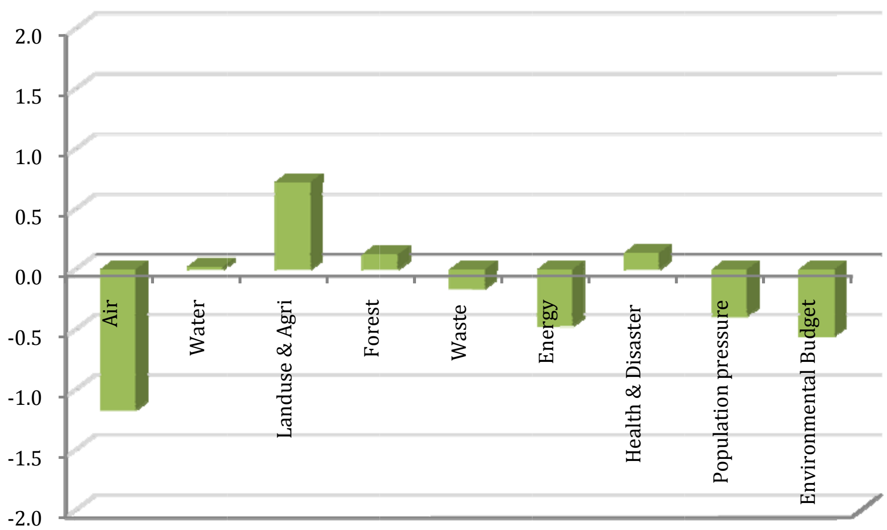


JHARKHAND

ESI Group	Orange
Other States in same ESI group	Maharashtra, Andhra Pradesh, Madhya Pradesh, Jammu & Kashmir
% Contribution to overall India's GDP	2.19
SGDP per capita/annum	24518
% of population living below poverty line	
Population density per square km area	382

ESI in 9 Sub-indices



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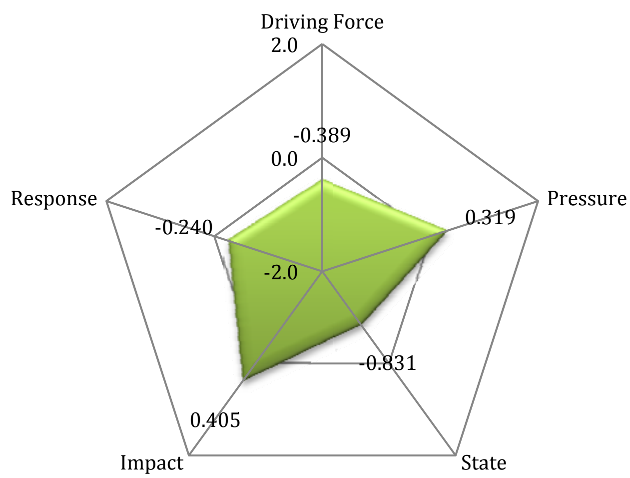
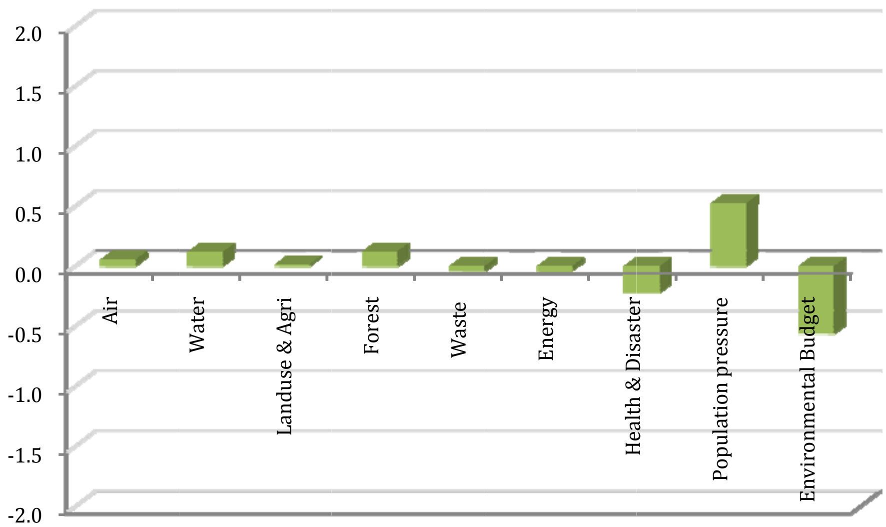


KARNATAKA

ESI Group	Yellow
Other States in same ESI group	Tamil Nadu, Assam, Orissa, Goa, Chhattisgarh
% Contribution to overall India's GDP	5.61
SGDP per capita/annum	32801
% of population living below poverty line	7.85
Population density per square km area	303

ESI in 9 Sub-indices



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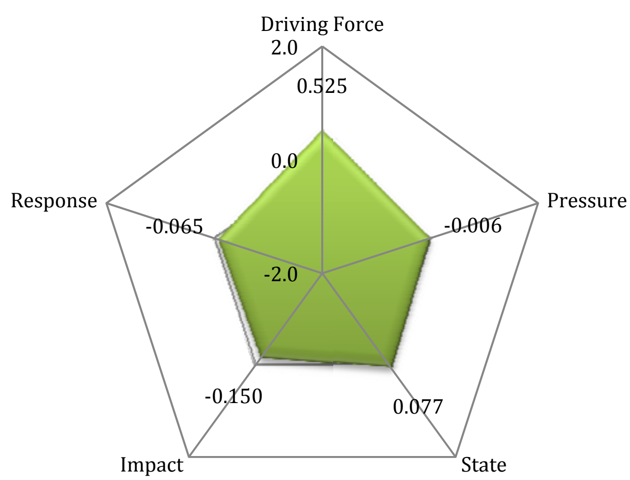
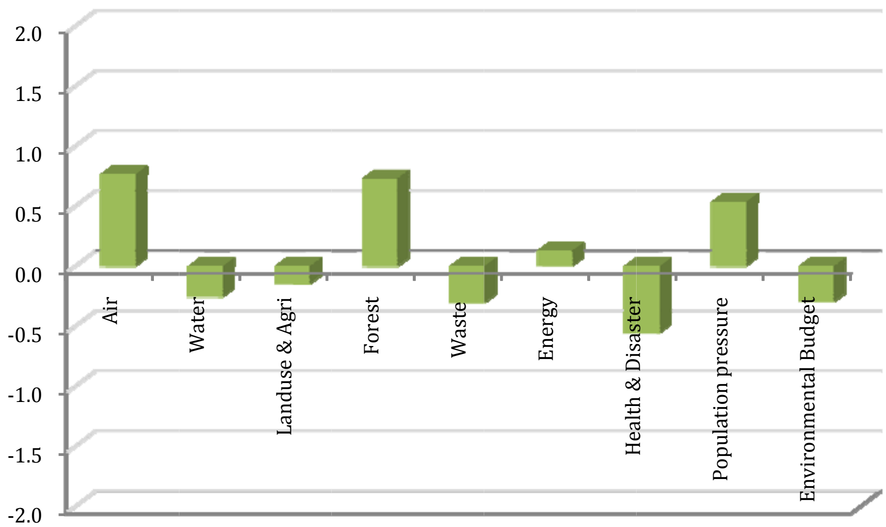


KERALA

ESI Group	Green
Other States in same ESI group	Meghalaya, Tripura, Himachal Pradesh, West Bengal
% Contribution to overall India's GDP	3.95
SGDP per capita/annum	41182
% of population living below poverty line	3.61
Population density per square km area	841

ESI in 9 Sub-indices



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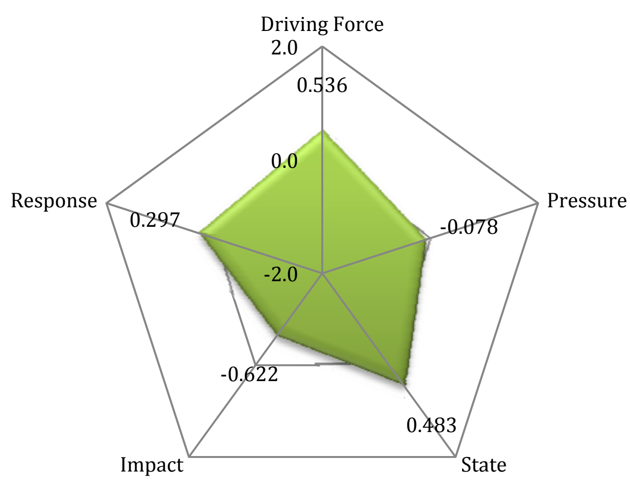
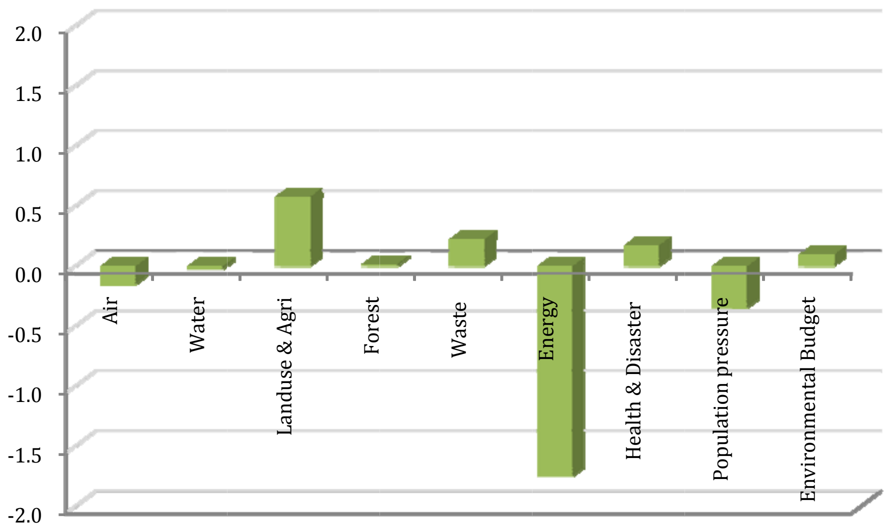


MADHYA PRADESH

ESI Group	Orange
Other States in same ESI group	Maharashtra, Andhra Pradesh, Jharkhand, Jammu & Kashmir
% Contribution to overall India's GDP	3.82
SGDP per capita/annum	18505
% of population living below poverty line	29.52
Population density per square km area	228

