Ecological Indicators 61 (2016) 928–940

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

Short Communication

Benchmarking sustainability using indicators: An Indian case study

Swati Kwatra[a,b,*], Archna Kumar[b], Prateek Sharma[a], Sumit Sharma[c], Shaleen Singhal[d]

[a] Department of Natural Resource Management, TERI University, Plot No. 10, Institutional Area, Vasant Kunj, New Delhi, India
[b] Department of Development Communication and Extension, Lady Irwin College (University of Delhi), Sikandra Road, Mandi House, Delhi, India
[c] Centre for Environmental Studies, The Energy and Resources Institute, New Delhi, India
[d] Department of Policy Studies, TERI University, Plot No. 10, Institutional Area, Vasant Kunj, New Delhi, India

ARTICLE INFO

Article history:
Received 9 November 2014
Received in revised form 19 October 2015
Accepted 19 October 2015
Available online 21 November 2015

Keywords:
Sustainable development
Indicators
Environmental performance
Socio-economic development
India

ABSTRACT

This paper develops an index to measure sustainability based on the broad themes of social, economy and environment. Nineteen appropriate indicators were selected based on relevance, data availability, and periodicity for each leg of sustainable development. A correlation analysis was carried out to assess relationships between the 19 indicators representing different parameters under the three themes. These parameters were then normalized using *Z*-score technique. The *Z*-scores computed for each of these parameters were then used to develop a Sustainable Development Index (SDI). The index is pilot tested on different States and Union Territories (UTs) of India. The values are compared and interpreted to adjudge the forerunners and laggards on the various dimensions of human well-being and environment. Significant relationships have been observed between income levels and area of administrative regions with sustainability indices of the regions. Smaller administrative regions with higher income levels have been observed with higher sustainability scores. The proposed index provides a useful measure of identifying problematic areas that can be plugged through policy measures and ensures that the region moves on sustainable development pathways.

1. Introduction

Since the Brundtland Commission's Report (UN, 1987), countries have begun to define their sustainable development objectives and priorities, reflecting national resources and needs, aspirations, and social and economic conditions. Several international and national organizations have developed indicator sets to measure and assess one or more aspect of sustainable development. These efforts received a major boost following the adoption of Agenda 21 (UN, 1992) at the Earth Summit in 1992. The Chapter 40 of the Agenda 21 document specifically asked countries and international governmental and non-governmental organizations to develop the concept of indicators of sustainable development and to harmonize them at the national, regional and global levels. Further, the Johannesburg Plan of Implementation (UN, 2002), and the United Nation Commission on Sustainable Development (UNCSD) at its 11th and 13th sessions also emphasized on development and reporting of indicators (UN, 2006).

Sustainability can be measured at different scales – global, national, regional and urban. Internationally, several indicators have been developed to gauge the progress made towards sustainable development (Moffatt, 1996; Hanley et al., 1998). Over 500 sustainability indicators have been reported on a global level developed by various governmental and non-governmental organizations. Of these 500 indicators, nearly 70 have application on global level, over 100 at national level, more than 70 are state or provincial level, and about 300 are local or metropolitan level (Parris and Kates, 2003). While, National level sustainability indicators are based on broad and generally applicable issues across different regions in a country, regional scale indicators are focused only on issues relevant to a specific region (e.g. coastal, hilly, industrial, etc.), and urban scale indicators deal with city level issues. However, to compare different regions, a common set of National scale indicators is required to adjudge their relative performances.

The indicators which are currently available in the Indian context have limited application in understanding sustainability concerns. Some of them measure just one of the three dimensions of sustainability – social, economic and environment. In India, there were efforts made to measure social development through indicators like Health Information Index (Department of Health and Family Welfare, Ministry of Health, Government of India); Gender Equality Index, etc. On environmental fronts, the Ministry of

* Corresponding author at: Department of Development Communication and Extension, Lady Irwin College, Delhi University, India. Tel.: +91 9899505495.
E-mail address: swati.kwatra@gmail.com (S. Kwatra).

http://dx.doi.org/10.1016/j.ecolind.2015.10.049
1470-160X/

Environment and Forests (MoEF), Government of India initiated the State of Environment (SoE) reporting process with all State Governments and Union Territories (UTs) through a scheme in the Tenth Five Year Plan (MoEF, 2009). These reports use different indicators to study the state and trends of the environment (land, air, water, forests and biodiversity), and issues of climate change, energy, food, and water security. On its footsteps, different States of India have been preparing their regional SoE reports. Other than governmental initiatives, TERI (1997, 2001, 2010) reported the state of environment in the country and suggested innovative pathways for sustainable development. CDF (2011), Chandrasekharan et al. (2013) also reported the use of indices to measure environmental sustainability in Indian context. Other than these, there are indicators which gauged the progress over social and economic legs of sustainability, together. Human Development Index and Composite Development Index (MoF, 2013) measure the progress made by different states of India on social and economic fronts.

Despite these efforts made to measure progress made on specific aspects of sustainability, there has been no comprehensive reporting of sustainability in the Indian context. The studies carried out in India have not come up with an aggregate measure of sustainability. This may lead to adhoc interventions for maintaining a balance between the three legs of sustainability. There is, thus a need of an index which comprehensively measures sustainability and provides a baseline to the decision makers/policy makers to take up decisions to improve sustainability in their region. This paper proposes a comprehensive index for comparative evaluation of different regions on their progress made towards sustainable development. The index has been pilot tested on administrative area divisions in India (States and UTs).

Fig. 1. Study domain and administrative boundaries.
Source: http://d-maps.com/carte.php?num_car=4184&lang=en.

2. Material and methods

2.1. Study domain

Growth in developing economies has been phenomenal in the last two decades. India as a developing country has been chosen as the case study for the current work. India is the world's 7th largest country in terms of its size (2.4% of the world surface area) and supports 1.21 billion population (nearly 17% of world's population). There is disparity in spatial distribution of population and resources leading to intra-generational inequalities. Economic reforms since 1991 have transformed it into one of the fastest growing economies. However, it still faces wide-ranging challenges – from improving its social and physical infrastructure to enhancing the productivity in agriculture and industry and addressing environmental concerns (MoEF, 2010). While the index of industrial production has gone up by about 30 times during last sixty years, more than 80% of Indian cities violate the prescribed standards for air pollution (particulate matter-PM_{10}). Rising dumps of wastes and untreated wastewater (domestic and industrial) are the other emerging problems. Other than growing environmental concerns, India has under performed on addressing human development issues. India ranks 136 out of 187 countries on Human Development Index (UNDP, 2013). Currently India ranks 155 out of 178 countries on the Environment Performance Index (YU, 2014).