ESI in 9 Sub-indices



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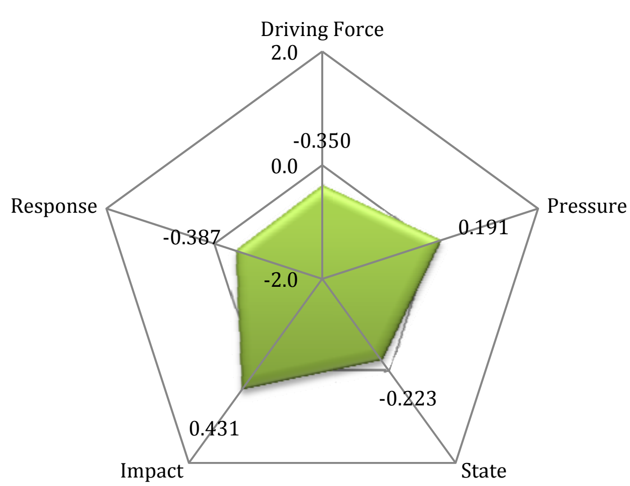
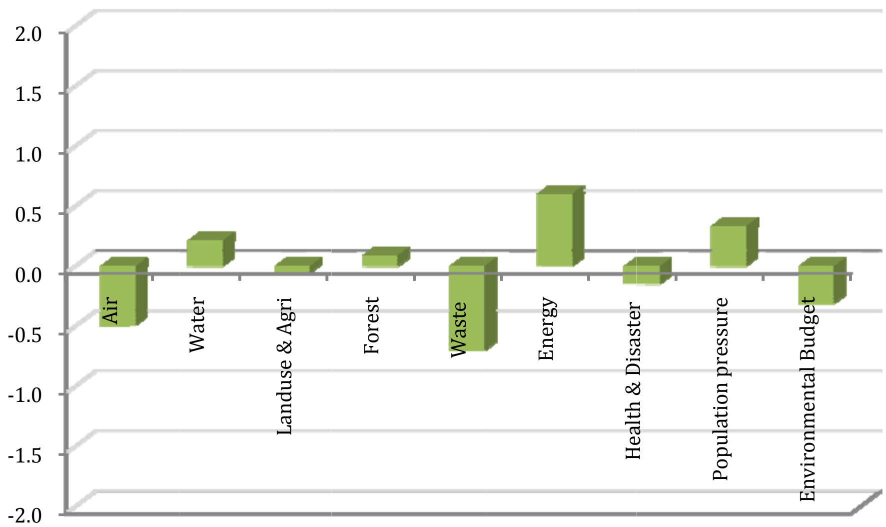


MAHARASHTRA

ESI Group	Orange
Other States in same ESI group	Jharkhand, Andhra Pradesh, Madhya Pradesh, Jammu & Kashmir
% Contribution to overall India's GDP	15.17
SGDP per capita/annum	47651
% of population living below poverty line	16.18
Population density per square km area	352

ESI in 9 Sub-indices



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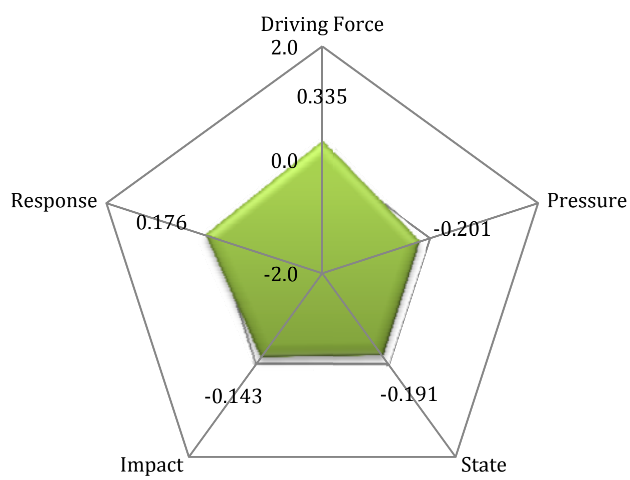
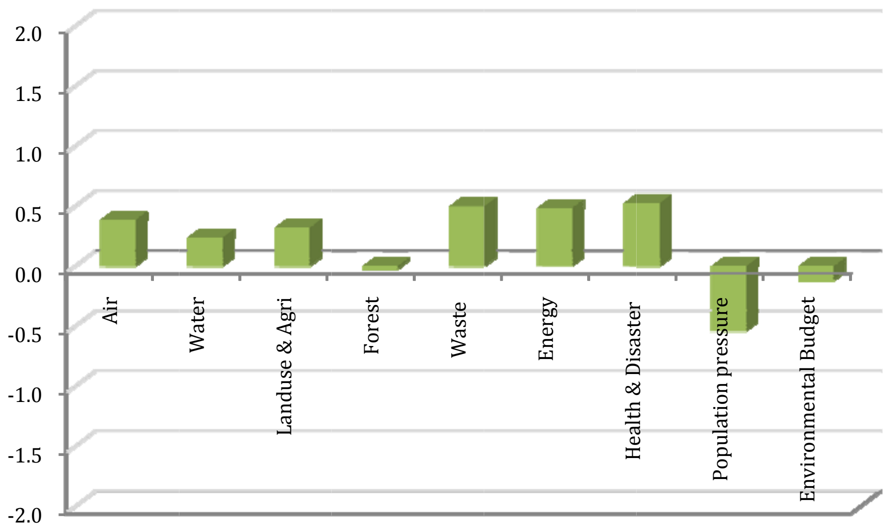


MANIPUR

ESI Group	Dark Green
Other States in same ESI group	Mizoram, Arunachal Pradesh, Sikkim, Nagaland, Uttaranchal
% Contribution to overall India's GDP	0.19
SGDP per capita/annum	24507
% of population living below poverty line	30.52
Population density per square km area	119

ESI in 9 Sub-indices



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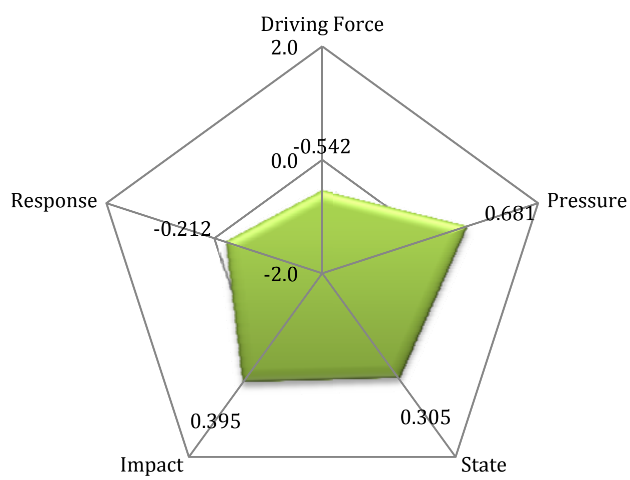
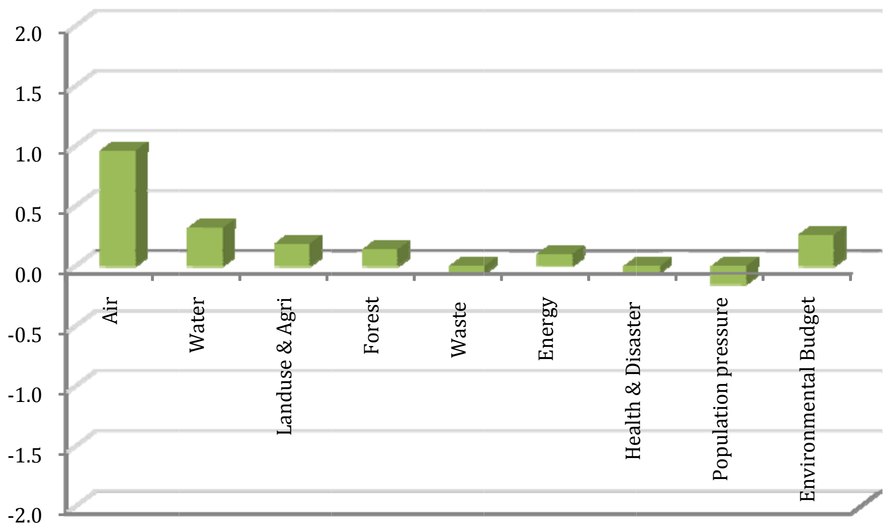


MEGHALAYA

ESI Group	Green
Other States in same ESI group	Tripura, Himachal Pradesh, West Bengal, Kerala
% Contribution to overall India's GDP	0.21
SGDP per capita/annum	27401
% of population living below poverty line	8.23
Population density per square km area	115

ESI in 9 Sub-indices



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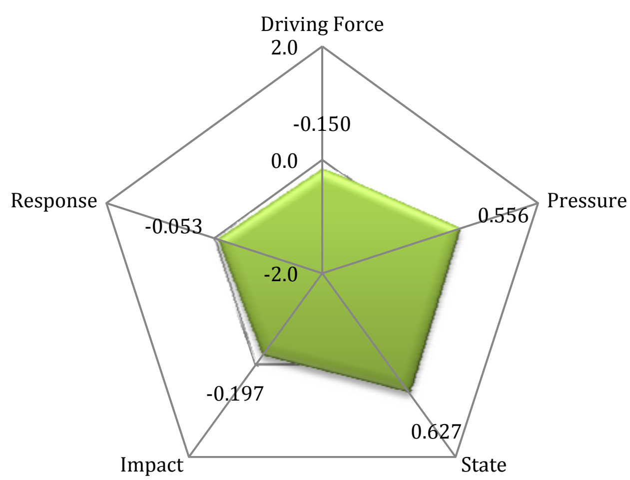
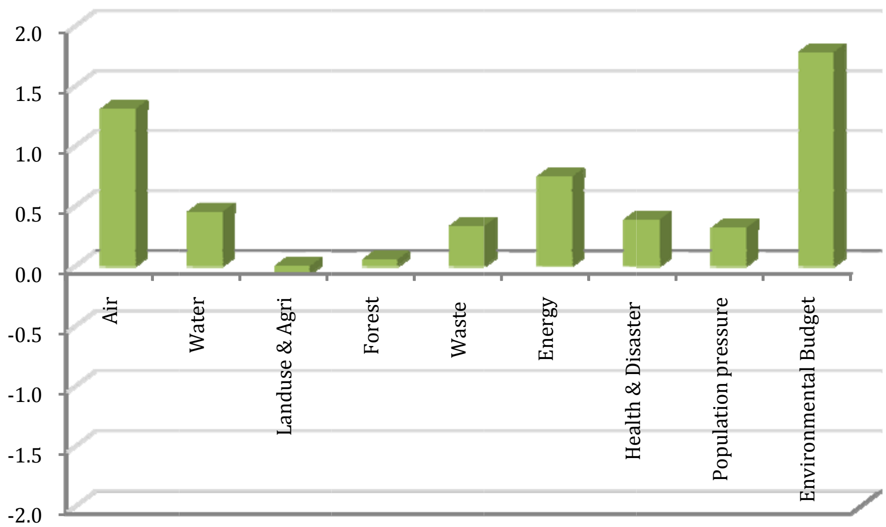


MIZORAM

ESI Group	Dark Green
Other States in same ESI group	Manipur, Arunachal Pradesh, Sikkim, Nagaland, Uttaranchal
% Contribution to overall India's GDP	0.09
SGDP per capita/annum	30459
% of population living below poverty line	20.76
Population density per square km area	47

ESI in 9 Sub-indices



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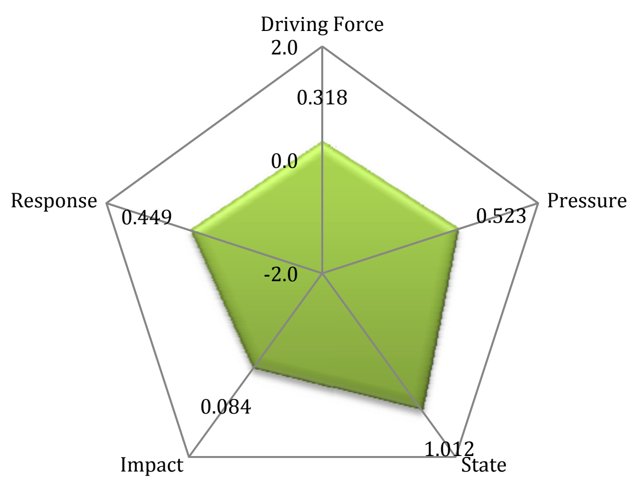
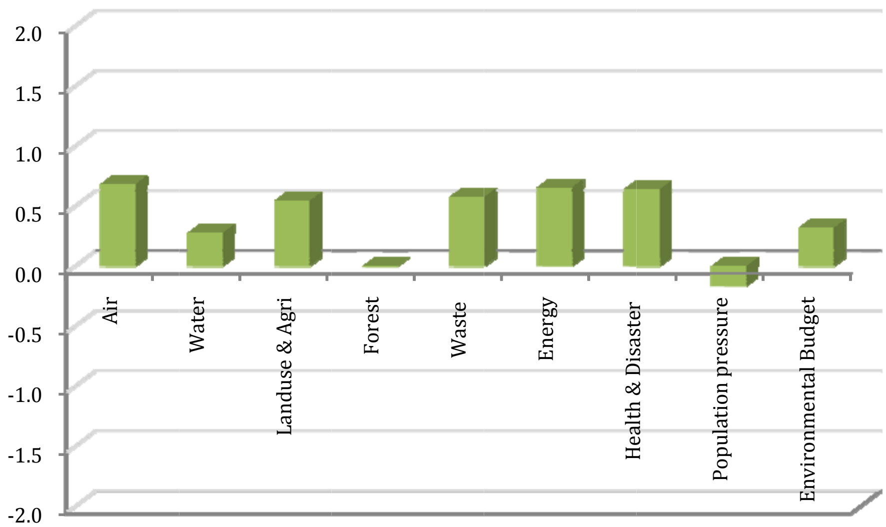


NAGALAND

ESI Group	Dark Green
Other States in same ESI group	Mizoram, Arunachal Pradesh, Sikkim, Manipur, Uttaranchal
% Contribution to overall India's GDP	
SGDP per capita/annum	
% of population living below poverty line	31.86
Population density per square km area	134

ESI in 9 Sub-indices



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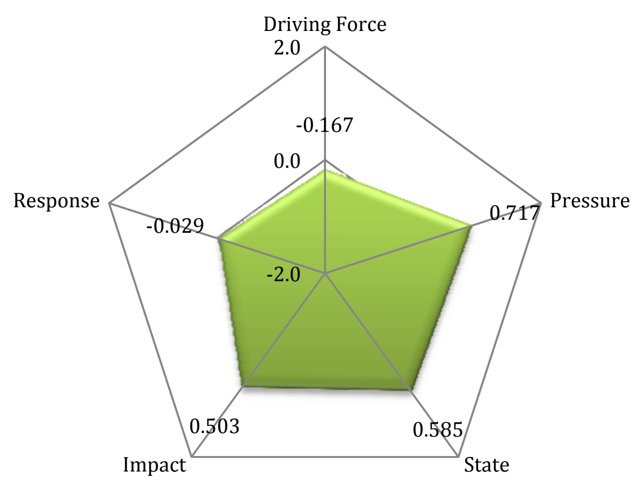
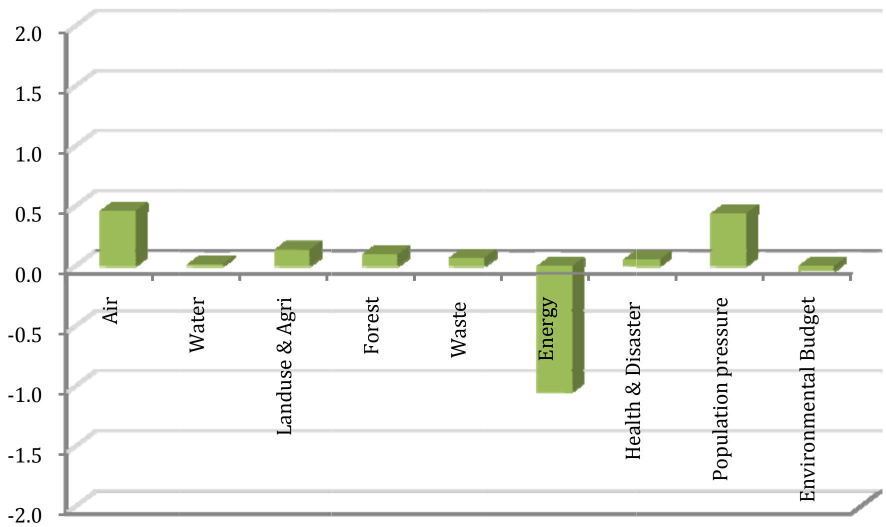


ORISSA

ESI Group	Yellow
Other States in same ESI group	Tamil Nadu, Assam, Karnataka, Goa, Chhattisgarh
% Contribution to overall India's GDP	2.72
SGDP per capita/annum	22845
% of population living below poverty line	41.04
Population density per square km area	260

ESI in 9 Sub-indices



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ESI in DPSIR

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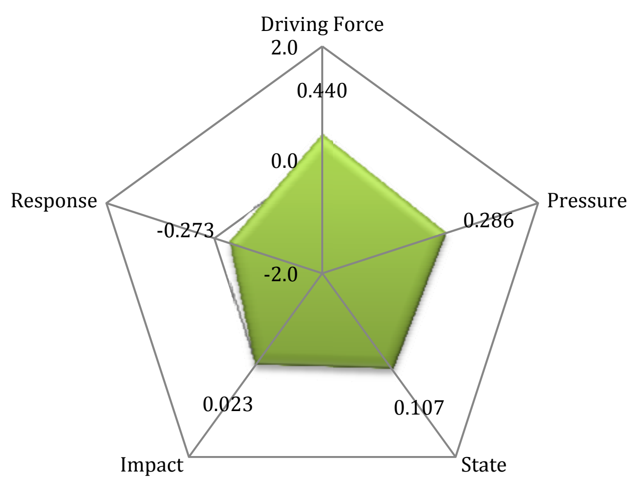
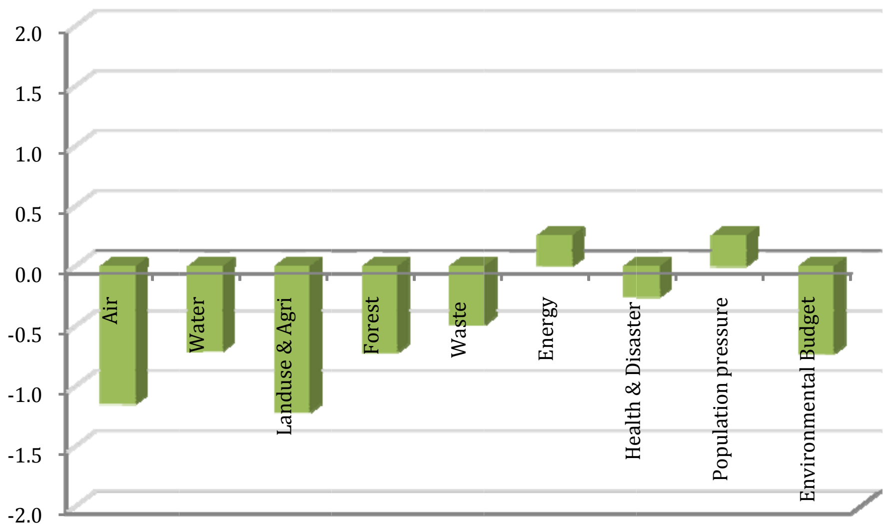


PUNJAB

ESI Group	Red
Other States in same ESI group	Rajasthan, Bihar, Gujarat, Haryana, Uttar Pradesh
% Contribution to overall India's GDP	3.68
SGDP per capita/annum	46406
% of population living below poverty line	2
Population density per square km area	535

ESI in 9 Sub-indices



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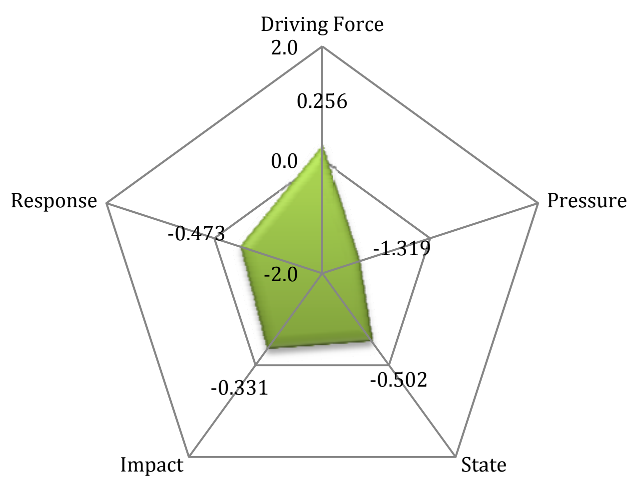
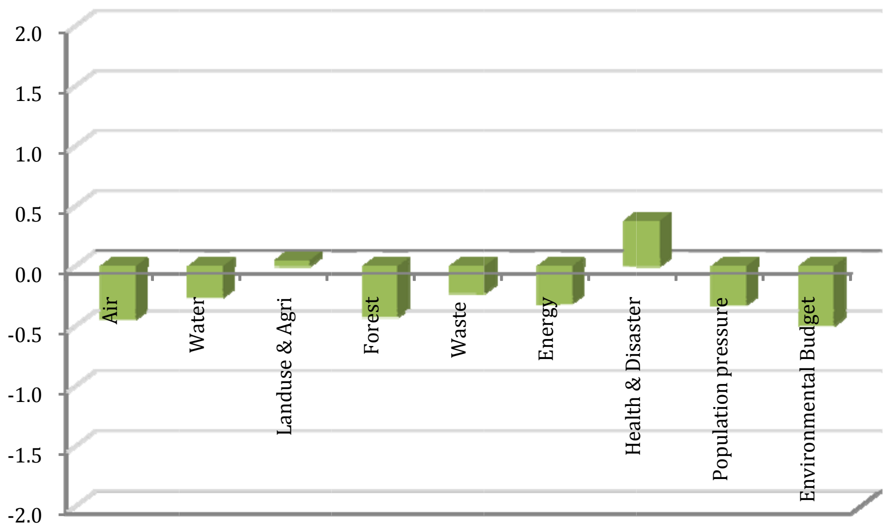