India is administratively divided into 28 States and 7 UTs (Fig. 1), where each State/UT is primarily governed by the State government and overseen nationally by the Central Government. The country is known for its huge geographical, cultural, ecological, socio-economic diversity. Geographically, towards south, India is bounded by the Indian Ocean, Arabian Sea on the southwest and Bay of Bengal on the southeast. Along with a landmass covering 3.28 million km^2, India also has two sets of islands-Lakshadweep in Arabian sea and Andaman and Nicobar in Bay of Bengal. In north and extending towards north-east, there lies the Himalayan mountain range and towards west lies the Thar Desert falling mainly in the state of Rajasthan. The northeast region (encompassing 7 states of Assam, Meghalaya, Mizoram, Tripura, Manipur, Sikkim, Nagaland, and Arunachal Pradesh) is deeply forested and less industrialized. Parallel to the Himalayan mountain range, there are Indo-Gangetic plains that are large flood plains of the Indus and the Ganga–Brahmaputra river systems. This is the most fertile region in the country covering states of Jammu and Kashmir, Punjab, Haryana, Uttar Pradesh, Bihar to Assam in the east. These states are known for most agricultural activities in the country. Since independence the population of India has grown from 345 million in 1947 to 1221 million in 2011. Population densities are higher in the UTs and mainly in the northern and eastern part of country in the states of Bihar, West Bengal and Uttar Pradesh. On social front, the country has made some progress; for instance, the literacy rates have gone up from just 12% in 1947 to 74% in 2011. However, there is variation among the states; higher population densities in some states have linkages with lower literacy rates than rest of the country. India is experiencing rapid growth in economy since last two decades. The GDP per capita levels (ppp) have grown from USD 1205 in 1991 to USD 4827 in 2011, although with disparity among different states. The more industrialized states of Gujarat, Tamil Nadu, and Maharashtra account for more than 30% of the total GDP of the country. Union Territories are urban regions, governed by the Central government, have higher income levels than the rest of the country. Rapid economic growth has led to deterioration of environmental quality in many parts of the country. The degradation of the environment however, has significant linkages with poverty also. Use of biomass for household energy demands, improper sanitation and waste management practices, and limited awareness about environmental issues, are all associated with poverty. Overall, there are states/UTs that seem to perform well on all socio-economic and environmental fronts. However, many of the States/UTs are striving for economic prosperity and social inclusiveness, environmental preservation has taken the backseat. Finally, there are regions which are not performing well on all three legs of sustainability. Therefore the variability of performance cannot be generalized over the whole country and requires in-depth analysis adjudging how different states are performing overall on sustainability and specifically on the three legs of sustainability. This paper tests the index of sustainability to understand the growth patterns in these States and UTs and scrutinize their progress on the basis of sustainability goals. This will provide a basis for the decision makers to formulate policies and programmes which would help in improving the sustainability of their region.

2.2. Methodology

Environmental, social and economic considerations comprise the main criteria to measure sustainability. Broadly speaking, sustainable development stresses on the long-term compatibility of the economic, social and environmental dimensions of human well being, while acknowledging their possible competition in the short term (Bao et al., 2011). The objective of this research is to develop a composite SDI comparing various regions of India. The methodology adopted in the current work comprises of the following steps

- carrying out a comprehensive literature review of indicators developed in past to adjudge social-economic and environmental performance
- selecting the most relevant, non-redundant, simple data-based set of indicators for Indian conditions
- evaluating the inter-relationships between the selected indicators
- developing a new composite SDI based on individual indicators
- testing the performance of the SDI for comparing the performance of Indian states and UTs.

An exhaustive literature review has been carried out to compile a set of relevant indictors for the present study. The major indicator sets reviewed in the study are Quality of Life Indicators, Audit Commission, UK (AC, 2005); OECD Indicators (OECD, 2001); United Nation Commission on Sustainable Development Indicators (UNCSD, 2007); EU Headline Indicators (EEB, 2001); Environment Performance Index, Yale University (YU, 2012); Human Development Index, UNDP (Neumayer, 2001) and Index of Sustainable Economic Welfare (ISEW) (Jackson et al., 2007). Other than these, the Environmental Sustainability Index (ESI) developed by the World Economic Forum in collaboration with the Yale Centre for Environmental Law & Policy, and the Centre for International Earth Science Information Network at Colombia University was also reviewed. On the social front, some of the common, well-recognized social indices that were studied include UN Gender Related Development Index, UN Human Poverty Index for Developing and Developed Countries, National Human Development Index, etc. The important considerations for selection of the indicators are:

- simplicity
- data availability and periodicity
- priorities of the country (socio-economic development, and environmental conservation).

While selection of the indicators, broader state level issues are considered rather than micro-level concerns. Thus, different States of India have been compared on set of broad issues relevant at the National scale. It is to be noted that all of these indicators do have relevance at the State-level, however with varying magnitudes. State of the resource indicators were assessed rather than evaluating cause-effect relationship. The indicators were chosen such that they give a clear picture of the whole system, among various dimensions of sustainable development, as well as the long-term implications of current decisions and behaviour. While selecting, it was also considered that changes in the indicator values over time must mark progress or lack of progress towards sustainable development (IAEA, 2005). Based on these criteria, 19 indicators were selected under the three themes of environment, social and economics (Table 1).

The chosen indicators are used to carry out two different analysis- correlation analysis and sustainability analysis. The correlation analysis is carried out to understand the inter-relationships between the selected indicators and a correlation matrix was prepared based on coefficient of correlation (r) (Minium et al., 2001). Different indicator pairs were classified in three categories of correlation- feebly correlated ($0.4 < r < 0.5$), moderately correlated ($0.5 < r < 0.6$), and strongly correlated ($r > 0.6$). Thereafter, sustainability analysis approach has been developed using the selected indicator values. First of all, all the indicator values are converted to positive indicators (which show improvements towards sustainability), e.g. poverty indicator has been converted to non-poverty indicator. The indicator values are in different units of measurement and to make them inter-comparable, Z-score normalization technique (Minium et al., 2001) has been used.

Z-score values computed for each of the indicators are averaged for different themes assuming equal weightages and social, economic, and environment indices are formed equation (1).

$$\begin{aligned}
&\text{Environmental index}\,(Z_{\text{Env}}) = \text{Average}\,Z\text{-scores}\,(A_1, A_2, \ldots, A_n)\\
&\text{Social index}\,(Z_{\text{Soc}}) = \text{Average}\,Z\text{-scores}\,(B_1, B_2, B_3, \ldots, B_n) \qquad (1)\\
&\text{Economic index}\,(Z_{\text{Eco}}) = \text{Average}\,Z\text{-scores}\,(C_1, C_2, C_3, \ldots, C_n)
\end{aligned}$$

where A, B, C are indicators under the themes of environment, social and economics, respectively.

Finally, the SDI equation (2) has been formed using average of the environment, social and economic indices for different States and UTs.

$$\text{SDI} = \text{Average}\,(Z_{\text{Env}}, Z_{\text{Soc}}, Z_{\text{Eco}}) \qquad (2)$$

There are many studies in the past which have assumed equal weights for the indicators under the three themes of sustainability (Xiao et al., 2010; Lee, 2007; UN-HABITAT, 2001; SOPAC, 2005). This study also assumes unbiased treatment to the three equally important legs of sustainability. SDI values have been analyzed and interpreted for various States/UTs of India to adjudge their performance on the three themes. The spatial variation (State/UT-wise) observed in socio-economic and environmental performance in India is analyzed using the SDI.

2.3. Data description

In order to do the pilot testing of the SDI for various States/UTs of India, 2010 is considered as the base year as recent data for all the selected indicators was available till 2010 only. Data sets have been obtained from reliable published Government sources and compiled using statistical software (EXCEL based). Environmental datasets published from the Ministry of Environment and Forests in India have been used for computing environmental indicators. Census-2011 (RGCC, 2011) has been used for collecting data on social indicators, while annual economic surveys were used for economic indicators. The data sources for all indicators are also shown in Table 1.

Table 1
Themes, parameters and indicators selected for the current study.

S. No.	Theme	Parameter	Indicator	Equation	Data source	Rational for selection w.r.t. state
1	Environment	Land	% degraded land of the total land cover of the state	Degraded land/total area of region	LS (2011)	• Land degradation refers to a decline in the overall quality of soil, water or vegetation condition commonly caused by human activities. • Land degradation shows us the non-usefulness of land in a particular state.
		Forest	% forest area of the total land cover of the state	Forest area/total area of region (to the maximum of 33% as per National Forest Policy (NFP)	FSI (2011)	• NFP aims at maintaining a minimum of 33% of country's geographical area under forest. • Although quality of forest is also a major concern but required state-wise data is not available.
		Water	(1) Quantity: Ground water (GW) abstraction (2) Quality: % stations violating standards for different parameters for surface and ground water	Avg.(V_1, V_2,. . ., V_n), where V_n = no. of stations violating the standard of nth parameters (pH, BOD, Nitrates, conductivity and faecal coliform)	CGWB (2010) CPCB (2011b)	• Both quality & quantity of water are considered equally important. • Quantity of surface water could not be accounted considering that river flows are irrespective of the administrative boundaries and hence cannot be appropriately attributed to particular State/UTs. • GW exploration was chosen to depict the state of available quantities of GW in a region. • Average violation of different water quality parameters was chosen as indicator accounting for all parameters defining water quality.
		Air	Exceedence of the average Respirable Suspended Particulate Matter (RSPM) concentrations in different cities of the region	$1/n\sum(C_i/S_i)$ n is number of stations/cities, C is RSPM concentration & S is standard	CPCB (2011a)	• RSPM is the pollutant of prime concern in India- 80% of Indian cities violate standards • Oxides of sulphur and nitrogen (SO_2 and NOx) are specific to some sources (power plants, vehicles, etc.) whereas RSPM is contributed by majority of sectors • Control of RSPM could lead to control of other pollutants too. • RSPM has highest health impact (0.6 million mortalities per year (Lim et al., 2012)
		Waste management	Treatment capacities for MSW and sewage generated in state	Waste treated/Waste generated	Sewage – CPCB (2009) MSW – CPCB (2013)	• Waste generation is expected to grow in future. • It has great potential to degrade the quality of land and water resources. • Appropriate capacities to treat the quantities and toxicities of the waste are required.
		Bio-diversity	% protected areas of the total land cover of the state	Protected area/total area of region	MoEF (2013)	• The indicator depicts the priority and attention given by a State/UT towards conservation of bio-diversity
2	Social	Poverty	% people below poverty line	Population BPL/Total population	PC (2013)	• The inter relationship between poverty and environment has been recognized as a major cause and effect of global environmental problem
		Population	% decadal growth rate	$(P_{new} - P_{base})/P_{base}$	RGCC (2011)	• Higher rates of population growth exert pressures on economic and natural resources
		Literacy	% literates	Literate Population/Total population	RGCC (2011)	• Close link between literacy and development
		Efficient and clean energy	% Liquefied Petroleum Gas (LPG) penetration	Households with LPG/Total households	RGCC (2011)	• Efficient and clean energy use is an important feature of a sustainable society. • LPG – higher calorific value, more efficient and emits lesser pollutants. Use of LPG denotes efficient and cleaner energy usage • Use of LPG in a region denotes efficient and cleaner energy usage and socio-economic upliftment • Renewables were neglected at the moment considering their limited penetrations due to unaffordability
		Basic amenities	% population having access to tap water, electricity, and sanitation	Number of household with access/Total households	RGCC (2011)	• Better access to these amenities indicates the social development of the region
		Law and order	Crime rate	Number of crimes/total population × 1000	MoHA (2011)	• Law and order in a state is linked to the socio-economic conditions and hence impacts the sustainability concerns
		Health	1. Average population served per bed in government hospital 2. Life expectancy	Number of beds/total population	MoHFW (2010) MoHFW (2011)	• In absence of information on state indicators like mortalities and morbidity, provision of health infrastructural facilities (in form of number of beds available) has been chosen. • Life expectancy is direct indicator of good health and better infrastructure facilities to support. Thus, it has been chosen as a positive indicator of health.
3	Economic	Livelihoods	Unemployment rate	Unemployed workforce/Total workforce	MLE (2010)	• High unemployment rate negatively impacts the economy, equity, may deteriorate social conditions like crime scenario and health, etc. • High unemployment rate denotes that economy is not able to produce enough jobs for the people.
		Income	Per capita Income	Total GDP/Population	MoF (2011)	• GDP per capita is the most widely used indicators which shows the average income levels and hence depicts economic prosperity of a region.

Table 2
Correlation matrix of 19 selected indicators.