RAJASTHAN

ESI Group	Red
Other States in same ESI group	Punjab, Bihar, Gujarat, Haryana, Uttar Pradesh
% Contribution to overall India's GDP	4.23
SGDP per capita/annum	21973
% of population living below poverty line	12.11
Population density per square km area	191

ESI in 9 Sub-indices



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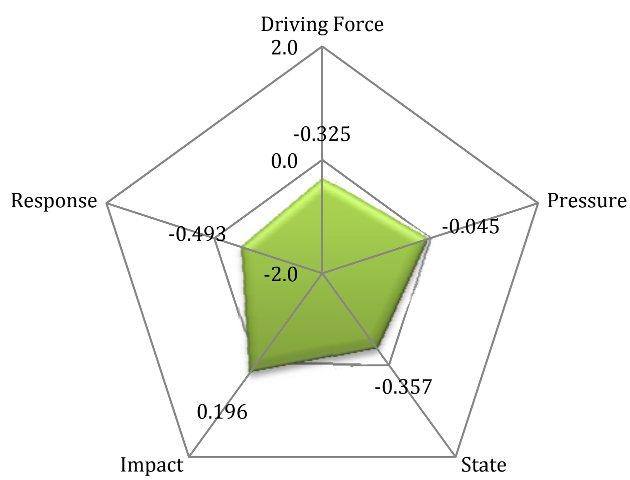
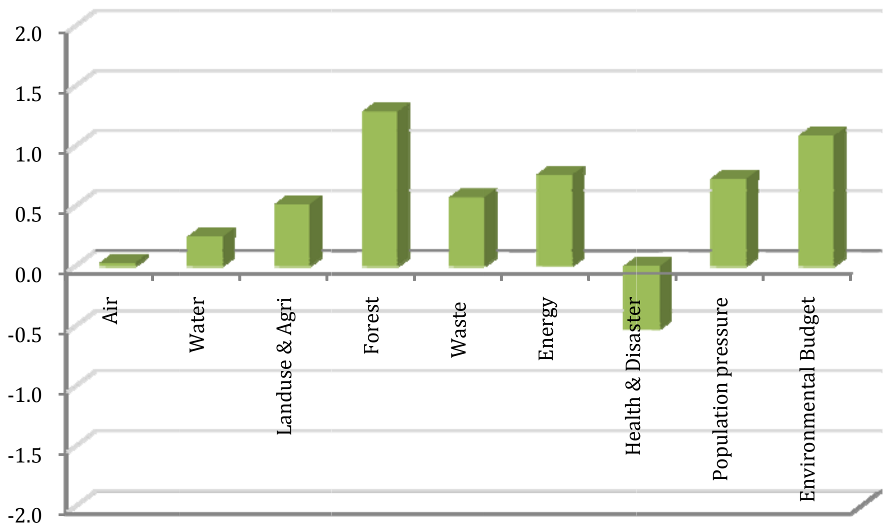


SIKKIM

ESI Group	Dark Green
Other States in same ESI group	Mizoram, Arunachal Pradesh, Nagaland, Manipur, Uttaranchal
% Contribution to overall India's GDP	0.06
SGDP per capita/annum	34343
% of population living below poverty line	33.78
Population density per square km area	85

ESI in 9 Sub-indices



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ESI in DPSIR

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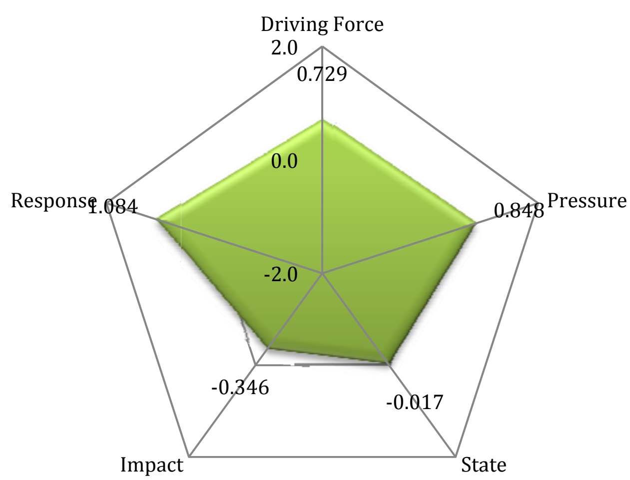
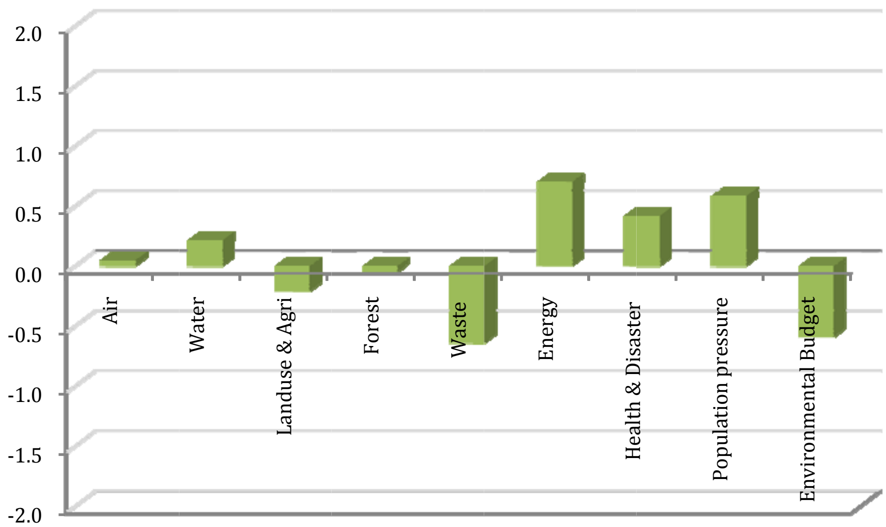


TAMIL NADU

ESI Group	Yellow
Other States in same ESI group	Assam, Orissa, Karnataka, Goa, Chhattisgarh
% Contribution to overall India's GDP	7.34
SGDP per capita/annum	37090
% of population living below poverty line	6.61
Population density per square km area	518

ESI in 9 Sub-indices



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ESI in DPSIR

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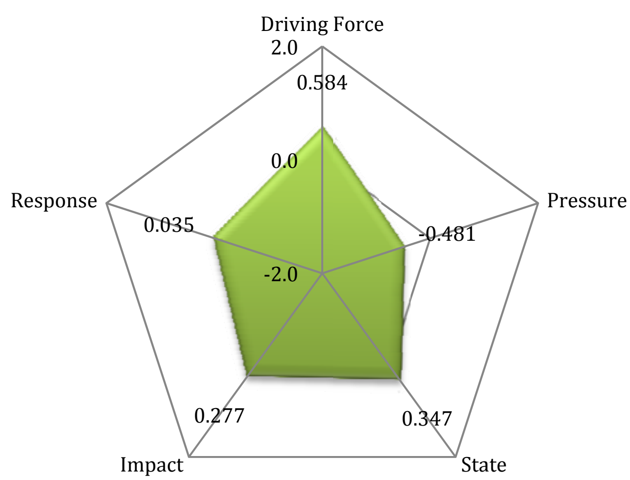
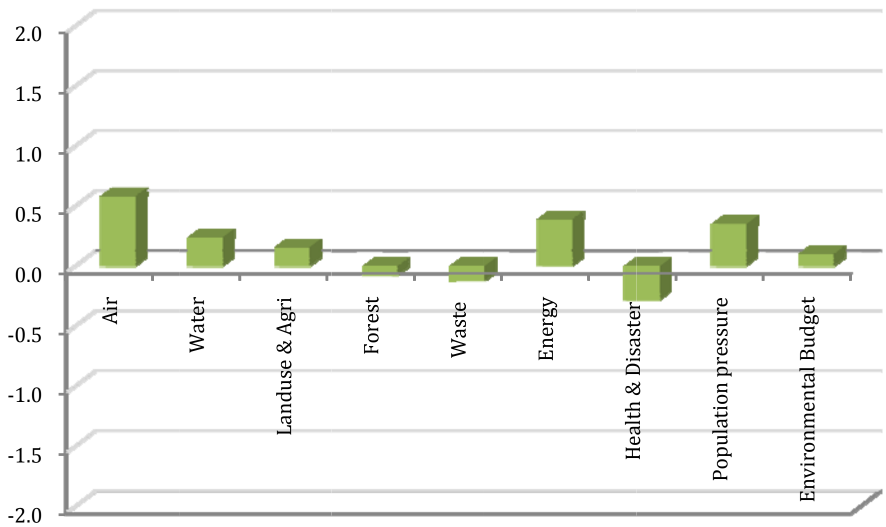


TRIPURA

ESI Group	Green
Other States in same ESI group	Meghalaya, Himachal Pradesh, West Bengal, Kerala
% Contribution to overall India's GDP	0.31
SGDP per capita/annum	29293
% of population living below poverty line	31.88
Population density per square km area	339

ESI in 9 Sub-indices



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ESI in DPSIR

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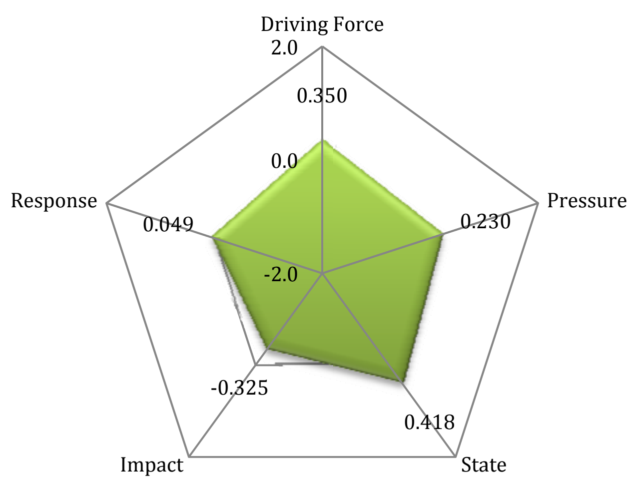
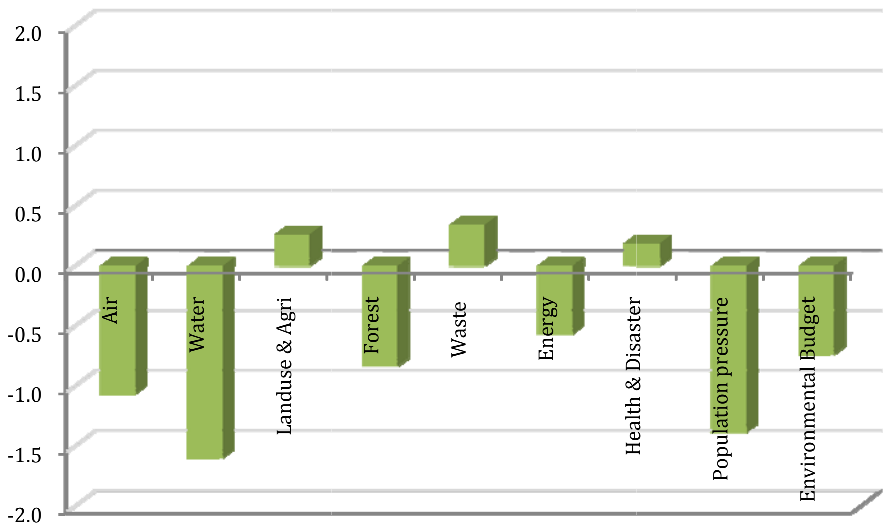


UTTAR PRADESH

ESI Group	Red
Other States in same ESI group	Rajasthan, Bihar, Gujarat, Haryana, Punjab
% Contribution to overall India's GDP	9.32
SGDP per capita/annum	16388
% of population living below poverty line	24.67
Population density per square km area	803

ESI in 9 Sub-indices



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ESI in DPSIR

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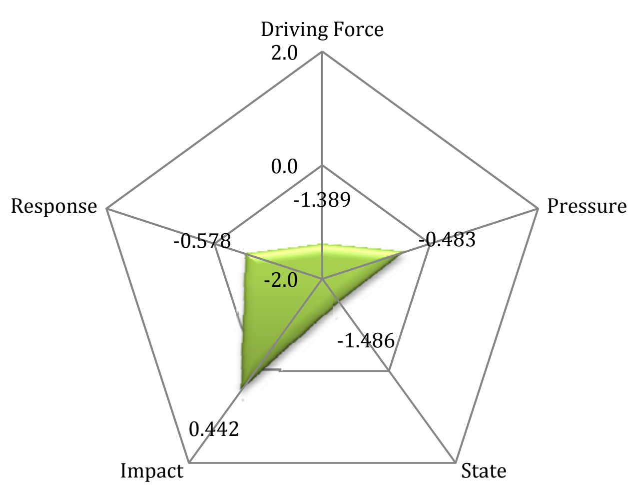
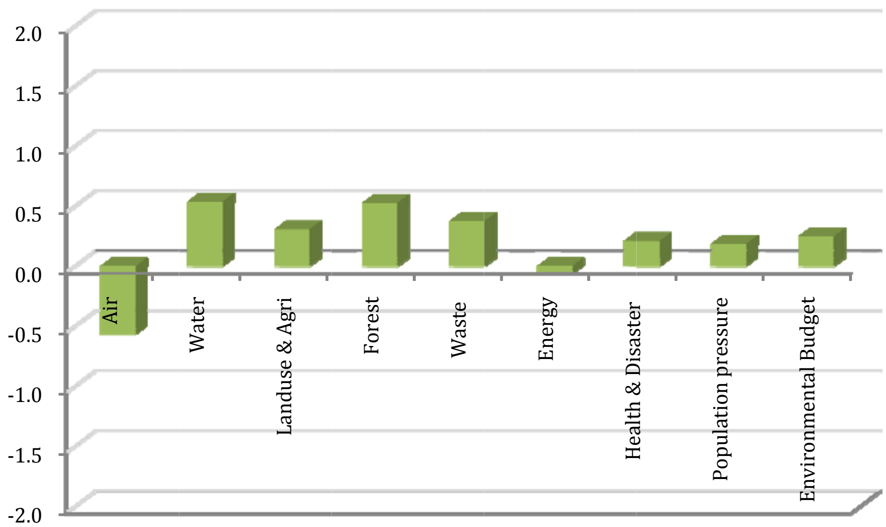


UTTARANCHAL

ESI Group	Dark Green
Other States in same ESI group	Mizoram, Arunachal Pradesh, Sikkim, Nagaland, Manipur
% Contribution to overall India's GDP	0.88
SGDP per capita/annum	31283
% of population living below poverty line	
Population density per square km area	180

ESI in 9 Sub-indices



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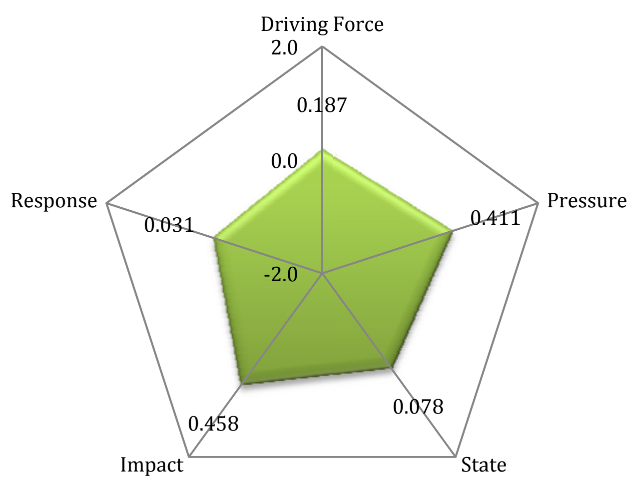
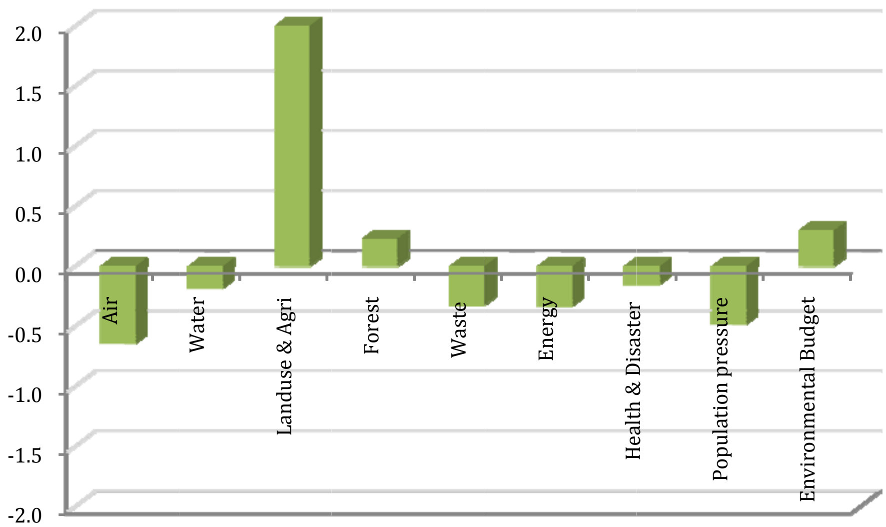


WEST BENGAL

ESI Group	Green
Other States in same ESI group	Meghalaya, Tripura, Himachal Pradesh, Kerala
% Contribution to overall India's GDP	8.12
SGDP per capita/annum	31023
% of population living below poverty line	18.3
Population density per square km area	1004

ESI in 9 Sub-indices



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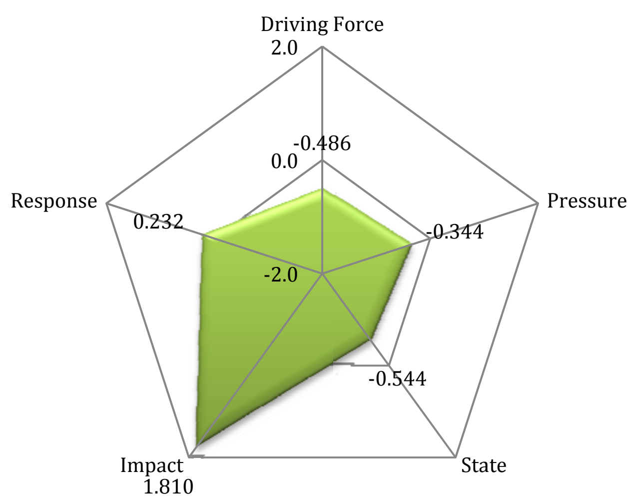

CHAPTER 4

ESI AS A MEASURE OF ENVIRONMENTAL SUSTAINABILITY AND STEWARDSHIP

State level ESI is primarily a diagnostic tool for informing and empowering the government and policy makers, concerned citizens, researchers and activists. It is developed with the objectives of (i) promoting information and evidence based policy making, (ii) prioritization among different environmental concerns within the state and identifying issues that require more attention in policy and budget allocation, (iii) encouraging states to realize their potential as drivers of India's overall environmental sustainability, and (iv) measuring and monitoring sustainable development at the state level.

i. Evidence based policy making

ESI is designed to inform the policy process by advocating an empirical, data driven approach to environmental policy. A state's long-term sustainability is a function of its present environmental conditions, resource use patterns, vulnerability and resilience to environmental shocks, and institutional capabilities to preserve the ecosystem. ESI accumulates information on all of the above aspects and compresses them into a simple and actionable format. By revealing a pattern of sustainability in terms of the sub-indices, it also points to areas that require further analysis and possible action.

ESI sensitizes, informs and empowers stakeholders. The magnitude of pollution and depletion of resources presented in a quantified manner should be a signal for various stakeholders to pay more attention to their environmental priorities.

ii. Prioritization in policy formulation and budget allocation

Each state is unique in terms of its economic conditions, growth history and the environmental issues it faces. The policy choices therefore also vary depending on each state's priorities, resources and capabilities to address certain issues. One of the most important uses of ESI lies in the identification of priority areas that needs more attention from the government and community. The nine sub-indices of ESI developed for each state show a state's environment across these nine areas: air, water, forest, land use, waste, energy, health, population and environment budget.

ESI also features inter-state and intra-state comparative pictures of the interacting dynamics of environmental issues in terms of DPSIR (Driving Force-Pressure-State-Impact-Response), thus highlighting the relationships between the origins, consequences and solutions of various environmental problems. While the comparison may create peer pressure with each state wanting to perform better than the others, there is also scope for mutual learning from best practices and opportunities for peer groups to analyze their relative situations and design policies accordingly.

iii. States as units of policy change

India's federal structure allows the states considerable jurisdiction and autonomy to formulate policies and implement strategies at the state level. Moreover, each state's environmental challenges are different from others, as are their resources and capability to address such challenges. ESI highlights environmental concerns at the sub-national level, focusing on states as the agents that can change the policy and environmental outcomes.

ESI creates a framework for relative evaluation of resource endowment and usage, pollution and its control, conservation efforts and outcomes – all at the state level. The national environment policy, other environment related policies and acts, and the National Action Plan on Climate Change are all developed at the national level, but there are many areas in which state policies affect environmental outcomes. Environmental priorities and pressures also vary widely across India's vast geographic terrain and the ESI provides one way of understanding these differences.

The report is thus a complement to the Ministry of Environment and Forest's State of the Environment (SoE) report, which is also developed at the state level with particular emphasis on state level issues and actions. The SoE does not facilitate comparison across states, however, and is more descriptive than analytical. The ESI gives an indication of a state's overall environmental condition, which has implications for future regulations as well as investment opportunities and risks.

iv. Measuring and monitoring development

The environment affects the quality of life and health, provides a resource base for most economic activities, creates livelihood options and food security for the poor and in less industrialized economies, and plays a significant role in reducing vulnerability. Hence environment should be considered a key criterion for measuring development of a society, country or state, as it is part of the context that contributes to well-being. Effective stewardship of ecosystem services is also important for sustaining these sources of wealth and livelihood.