Indicators	Land quality	Forests	Water quality	Water Quantity	Air quality	Waste management	Bio -diversity	Inverse poverty rate	Inverse population growth	Literacy	Clean Energy	Tap water	Electricity	Sanitation	Avg. access to amenities	Inverse Crime rate	Hospital bed/ population	Life Expectancy	Employment	Income
Land quality	1	−0.37	−0.59	−0.31	0.23	−0.03	0.33	0.25	0.08	0.14	0.57	0.49	0.29	0.2	0.39	−0.19	0.05	0.09	0.16	0.43
Forests	−0.37	1	0.19	0.62	0.29	−0.14	0.07	0.13	−0.23	0.34	−0.2	−0.12	0.02	0.41	0.1	0.31	0.58	0.11	−0.2	−0.16
Water quality	−0.59	0.19	1	0.46	−0.01	−0.19	−0.15	−0.29	−0.04	−0.33	−0.59	−0.34	−0.37	−0.42	−0.43	0.05	−0.29	−0.43	−0.16	−0.49
Water Quantity	−0.31	0.62	0.46	1	0.18	0.06	0.33	−0.15	−0.16	−0.05	−0.42	−0.2	−0.29	−0.03	−0.2	0.27	0.12	−0.29	−0.09	−0.32
Air quality	0.23	0.29	−0.01	0.18	1	−0.2	−0.01	0.15	−0.05	0.56	0.26	0.24	0.37	0.39	0.37	−0.15	0.49	0.48	−0.02	−0.01
Waste management	−0.03	−0.14	−0.19	0.06	−0.2	1	0.19	0.34	0.07	0.25	0.35	0.48	0.36	0.21	0.42	−0.1	0.25	0.31	0.1	0.51
Biodiversity	0.33	0.07	−0.15	0.33	−0.01	0.19	1	0.22	0.03	0.04	0.12	0.34	0.23	0.16	0.29	0.03	0.22	−0.01	0.26	0.13
Inverse poverty rate	0.25	0.13	−0.29	−0.15	0.15	0.34	0.22	1	0.02	0.6	0.56	0.68	0.68	0.59	0.76	−0.21	0.55	0.78	0.07	0.59
Inverse population growth	0.08	−0.23	−0.04	−0.16	−0.05	0.07	0.03	0.02	1	0.02	0.14	0.04	0	−0.06	−0.01	−0.75	0.02	0.7	−0.15	0.24
Literacy	0.14	0.34	−0.33	−0.05	0.56	0.25	0.04	0.6	0.02	1	0.55	0.42	0.63	0.82	0.71	−0.15	0.54	0.78	0.16	0.47
Clean Energy	0.57	−0.2	−0.59	−0.42	0.26	0.35	0.12	0.56	0.14	0.55	1	0.82	0.71	0.54	0.82	−0.36	0.35	0.73	0.14	0.83
Tap water	0.49	−0.12	−0.34	−0.2	0.24	0.48	0.34	0.68	0.04	0.42	0.82	1	0.75	0.43	0.87	−0.25	0.44	0.49	0.25	0.71
Electricity	0.29	0.02	−0.37	−0.29	0.37	0.36	0.23	0.68	0	0.63	0.71	0.75	1	0.6	0.91	−0.29	0.44	0.71	0.3	0.62
Sanitation	0.2	0.41	−0.42	−0.03	0.39	0.21	0.16	0.59	−0.06	0.82	0.54	0.43	0.6	1	0.78	0	0.59	0.8	0.23	0.4
Average access to amenities	0.39	0.1	−0.43	−0.2	0.37	0.42	0.29	0.76	−0.01	0.71	0.82	0.87	0.91	0.78	1	−0.21	0.57	0.76	0.28	0.68
Inverse Crime rate	−0.19	0.31	0.05	0.27	−0.15	−0.1	0.03	−0.21	−0.75	−0.15	−0.36	−0.25	−0.29	0	−0.21	1	−0.04	−0.32	−0.12	−0.44
Hospital bed/population	0.05	0.58	−0.29	0.12	0.49	0.25	0.22	0.55	0.02	0.54	0.35	0.44	0.44	0.59	0.57	−0.04	1	0.54	−0.07	0.29
Life Expectancy	0.09	0.11	−0.43	−0.29	0.48	0.31	−0.01	0.78	0.7	0.78	0.73	0.49	0.71	0.8	0.76	−0.32	0.54	1	0.09	0.69
Employment	0.16	−0.2	−0.16	−0.09	−0.02	0.1	0.26	0.07	−0.15	0.16	0.14	0.25	0.3	0.23	0.28	−0.12	−0.07	0.09	1	0.03
Income	0.43	−0.16	−0.49	−0.32	−0.01	0.51	0.13	0.59	0.24	0.47	0.83	0.71	0.62	0.4	0.68	−0.44	0.29	0.69	0.03	1

3. Results

Based on the methodology discussed in the previous section, the data of the selected indicators was analyzed and correlation and sustainability analysis were carried out. While, correlation analysis explains the inter-relationships between different indicators, the sustainability analysis uses the indicators to compute SDI values for each state and UTs.

3.1. Correlation analysis

Correlation analysis was carried out for 19 indicators for 28 States and 7 UTs. Coefficient of correlation was computed for different pairs of indicators and a correlation matrix was prepared (Tables 2 and 3).

There have been many revelations about the relationships between indicators of same or other themes. Many social indicators have been found to have strong/moderate correlation with environmental and economic indicators.

For example, land degradation is generally caused due to deforestation, erosion which causes siltation of streams and rivers, reduced water infiltration and gradual drop in water table (ECHO, 2012). Current study finds a significant correlation between land quality and clean energy access (0.57) in Indian States. The regions with low access to LPG are dependent on firewood for cooking and have also shown higher percentages of degraded lands.

Calder et al. (2007) stated that water availability and quality are deeply influenced by forest. The analysis of state level data of forest cover and water availability also show strong correlation. Most of the north-eastern states (Arunachal Pradesh, Meghalaya, Manipur, Mizoram and Nagaland) show large areas under forests and lesser groundwater abstraction (which is influenced by water availability). The quality of water is also found to be correlated with the water quantities.

Poverty is quite commonly associated with low per capita incomes, lower literacy rates (Wamba, 2011), lesser access to basic amenities (MoHUPA, 2009) and lower life expectancy (Weiss et al., 1991). In Indian datasets, there is high degree of correlation observed between poverty and access to tap water ($r \sim 0.68$), LPG (0.56), electricity (0.68), sanitation facilities (0.59). Access to clean drinking water, use of cleaner energy options (LPG/electricity) and special attention towards health and hygiene has been found to be positively correlated with better environmental conditions and correspondingly enhanced life expectancy. Life expectancy has been found to be highly correlated with access to clean energy ($r \sim 0.73$), inverse population growth rates (0.70) and lower poverty levels (0.78). Access to basic amenities has been found to be linked strongly with per capita income levels. Goa (a state with higher per capita incomes and hence lesser poverty) has most of its population covered with tap water supply, LPG fuels, electricity and proper sanitation facilities. Higher per capita income levels have also been found to have higher correlation with waste management practices. This is in line with the philosophy of the Kuznet curve (Dinda, 2004) which indicates enhanced environmental awareness with rising income levels. In addition to poverty and environmental parameters, life expectancy is also influenced by the type of health infrastructure facilities available in the region. Number of hospital beds available in different states and UTs have shown a moderate correlation with the life expectancy indicator ($r \sim 0.54$). It can therefore be concluded that the life expectancy of a region depends up on a number of parameters such as the economic conditions, access to basic amenities, environmental factors and health infrastructure.