Gross Domestic Product (GDP) per capita is the most accepted single indicator of economic development, while the Human Development Index (HDI) measures two additional dimensions of social well being: health and education. Even GDP and HDI taken together cannot provide a complete picture of a country or state's development, as the impact on natural systems is not captured, the negative externalities of growth in terms of resource use and pollution accumulated are not accounted for and the positivity of adopting a resource use trajectory that results in long-term sustainability at the cost of immediate gains is not considered. Incorporating such impacts requires a different kind of framework—one that gauges a state's overall condition by linking ecosystem vitality with economic and social development. The Environmental Sustainability Index (ESI) for Indian states is an effort to link environmental sustainability and development activities. Thus GDP can be used for measuring *economic growth*, HDI for tracking *development* (economic + social) and ESI for mapping *sustainable development* (economic + social + environmental). Combining the three can give a holistic picture of a society's overall well-being.

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ANNEX 1

Limitations of ESI and How They Were Addressed

i. Responding to Data gaps

Since ESI is a date intensive effort, the quality of ESI is greatly determined by the data that goes into it. Consequently, data gaps are the foremost limitations of ESI. Some of the environmental aspects are usually not measured, especially at the state level. For example, per capita freshwater availability, which is a function of precipitation, rivers, other surface water sources and ground water, is difficult to measure by aggregating each of these parameters that are again highly seasonal and location specific. Therefore, ESI uses a set of related indicators such as access to piped drinking water, replenishable groundwater and water usage in irrigation.

Conversely, some environmental information that can be quantified and monitored had to be excluded from ESI since it was not applicable to all the states. For example, glacial melting, coastline and fishing intensity and mineral reserves etc are limited to few states only. Coastline related indicators are of significant importance for all the nine coastal states. However, for rest of the states, such indicators are not applicable. Therefore, ESI does not cover any marine and coastal indicators. ESI being a state level comparative study had to be based on indicators that are relevant to and uniform across all states.

In some cases, it was possible to use substitute indicators. For example: to measure % land under anthropogenic pressure, multiple indicators such as land under agriculture/grazing/settlement were taken. For the non-excludable indicators for which reliable data sources could not be found, proxy indicators were used instead. One such example is taking non-LPG fuel consumption as indicator of indoor air pollution. Biodiversity is another essential indicator determining the 'stock' of resource for a given state. The State of Environment reports, botanical and zoological survey of India monitor collect and publish biodiversity data. However, the data is not uniform in terms of reference years and also is available only for select states. Therefore, wetland and protected area were taken as proxy for biodiversity. Similarly vehicle density of a state was taken as the proxy for vehicular emission. For some indicators, data was available, but not for all states or for a particular year. This problem was observed mostly in case of the north-eastern states, Jammu & Kashmir and the three new states - Chhattisgarh, Jharkhand and Uttarakhand. Tracking change in some datasets was not possible due to the three new states.

Data unavailability was mostly adjusted by dropping that particular indicator and selecting a suitable proxy for it. However, in case of critical indicators where a few observations were missing, the missing values were estimated through the statistical process of imputation, which provides a correlation with values of other variables but not the actual measured value. For certain indicators, the most updated datasets could not be found. For example, sanitation, population and fuel use data are also generated as part of census which is once in 10 years. The latest data on wetland is that of 2001. Similarly, data on wastewater generation and sewage treatment have not been updated since 2001 and 2006 respectively. Forest and land use data are collected biannually whereas air and water quality are updated every year. This leads to lack of a common base year and baseline data.

Since ESI is a relative measure of long term sustainability, multiple base years do not create problems in constructing the index. However, if uniform data were made available with regular updates, performance of each state can be tracked over time and trends can be identified.

ii. Overcoming Limitations of Aggregate Index

ESI is an overview index constructed at the macro-level; thus limitations that are inherent to composite indices are also noted in ESI. Being a data-driven index, it does not integrate the descriptive and/or non-quantifiable information on sustainability. For example, while number of species in an ecosystem can be measured, it is not easy to quantify the quality or richness of species diversity. ESI is extensive in covering environmental parameters by including many environmental indicators of similar and different natures across various sectors. But, it is not an intensive model to provide in-depth insight on any of these indicators. It explores different sectors of environment like air, water, forest etc and even points out the issues of more relative importance; but specific environmental issues characteristic to a state cannot be accommodated in ESI. Effort has been made to address these limitations by preparing state specific case studies which go beyond the numbers and take into account qualitative aspects such as governance structures, institutional mechanisms, intra-state differences in socio-economic variables, resource endowment, management priorities and citizen initiatives etc to accompany the ESI report. These reports will be released throughout the year. These cases are much more detail oriented and thus gives a more nuanced picture of the environmental concerns and conflicts within a particular state.

Similarly in the uniformity context, a state might want to emphasize few selected dimensions of sustainability more than the others. For example, State A attaches more weight to water whereas State B considers forest to be of critical importance. Although it is difficult to accommodate such perceptions in a quantitative index, they cannot be ignored from the intended utility of ESI to inform and empower policymakers and citizens. Thus ESI is developed as an equal-weight-averaged index with provisions for changing weights of sub-indices, if anyone wishes to experiment.

iii. Clustering of Peer states to adjust Inter-state Heterogeneity

ESI uses the state as the unit of measurement. Each state has different ecological, geographical, social, economic and institutional structures. Beyond inter-state differences, variation within states, especially large states, can be quite high. While large states like Uttar Pradesh or Maharashtra are heterogeneous with unequal wealth and resource distribution, smaller states like Goa are more homogenous with a small population and geographical area. This limitation is addressed by grouping the states into peer groups with similar GDP per capita and economic size of the states for the purpose of comparison and analysis.

iv. Relative measure Vs. Absolute Evaluation

ESI is a measure of relative sustainability which is founded on the pattern and degree of variation within the dataset, not a proximity-to-target approach where a state's performance is measured and compared in absolute terms. Lack of environmental benchmarks makes the case for a relative index. Being a relative measure, it does not tell how states fared this year as compared to previous years. At the same time ESI derives its strength for the relative measure, which projects long term sustainability instead of a snapshot of present performance. The future sustainability capacity is especially necessary for planning.

ANNEX 2

Comparing ESI with Similar Indices and Efforts

ESI is compared with several similar policy tools and indices such as (i) State of the Environment (ii) environmentally adjusted GDP (iii) Environmental impact Assessment; and composite indices such as (iv) Environmental Vulnerability Index, (v) Sustainable Livelihood Security Index, (vi) Environmental Performance Index.

State of the Environment (SoE)

The State of the Environment reporting is a Government of India initiative that mandates the states and Union Territories (UTs) to report an overview of the environmental scenario of the States/UTs with the objective that the SoE reports will aid in policy making through integrating environmental concerns into the planning process. SoE is a progressive step towards strengthening the environmental reporting system at national and sub-national level, with systematic data collection, collation and public dissemination. The main distinction is that SoE uses data as an evidence to describe the states' environment and bring out issues of concern, whereas ESI uses these data as the empirical basis of mapping a states environment and drawing comparisons among states to encourage learning from peers and recognition of the possibilities for improved environmental performance at all income levels and across various policy areas.

Both ESI and SoE explore states' environment in sub-components such as environment quality, socio-economic conditions, environment sensitive zones, air pollution, land degradation. The two reports vary in their approaches, however: SoE covers most parts of the big picture in individual small pieces, whereas ESI sows the big picture as a jigsaw of smaller pieces put together. Thus ESI has the advantages of aggregation and synthesis over SoE. On the other hand, since ESI is based on a standardized format of comparable indicators across all states, it does not explore specific environment issues in as much depth as SoE and there is loss of information to some extent.

ESI and SoE are similar in terms of (i) the objective to strengthen evidence based policy making, (ii) use of DPSIR framework as the foundation, (iii) collecting environment data at state level and presenting it in user-friendly format.

Environmental Vulnerability Index (EVI)

This composite index is data intensive like ESI; combining indicators on hazard, damage and resistance, it measures environmental vulnerability. Its focus is entirely on the negative environmental factors and consequences, however. This makes it especially useful for small island countries or underdeveloped economies where the vulnerability is very high and every policy effort must be directed towards reducing it. One of the sub-indices of ESI, 'impact on human health,' is similar to EVI as it includes environmental burden of diseases and impact of natural disasters on human life and ecosystem vitality. EVI was developed by the South Pacific Applied Geoscience Commission (SOPAC).

Sustainable Livelihood Security Index (SLSI)

SLSI is a composite index which equates indictors of economic efficiency with that of ecological security and social equity to map sustainable development. SLSI was originally proposed by Swaminathan in 1991, later empirically illustrated by Saleth and Swaminathan in 1993, and adapted by Mishra and Hiremath in 2008.

Both ESI and SLSI are relative analysis indices. But in SLSI only the indicators of ecological security are taken whereas ESI accounts for a broader set of indicators ranging from security, current state, depletion, protection effort etc. It is good as a diagnostic tool to identify underdeveloped regions with a holistic approach. However, the social and economic components diminish the importance of ecological sustainability aspects. If a very ambitious SLSI is designed with more comprehensive list of ecological indicators, the ecological sub-index would be similar to ESI.

Environment Performance Index (EPI)

EPI is another composite index developed by World Economic Forum, which is similar to ESI in terms of the objectives of decision making based on empirical evidence and measurement of environment. But, EPI is based on a proximity-to-target approach where each country's performance across select environmental indicators is measured against the desired target. While EPI shows the current performance of countries, ESI can project overall sustainability and a country's capability to protect its environment over the coming years.

Environment Impact Assessment (EIA)

EIA is a tool used to identify and assess the possible environmental impacts of a development project. It also requires developing strategies to minimize the negative environmental impacts and provide contingency plans. It is a decision making tool, which informs the project proponents regarding the possible risks and guides decision makers in taking appropriate decisions prior to sanctioning clearance. EIA is done at a project scale, thus is a micro-level decision making tool. For guiding policy for an entire state, EIA cannot be applied, neither is it sufficient in that context.

Ecological footprint

Ecological footprint (EF) is a measure of the resource use to meet human needs against the ecosystem's capacity to regenerate. It is done at country level and can also be adapted to the state level. EF can highlight the unsustainability of consumption and growth, but is not focused on identifying sustainability of use of resources in a particular geographic area. For example, if a state has high ecological footprint, it is living beyond its means and is drawing resource from other states/locations. Similarly states with lower EF are consuming less resource, but this does not necessarily mean they are preserving it since those resources are being consumed by states with higher EF. While EF is effective for bringing awareness, its use in guiding specific policy actions is limited.

Environmental Accounting or Natural Resource Accounting

In developing economies where primary sector contributes major part of GDP, most of these activities such as agriculture, livestock, fishery, forestry, mining etc. are extractive and depletes natural capital. Through environmental accounting adjustments can be made to GDP based on the natural capital created or depleted, thus providing more realistic account of national income. One such similar measure is the Index of Sustainable Economic Welfare (ISEW by Daly and Cobb, 1989), which incorporates environmental and social externalities in national income account. While such measures can guide growth policy efforts to be more environmentally conscious, unlike ESI these do not provide information on specific areas for improvements. While green GDP adds the ecological aspect to growth indicators, ESI is meant to act as an independent yet complimentary aspect that shows growth in a more balanced manner.

ANNEX 3

List of Indicators Considered for ESI 2009

Indicators	
Annual average SO2 concentration	Soil erosion
Annual average NO2 concentration	Annual GW draft as % of annual net GW available
Annual average SPM concentration	Population density
Annual average RSPM concentration	Population growth CAGR
No of motor vehicles used/million population	Total fertility rate
Ozone concentration	Migration
Fuel wood consumption per capita	Urbanization rate
% of household using biomass/kerosene fuel	Rate of industrial growth
Per capita freshwater availability	Access to safe drinking water
annual replenishable GW per Sq Km of area	Access to private sanitation
Average annual rainfall	Infant mortality rate
Mean Biological Oxygen Demand	Average incidence of acute respiratory diseases
Mean fecal coliform	Average incidence of water borne diseases
Mean Total Suspended Solids	Biodiversity species diversity
% Change in Forest Area	Threatened species as % of total species
% forest area encroached	Wetland as % of total geographic area
Protected area as % of total geographical area	% of flood affected area to total geographic area
Compensatory reforestation	% of drought prone area to total geographical area
% change in Grazing land	% of district declared as hazard-prone
% change in Agriculture land	Disaster loss (life, economic value)
% of land affected by desertification, salinization & acidification	Energy use per capita (Kg oil Equivalent)
% of degraded/wastelands to total geographical area	Annual per capita power consumed
% of untreated wastewater to total wastewater discharged	Renewable Energy as % of Total Energy Installed Capacity
Fertilizer consumption kg/ha of gross cropped area	Energy used to produce 1 unit of GSDP
Pesticide consumption kg/ha net sown area	Renewable Purchase Obligation Standard
Annual per capita municipal solid waste generated	Investment made in RE & energy efficiency sector
Annual Per capita Hazardous waste generated	Area under JFM as % of total geographical area of the state
% of municipal solid waste recycled	No. of NGOs working on Environment
% of sewage treated before disposal	No. of Public Interest Litigations filed
Use of ozone depleting substance	Industries defaulting and closed as % of total 17C industries
Coal consumption per capita	% of projects denied of Environment clearance
Per capita water consumption	Share of environmental budget as % of state GDP
Water use in industry & agri per unit of GDP	Actual expenditure as % of agreed outlay for ecology & environment
Cropping intensity	Govt. expenditure on Renewables & other sustainability programs
Fishing intensity	% of revenues as fines/fees, pollution/carbon/eco tax collected from polluters
Timber harvest rate	Number of CDM projects as % of total CDM projects in India
Depletion of minerals as % of proven reserve	Per capita GHG emission

ANNEX 4

Sub-indices and Underlying Indicators in ESI 2009

1. ***Air Quality and Pollution***

Clean air is one of the pre-requisite for human life. Industrial and vehicular emissions pollute the air causing various health problems including respiratory diseases, reduced visibility, smog and acid rain. The pollution load changes the atmospheric composition, thereby impacting temperature and water cycle. Since most of the states in India are experiencing rapid economic growth, burning of fossil fuels, emission from industries and use of vehicles are likely to grow leading to further pollution. Air quality in terms of atmospheric concentration of SO2, NO2 and particulate matters gives an indication of overall pollution levels.

Underlying Indicators: Annual average concentration of SO2, NO2, SPM and RSPM, motor vehicles used per million population

2. Water Quality and Availability

Water is another vital constituent of environment systems and necessary for all forms of life. Access to safe drinking water is a basic necessity for development. While freshwater from monsoon rainfall, surface and ground water sources have been adequate to meet the water requirement in most states; there is an increasing trend of water scarcity, pollution resulting from effluent discharge and agricultural run-off, conflict over multiple demand of same water resource by various user groups. Water is a finite yet renewable resource; thus economized and efficient usage, recycling and maintaining the quality for human consumption can reduce water stress and aid in maintaining ecosystem health and vitality.

Underlying Indicators: Biological oxygen demand, total coliform/bacterial contamination, average annual rainfall, annual ground-water draft and replenishment, irrigation usage and access to piped drinking water

3. Land use and Agriculture

Land use patterns and changes in landscape due to deforestation, agriculture, mining, urbanization and industrialization alter topography, vegetation cover, water retention capacity and soil fertility. Pesticide and fertilizer runoff from agricultural fields contaminate the water. Intensification of agriculture and over-grazing exert pressure on carrying capacity of land leading to further degradation in form of erosion, water logging and salinity making the land unsuitable for cropping and human habitation.

Underlying Indicators: Land under grazing, agriculture and wasteland, salinity and acidity affected land, soil erosion, fertilizer and pesticide consumption

4. Forest and biodiversity

Forests act as the carbon sink of the ecosystem, vital for maintaining ecosystem balance through maintaining water cycle, purifying air, regulating temperature, sustaining biodiversity and genetic pool. Forests also play important role in socio-economic development in form of addressing food security and providing fodder, fuel wood, timber and non-timber products and recreation. Deforestation and diversion of forests for agriculture and habitation development, unsustainable timber harvesting, mining, shifting cultivation lead to loss of forest and biodiversity which in turn cause soil and wind erosion, land degradation among other negative impacts.

Underlying Indicators: % of state's area under forest cover, protected areas and wetlands, change in forest area, encroachment on forest land, joint forest management and compensatory reforestation

5. Waste Management

While pollution and waste accumulation are inevitable as result of production and consumption functions; appropriate waste management can reduce the impact of these on ecosystem and human health. Responsible consumption and recycling can aid in resource conservation whereas waste segregation, composting, treatment and proper disposal can prevent health hazards, improve quality of habitations and keep air and water clean.

Underlying Indicators: Per-capita municipal solid waste and hazardous waste generated, sewage treatment

6. Energy Management

Energy is derived from natural environment either in form of extraction of fossil fuels (coal, oil, gas) or harnessing the renewable sources (solar, hydro, wind, biomass etc). Emission generated from extraction and burning of fossil fuels leads to atmospheric pollution. The energy-poverty-environment nexus creates a vicious cycle in form of increased biomass collection and burning by the poor, incompatibility of traditional fuels with modern equipments, inefficient fuel use leading to higher emission and inability to control emission as that might limit growth.

Underlying Indicators: Use of non-LPG fuel, renewable energy installed and energy-GSDP ratio

7. Impact on Human Health

Pollution and degradation cause adverse impact on ecosystem and human health, both in the short and the long terms. Exposure to indoor air pollution and soil contamination, lack of access to safe drinking water and adequate sanitation facilities directly affects the health, immunity and disease incidence in a particular population. Over a period of time, poverty related factors further aggravate the health impacts. Malnutrition, increased mosquito population, unhealthy living conditions, hazardous working conditions (mines, factories) and declining immunity create greater health challenges. On the other hand, long term changes in terms of changes in temperature and rainfall patterns; changing forest cover, land use and course of rivers lead to natural disasters such as flood, cyclone, drought and landslides which negatively affect human lives, livelihoods and the ecosystem itself. Drought and flood are stress situations, affect wealth and wellbeing, increase vulnerability and reduce productivity and disturb the ecological balance.

Underlying Indicators: Incidence of respiratory and waterborne diseases, flood and drought prone area, loss of human life due to natural disasters

8. Population Pressure on Ecosystem

Population pressure is a major driver of many subsequent activities such as food and fuel collection, alteration of topography to meet anthropogenic needs of habitat, agriculture and industrial production. Since the carrying capacity of every ecosystem is finite, more population density and growth mean more extraction of resources and accumulation of pollution. States with higher population density face the 'endowment challenge' of resource appropriation and challenge in use of resources in a sustainable manner. This is a challengefor states with high population growth also. Stabilizing population is a major challenge and requirement for India. Though this does not come under the purview of environmental policy, its correlation with all components of environment and the pivotal role it plays in protecting, maintaining and preserving ecosystem makes it an essential area for measuring overall sustainability of a state.

Underlying Indicators: Population density, population growth and total fertility rate

9. Environment Budget

While environment budget as % of state GDP indicates a state government's commitment to manage its environment and willingness to spend for sustainability, the outlay and expenditure ratio shows the efficiency of such spending. The renewable energy spending is an indicator of the proactiveness of the government to look for green growth solutions. Institutional frameworks and capabilities have not been covered since ESI is constrained by considering indicators that are objectively comparable.

Underlying Indicators: Environment budget as % of State GDP, environmental budget outlay and expenditure ratio, government expenditure on renewable energy development

ANNEX 5

Weights of the 40 Indicators in ESI

Population density	3.70
Population growth CAGR	3.70
Total fertility rate	3.70
Driving Forces (D)	**11.11%**
No of motor vehicles used/million population	2.22
Annual GW draft as % of annual net GW available	1.85
Water usage in irrigation	1.85
Grazing land as % of total land	2.22
Fertilizer consumption kg/ha of gross cropped area	2.22
Pesticide consumption kg/ha net sown area	2.22
% Change in Forest Area	1.59
% forest area encroached	1.59
Annual per capita municipal solid waste generated	3.70
Annual percapita Hazardous waste generated	3.70
Pressure on Ecosystem (P)	**23.17%**
Annual average SO2 concentration	2.22
Annual average NO2 concentration	2.22
Annual average SPM concentration	2.22
Annual average RSPM concentration	2.22
Mean Biochemical Oxygen Demand	1.85
Mean total coliform	1.85
annual replenishable GW per Sq Km of area	1.85
Access to piped drinking water	1.85
% land area under forest cover	1.59
State/Quality of the Environment (S)	**17.88%**
% of land affected by salinity, acidity and water logging	2.22
% of land affected by Soil erosion	2.22
Average incidence of acute respiratory diseases	2.22
Average incidence of water borne diseases	2.22
% of flood affected area to total geographic area	2.22
% of arid/drought prone area to total geographical area	2.22
Life loss due to disaster	2.22
Impact on Human Health & Ecosystem (I)	**15.55%**
Protected area as % of total geographical area	1.59
Compensatory reforastation	1.59
Wetland as % of total geographic area	1.59
Area under JFM as % of total forest area of the state	1.59
Sewage treatment	3.70
% of household using non LPG fuel for cooking	3.70
Renewable Energy Installed Capacity	3.70
Energy used to produce 1 unit of GSDP	3.70

Govt. expenditure on RE as % of GDP	3.70
Share of environmental budget as % of state GDP	3.70
Actual expenditure vs. agreed outlay for environment	3.70
Response from Government & Society (R)	**32.28%**

ANNEX 6

State-wise share of National GDP and Population

States by contribution to population		States by contribution to GDP	
State	% of India's population	State	% of India's GDP
Uttar Pradesh	16.96	Maharashtra	15.17
Maharashtra	9.50	Uttar Pradesh	9.32
Bihar	8.34	West Bengal	8.12
West Bengal	7.81	Andhra Pradesh	8.02
Andhra Pradesh	7.30	Gujarat	7.58
Madhya Pradesh	6.16	Tamil Nadu	7.34
Tamil Nadu	5.90	Karnataka	5.61
Rajasthan	5.74	Rajasthan	4.23
Karnataka	5.10	Kerala	3.95
Gujarat	5.01	Madhya Pradesh	3.82
Orissa	3.54	Haryana	3.77
Kerala	2.86	Punjab	3.68
Jharkhand	2.67	Bihar	2.95
Assam	2.66	Orissa	2.72
Punjab	2.36	Jharkhand	2.19
Haryana	2.11	Assam	1.94
Chhattisgarh	2.10	Chhattisgarh	1.91
Jammu & Kashmir	1.10	Uttaranchal	0.88
Uttaranchal	0.84	Jammu & Kashmir	0.86
Himachal Pradesh	0.58	Himachal Pradesh	0.84
Tripura	0.31	Goa	0.43
Manipur	0.23	Tripura	0.31
Meghalaya	0.23	Meghalaya	0.21
Nagaland	0.19	Manipur	0.19
Goa	0.14	Arunachal Pradesh	0.10
Arunachal Pradesh	0.11	Mizoram	0.09
Mizoram	0.09	Sikkim	0.06
Sikkim	0.05	Nagaland	Not included due to data unavailability

ANNEX 7

DETAILED METHODOLOGY

Selection of the Indicators in ESI

In calculating ESI, data covering a wide range of environmental factors were sought. The indicators were chosen according to their relevance. If the chosen datasets were relevant, they were further scrutinized for accuracy and reliability.