Poverty levels have shown a moderate correlation and found to be decreasing with increasing literacy rates. Higher literacy rates in Indian states/UTs have been correlated with lower poverty rates (0.6), with better choices of energy use e.g. LPG (0.55) and improved air quality (0.57). Kerela being the most literate state (94% literacy) of the country depicts better access to cleaner fuel like LPG (36%, about 3 times the national average) which certainly improves the air quality to some extent.

A negative correlation has been observed between the inverse crime rate and income levels, clearly showing that crime increases with rise in economic growth and stringent measures are required to keep it in control.

Table 3
Classification of different pairs of indicators under different categories based upon coefficient of correlation.

Feebly correlated ($0.4 < r < 0.5$)	
Water quality	Water quantity
Access to tap water	Waste management
Life expectancy	Air quality, Access to tap water
Per capita income	Land quality, Literacy, Sanitation
Moderately correlated ($0.5 < r < 0.6$)	
Energy – LPG usage	Land quality, Inverse poverty rate
Literacy	Air quality, Clean energy, Inverse poverty rate
Bed per population	Inverse poverty rate, Literacy
Life expectancy	Bed per population
Per capita income	Waste management
Sanitation	Inverse poverty rate, Other amenities (electricity, clean energy)
Strongly correlated ($r > 0.6$)	
Water quantity	Forest cover
Access to tap water	Clean energy, Inverse poverty rate
Access to electricity	Clean energy, Inverse poverty rate, Literacy, Access to tap water
Life expectancy	Clean energy, Inverse poverty rate, Population, Literacy, Access to electricity, Sanitation
Income	Clean energy, Access to tap water, Electricity, Life expectancy
Negatively correlated	
Inverse crime rate	Income

3.2. Sustainability analysis

This section presents the analysis of each of the three themes i.e. environment, social and economic, which influence the sustainability of a region. Indicators selected in Table 1 under the three themes have been fed with data collected from reliable sources and *Z*-scores have been computed for relative comparison of the States. The critical analysis of various indicators has been carried out to understand its causes and implications in different States. Regional differentiations have been observed both in terms of socio-economic development and environmental degradation. Different States were compared for their comparative performance using the SDI. The details are presented in subsequent sections.

Six parameters have been considered under the environment – air, water, forest, bio-diversity, waste, and land.

Air quality is a very important part of environment. Under the National Air Monitoring Programme (NAMP), air quality is measured at 342 monitoring stations across various States/UTs of the country. The air indicator values show that the north-eastern States/UTs (like Mizoram, Meghalaya) with less industrial activity and significant forest cover are better-off in terms of air quality than rest of the country. Delhi being a heavily populated city shows the most negative value of the indicator. Coastal states (like Goa, Kerela, and Tamil Nadu) are influenced by the sea breeze effect and hence show lesser air pollution levels. Better performance of the State Pollution Control Boards could possibly be another reason for controlled air pollution or relatively better air quality.

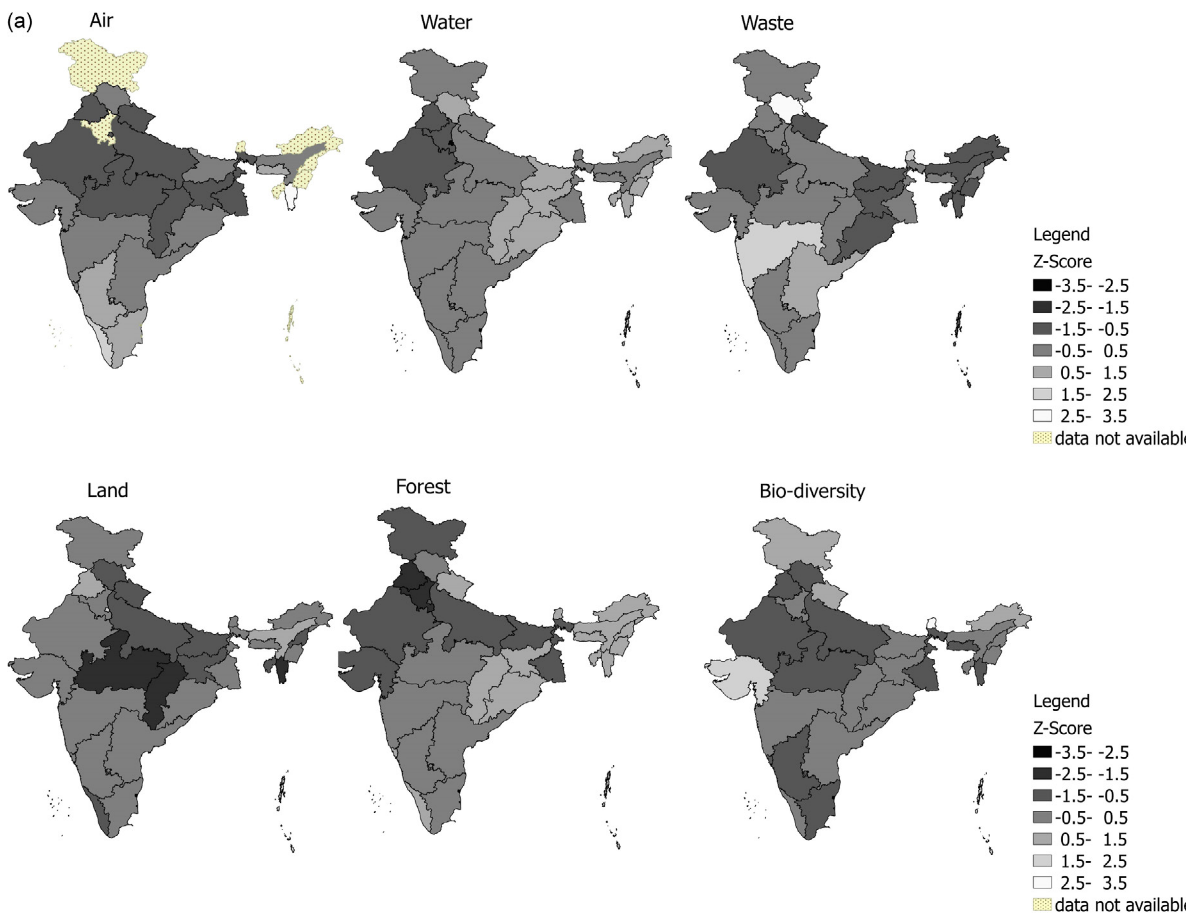

Fig. 2a. *Z*-scores of different States/UTs for different environment indicators.

Water quantity and quality, both were considered under water. Percentage of ground water abstraction has been used as an indicator to represent water quantity. For this purpose state-wise data was collected from the Central Ground Water Board (CGWB, 2010). The *Z*-scores clearly suggest very high ground water abstraction rates in agriculture dominated States (like Punjab and Haryana) and highly urbanized regions like Delhi. Lowest abstractions are observed in less industrial north-eastern region. Urban population pressures and agricultural water demands are major causes for excessive ground water abstraction. The water quality indicator adopted in this study is based on average violations of different water quality parameters in different states. Highly urbanized and industrialized regions show lower scores which depict deterioration of surface water quality.

Importance of forests is globally recognized not only as important source of subsistence, employment, revenue earnings, raw materials to a number of industries but also for their vital role in ecological balance, environmental stability, biodiversity conservation, food security and sustainable development of a country. The current National Forest Policy (MoEF, 1988) aims at maintaining a minimum of 33% of country's geographical area under forest and tree cover. It is observed that the States/UTs of most of the north eastern States and some of the southern states (like Goa, Kerela) have better forest cover than the rest. With limited development activities in the north east part of the country, forests still remains as an important land use category. However, with growth and development activities the forest cover may face competitive pressure from other land uses. Highly industrialized and populated States/UTs show lowest percentage of areas under forest.

For bio-diversity, certain States/UTs (like Sikkim, Chandigarh, and Goa) have shown higher percentage allocation of their geographical areas as protected areas. Growing population pressures have led to generation of huge quantities of municipal solid waste and sewage on daily basis. Present scenario of waste treatment in India is not very good, however certain States and UTs perform a bit better than the other. The UTs show more utilization of land, and hence show less degradation of land resources.

The *Z*-score values for all the six indicator are shown in Fig. 2a and are then averaged to compute the values for Environmental Index (Z_{Env}). Northern States/UTs of Punjab, Uttar Pradesh, Delhi, and Rajasthan are lagging behind in their environmental quality. States/UTs showing better environmental indices are Sikkim, Chandigarh, and A&N islands.

In the current study, parameters such as population growth rate, literacy, poverty, health infrastructure, crime rates and access to clean energy and basic amenities have been considered for formulation of an index to depict social development. Growth rate of population is an important parameter to assess the pressures on the existing resources and facilities. Higher rates of population growth can therefore have negative impact on sustainable development. Population data for the years 2011 and 2001 have been collected from Census 2011 (RGCC, 2011) and Census 2001 and decadal growth rates have been calculated. It is observed that southern States/UTs of India have lower population growth rates than the rest which can be attributed to higher literacy rates. Literacy may lead to better family planning which in turn reduces the natural population growth rate of these regions.

The inter relationship between poverty and environment has been recognized by the World Commission as a major cause and

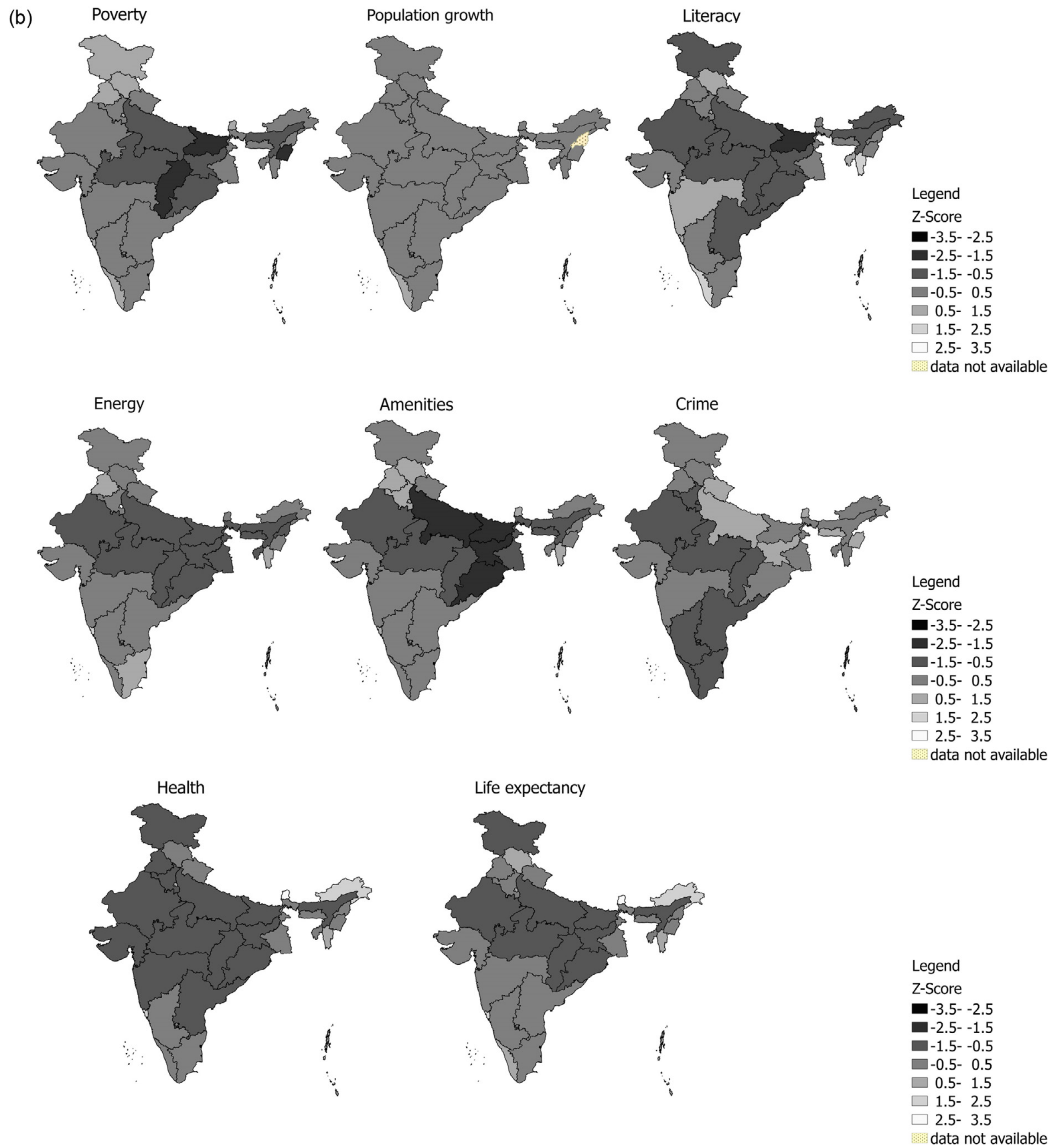

Fig. 2b. *Z*-scores of different States/UTs for different social indicators.

effect of global environmental problem. The UTs and some of the industrialized States have less population Below Poverty Line (BPL), than the rest. Central and north-eastern part of India is under developed and less industrialized, and thus shows high poverty levels.