In most cases, data were sought from the most recent available government sources, surveys and reports, Census of India, Central Pollution Control Board data archives and studies, State Government Departments such as Forest Department, Department of Water Resources, Finance Department, Transport Department, and Department of Energy. Care has been taken to include only published data collected using standard methodology. The literature and data sources available within the environment information system (ENVIS), India were also consulted for the study. Additionally, the parliamentary session data books proved useful, as they provided testimony to the concerns of policy makers regarding the environment, as well as steps taken to mitigate environmental degradation. Other reports consulted includes: Annual Forests Reports, Annual Plans, National Human Development reports, National Population Census, Agricultural Census, National Family and Health Survey reports, National Sample Survey reports, Statistical Compendium of Environmental Indicators, other Central Statistical Organization (CSO) reports, State Budgets, and other government reports.

Datasets had to be customized with data gathered from multiple sources. For some indicators, as was the case for air and water pollution, data sets had to be prepared for each state by aggregating each monitoring station-wise data. In certain cases proxy variables were used to capture important measures. For biodiversity, since data for threatened species of mammals, birds and reptiles as a percentage of total known breeding species were not available at the state level, the proxy variables of total percentage of wetland area and total percentage of protected area were used instead. Similarly, use of non-efficient fuels was taken as proxy for indoor air pollution.

Standardization of the indicators for comparisons across states

To use data for calculating the ESI score for each state, the raw data should be on a comparable scale; therefore wherever possible data were taken measured as percentages, ratios and concentrations. Also the percentage change of a variable was taken into account in some cases to capture the rate of flow of resources or the rate of accumulation of waste. In doing so, a state's relative performance over the years is gauged; this procedure further mitigates differences arising from area or population size. For the rest of the data sets suitable denominators were chosen to transform data into a comparable scale. For example, data like forest cover and replenishable groundwater were made comparable by taking total geographic area as the denominator; while data on incidence of respiratory disease, water borne diseases were made comparable by taking total population as the denominator. The most commonly used denominators were GDP, total population and total geographical area. This process ensured that no state was given undue advantage or disadvantage because of its geographical size or population.

Transformation of the variables for the imputation and aggregation procedures

After adjusting the data for comparisons across states, the data were then aggregated. In order to adjust for the different units of the different variables and the need to assign a relative score to each state, the data were transformed into Z-scores, which represent standardized deviations from the mean. These Z-scores have a mean of 0 and a standard deviation equal to 1. The Z-score is calculated from the following formula:

$$Z = (x - \mu)/\sigma$$

Where,

X = value of the variable; μ = mean; σ = standard deviation

Z-scores computed from datasets with different units can be directly compared since these numbers do not express the original unit of measurement. As the Z-score represents the number of standard deviations from x to the mean, it gives a relative score for all variables. In the cases where a state's performance on either extreme of the spectrum might have skewed its overall score, logarithmic transformation was performed to reduce the impact of outliers. All variables that had a skewness value less than 2.5 were transformed using the Z-score transformations and the rest were transformed using the logarithmic transformations. The latter were then again converted into Z-scores such that they can be aggregated.

Substituting values for missing data

There were many instances where no value was available for the variable in the current dataset. As discussed earlier, this is a serious constraint of the study, as no values for a particular state may affect its ESI score. Missing data may also reduce the precision of a calculated ESI score because there is less information than originally planned. The data can either be missing completely at random (MCAR) (i.e. the probability that an observation is missing is unrelated to the value of the observation or to the value of any other variables), or missing at random (MAR) (i.e. the probability that an observation is missing may not be completely random but may depend on other observed variables). For the missing value analysis, the data were assumed to be MAR. This is based on the assumption that the values for a variable were either not measured or not recorded. But at the same time, such missing values are dependent on similar recorded values for other variables. The regression imputation method was used to impute the missing values. It is based on the assumptions that the marginal distributions of the data are normal and that linear relationships between variables exist that can be utilized for building linear regression models that predict the missing data.

Changing direction of the Z-Score according to the ESI

Since there were both positive and negative variables among the chosen ones, the computed Z-score for all variables lie within the range +3 to -3. For example, in the case of the variable % change in forest cover, a positive Z-score would highlight a change in a favourable direction and a negative Z-score would highlight a change in an unfavorable direction. Here, the interpretation of Z-score is the same as that of the ESI score. So in such cases Z-score can be used directly without recoding it for direction. But in the case of the variable population density, a more positive deviation from the mean (i.e., a higher Z-score), would mean a higher absolute value for a state. Thus a higher positive Z-Score would mean a high population density, which is not in a favorable direction for the ESI of that State. The Z-score should therefore be recoded for its direction. This was done by simply changing the sign of the z-score while keeping the magnitude of the Z-score same. Thus, all higher positive Z- scores would get converted into lower negative Z-scores and vice versa.

Aggregation of the data to indicator scores and the final ESI score

Out of the multiple methods of aggregation; the equal weighted average has been used to compute the ESI. There were 44 underlying variables, which were aggregated into the 15 indicators that were used to calculate the final ESI score. While taking the aggregate, equal weight was given to the each variable. The score for all the 15 indicators was combined to give the final ESI score.

The ESI score was made comparable by rescaling the scores from a low of 0 to a high of100. The states were ranked according to their ESI score. The higher the ESI score the better the state's performance and the higher its ranking.

ANNEX 8

Data Sources

Indicators	Data Sources
Annual average SO2 concentration	Central Pollution Control Board, National Ambient Air Quality Monitoring, 2007
Annual average NO2 concentration	Central Pollution Control Board, National Ambient Air Quality Monitoring, 2007
Annual average SPM concentration	Central Pollution Control Board, National Ambient Air Quality Monitoring, 2007
Annual average RSPM concentration	Central Pollution Control Board, National Ambient Air Quality Monitoring, 2007
Number of motor vehicles used per thousand people	Department of Road Transport and Highways, Government of India, 2004
Annual replenishable ground water	Central Gound Water Board, 2007
Mean Biochemical Oxygen Demand	Central Pollution Control Board, National Water Quality Monitoring, 2007
Mean total coliform	Central Pollution Control Board, National Water Quality Monitoring, 2007
Water usage in irrigation	Parliamentary Questions (Lok Sabha Starred Question No. 487, dated on 28.04.2008. Rajya Sabha Unstarred Question No. 1691, dated 16.12.2008.)
Annual ground water draft as % of annual net ground water available	Central Ground Water Board, 2007
Access to piped drinking water	Third National Family and Health Survey , 2006
Grazing land as % of total land	National Bureau of Soil Survey & Land Use Planning, Ministry of Agriculture & Cooperation 2005
Agriculture land as % of total land	National Bureau of Soil Survey & Land Use Planning, Ministry of Agriculture & Cooperation 2005
% of land affected by salinity, acidity and water logging	National Bureau of Soil Survey & Land Use Planning, Ministry of Agriculture & Cooperation 2005
Total wasteland as % of total geographic area	National Bureau of Soil Survey & Land Use Planning, Ministry of Agriculture & Cooperation 2005
Fertilizer consumption kg/ha of gross cropped area	Integrated Nutrient Management Division, Department of Agriculture & Cooperation, 2006-07
Pesticide consumption kg/ha net sown area	Directorate of Plant Protection, Quarantine & Storage, Department of Agriculture & Cooperation 2006-07
% of land affected by Soil erosion	National Bureau of Soil Survey & Land Use Planning, Ministry of Agriculture & Cooperation 2005
% Change in Forest Area	Forest Survey of India 2001 & 2005
% forest area encroached	Parliamentary Questions, 2004 (Lok Sabha Starred Question No. 284, dated 16.8.2004.)

Protected area as % of total geographical area	Forest Survey of India, 2005
% achievement of targeted reforestation	Parliamentary Questions, 2008 (Lok Sabha Unstarred Question No. 4230, dated on 23.04.2008.)
Wetland as % of total geographic area	Forest Survey of India, 2005
Area under JFM as % of total forest area of the state	Forest Survey of India, 2005
Annual per capita municipal solid waste generated	Central Pollution Control Board, 2005
Annual per capita Hazardous waste generated	Inventory of Hazardous Waste, Central Pollution Control Board, 2008-09
Gap in sewage treatment	Central Pollution Control Board, 2006
% of household using non LPG fuel for cooking	Census of India 2001
Renewable Energy as % of Total Energy Installed Capacity	Ministry of Power, 2006-07
Energy used to produce 1 unit of GSDP	Ministry of Power, 2006-07
Average incidence of acute respiratory diseases	Ministry of Health and Family Welfare, 2006
Average incidence of water borne diseases	Ministry of Health and Family Welfare, 2006
% of flood affected area to total geographic area	Parliamentary questions (Rajya Sabha Unstarred Question No. 1783, dated 19.03.2002.)
% of arid/drought prone area to total geographical area	Parliamentary questions (Lok Sabha Starred Question No. 344, dated on 19.08.2004.)
Economic loss due to disaster as % of GSDP	Parliamentary questions (Lok Sabha Starred Question No. 344, dated on 19.08.2004.)
Population density	Census of India 2001, Census Projection 2006-08
Population growth	Census of India 2001, Census Projection 2006-08
Total fertility rate	Third National Family and Health Survey , 2006
Environmental budget as % of state GDP	State Finance Department & Budget, 2006-07
Govt. expenditure on renewable energy development as % of GDP	State Renewable Energy Development Authorities and Finance Departments, 2006-07
Actual expenditure as % of agreed outlay for environment	11th five year plan, Planning Commission, 2002-07

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