There is a strong linkage between literacy and development. The literacy indicator shows that States/UTs of Southern and some of the north eastern parts have better literacy rates, than the rest. However, the lowest literacy is observed in central part of India. High literacy regions have shown better indicator values for economic and environmental themes.

Efficient and clean energy use is an important feature of a sustainable society. LPG is a fuel which not only has higher calorific value (hence more efficiency of combustion) but also emits lesser pollutants. The data of access to LPG as a cooking fuel suggests that economically weaker States have the least penetration of LPG and economically welloff States/UTs of (Delhi, Goa, Chandigarh, and Puducherry) are ahead of others. This also reveals the fact that other than economic reasons, access and supply of LPG cylinders seems to be better in smaller State/UTs than the bigger ones. In a similar manner, smaller States and UTs are found to have better access to the amenities like tap-water, electricity, and sanitation.

Deprived socio-economic conditions in a region may hamper the law and order situation. The income disparity between the populations is also an important factor which increases crime rates, especially in urban regions. The indicator on crime rates shows that socio-economically well-off States/UTs generally show higher crime rates than the other. Presence of some of the States in extreme low crime categories raises the question of data reliability and

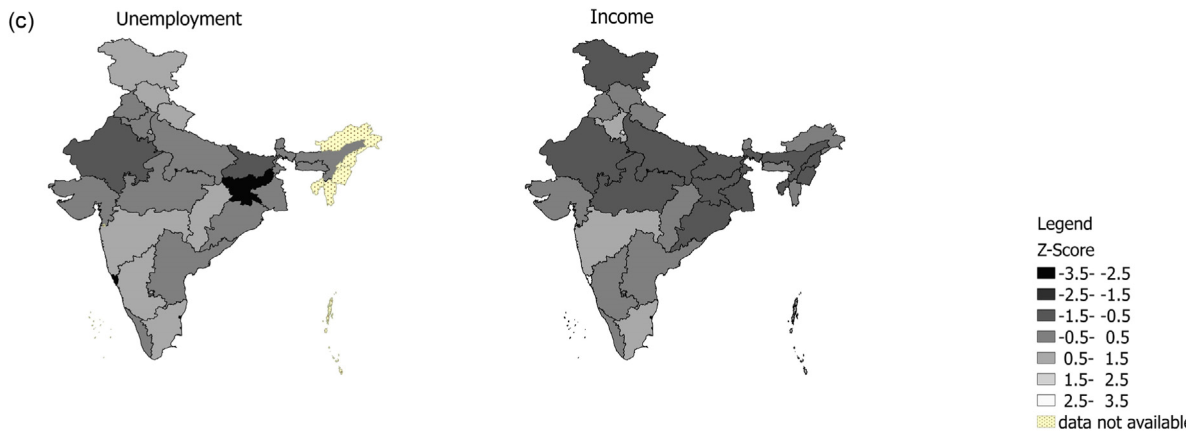

Fig. 2c. *Z*-scores of different States/UTs for different economic indicators.

probability of non-cognizable crimes in these States. Thus, more research for development of a true indicator in this field is required.

Health facilities are one of the most important components which indicate development on the social fronts. The data for availability of the total number of beds per 0.1 million population in a region gives an idea of the state of primary health care facilities in different State/UTs. The indicator shows that smaller States/UTs have shown higher number of beds per 0.1 million population than the other. Data for life expectancy (at birth) has been collected from MoHFW (2011) and added as an indicator of health status and facilities in the States/UTs. The indicator shows that life expectancy is lowest (58–60 years) in socio-economically deprived States/UTs. Correlation analysis also revealed that poor health facilities affect the life expectancy in a particular region.

Averaging the *Z*-scores of all social indicator values gives the Social Index (Z_{Soc}). The *Z*-score values of different indicators under the social category are presented in Fig. 2b. Overall, the smaller States/UTs such as Goa, Sikkim, Puducherry, and Delhi have performed better on the social front than the rest. On the other hand, central eastern states of Bihar, Chattisgarh, Jharkhand, and Madhya Pradesh are on the lower side.

Rapid and unplanned economic development is the main driver in rendering the development unsustainable. However, it is important since it depicts country's growth and monetary well-being. A

Table 4
Values of sustainability indices for various States/UTs.

State	Social index, Z_{Soc}	Economic index, Z_{Eco}	Environmental index, Z_{Env}	SDI
A&N Islands[a]	0.72	0.650	0.86	0.74
Andhra Pradesh	−0.24	0.217	−0.08	−0.04
Arunachal Pradesh	−0.09	−0.168	0.29	0.01
Assam	−0.73	−0.214	0.21	−0.25
Bihar	−1.19	−1.187	−0.49	−0.96
Chandigarh[a]	0.53	1.747	0.86	1.05
Chhattisgarh	−0.92	0.231	−0.08	−0.25
Dadra & Nagar Haveli[a]	−0.17	−0.178	0.59	0.08
Daman & Diu[a]	0.30	0.017	−0.24	0.03
Delhi[a]	0.81	1.734	−0.68	0.62
Goa	0.97	0.012	0.49	0.49
Gujarat	−0.02	0.104	0.11	0.06
Haryana	−0.02	0.710	−0.38	0.10
Himachal Pradesh	0.45	0.307	0.30	0.35
Jammu & Kashmir	−0.17	−0.078	0.17	−0.03
Jharkhand	−0.87	−1.791	−0.31	−0.99
Karnataka	−0.07	0.550	−0.01	0.16
Kerala	0.47	−0.034	0.14	0.19
Lakshadweep[a]	0.64	−0.179	−0.25	0.07
Madhya Pradesh	−0.83	−0.403	−0.42	−0.55
Maharashtra	0.07	0.749	0.11	0.31
Manipur	−0.11	−0.959	0.21	−0.29
Meghalaya	0.00	−0.302	0.21	−0.03
Mizoram	0.57	−0.372	0.19	0.13
Nagaland	−0.22	−1.256	0.10	−0.46
Orissa	−0.76	−0.354	0.13	−0.33
Puducherry[a]	0.82	−0.057	−0.29	0.16
Punjab	0.29	0.130	−0.77	−0.12
Rajasthan	−0.60	−0.917	−0.62	−0.71
Sikkim	0.91	0.105	1.32	0.78
Tamil Nadu	0.15	0.561	−0.05	0.22
Tripura	0.10	−0.641	0.07	−0.16
Uttar Pradesh	−0.57	−0.447	−0.73	−0.58
Uttarakhand	0.39	0.557	−0.02	0.31
West Bengal	−0.27	−0.397	−0.31	−0.33

[a] UTs.

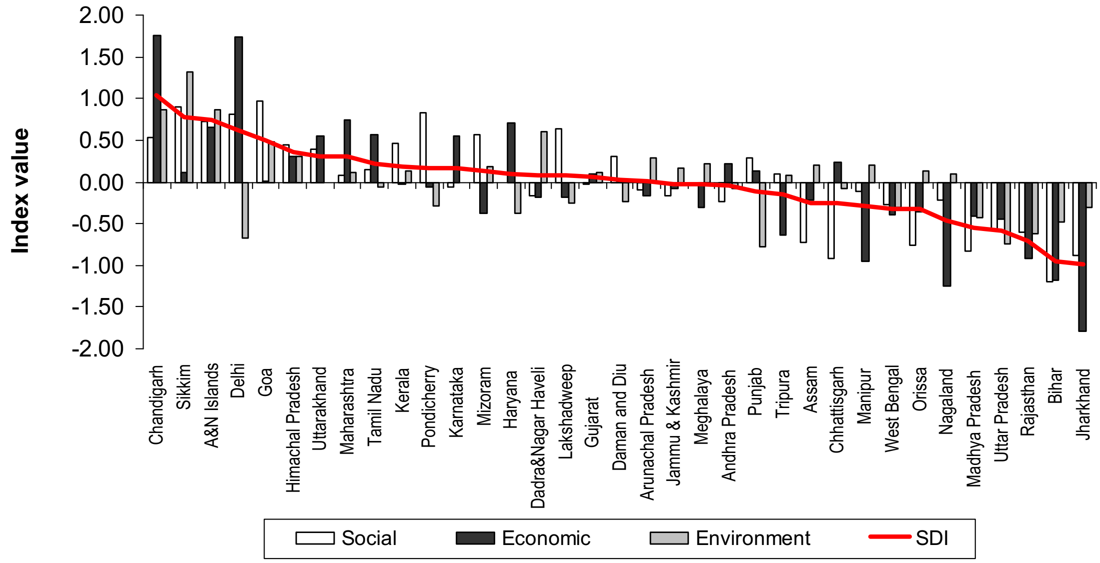

Fig. 3. Comparison of SDI of different States/UTs.

region's Gross Domestic Product, or GDP, is one of the ways for measuring the size of its economy. Per capita Income is often used as an indicator of standard of living in an economy. The indicator values for different states show that industrialized States or UTs have the higher incomes, while north eastern and central regions show the lower values (Fig. 2c).

Economy of the region is also linked to the employment patterns. Employment-to-population ratio is a statistical ratio that measures the proportion of the country's working-age population that is employed. The unemployment rate is the number of people unemployed in a region per unit working population. Having a high unemployment rate means that an important proportion of the population in working age is unemployed and the economy is not able to produce enough jobs for the people. This generally has a negative effect on the GDP per capita of the region. The unemployment indicator shows that places like Delhi and southern States offer more employment opportunities and hence show lower unemployment rates (Fig. 2c).

Overall, in terms of economic development States/UTs of Chandigarh, Delhi, Maharashtra, Haryana and A&N islands are performing well than the rest. However, the states of Jharkhand, Nagaland, Bihar, Manipur and Rajasthan have shown lower Economic Index Z_{Eco}.

3.3. Sustainable Development Index (SDI)

The indices estimated for the three legs of sustainable development are averaged to calculate the SDI. Many of the previous studies have used this assumption of providing equal weights to the three themes of sustainability. However, weightages can also be derived through expert consultations which may vary from State to State. The SDI values estimated in the present paper are based on the average scores of social, economic and environment themes. It may be noted that SDI thus computed may average out the impact of anti-correlated sub-indicators viz. Z_{Env}, Z_{Soc}, Z_{Eco}, and may not communicate the causal factors for the high or low values of the index. Thus, in order to know these causal factors, the sub-indicators must be assessed independently. This will also help the policy makers in taking appropriate corrective actions for specific sub-indicator and will thus help in improving the overall SDI score. For instance, Delhi performs relatively very well in terms of social and economic sub-indicators (fourth and second, respectively), but performs poorly in environment sub-indicator. This clearly indicates that just due to one poor performing sub-indicator the overall SDI falls down despite other sub-indicators performing relatively much better. Thus, in order improve the overall SDI efforts must be targeted to

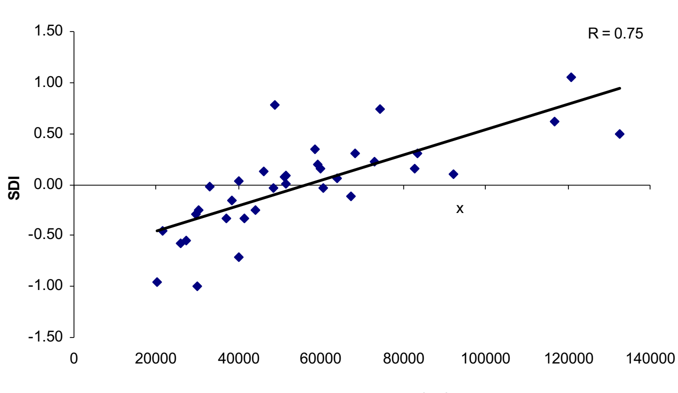

Fig. 4. Correlation between SDI and per capita income of various States and UTs of India.

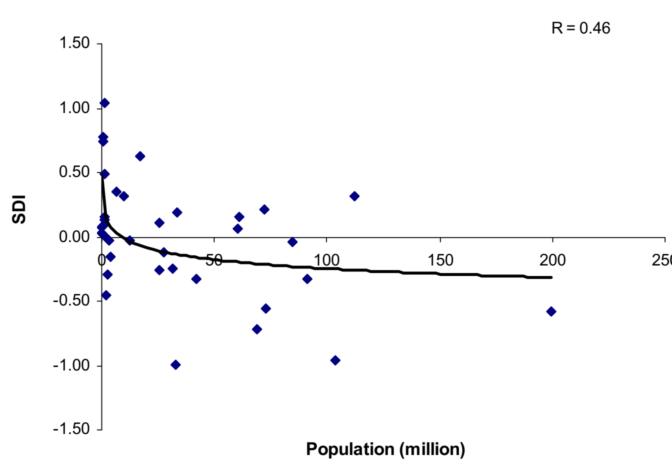

Fig. 5. Correlation between Environment Index and population of various States and UTs of India.

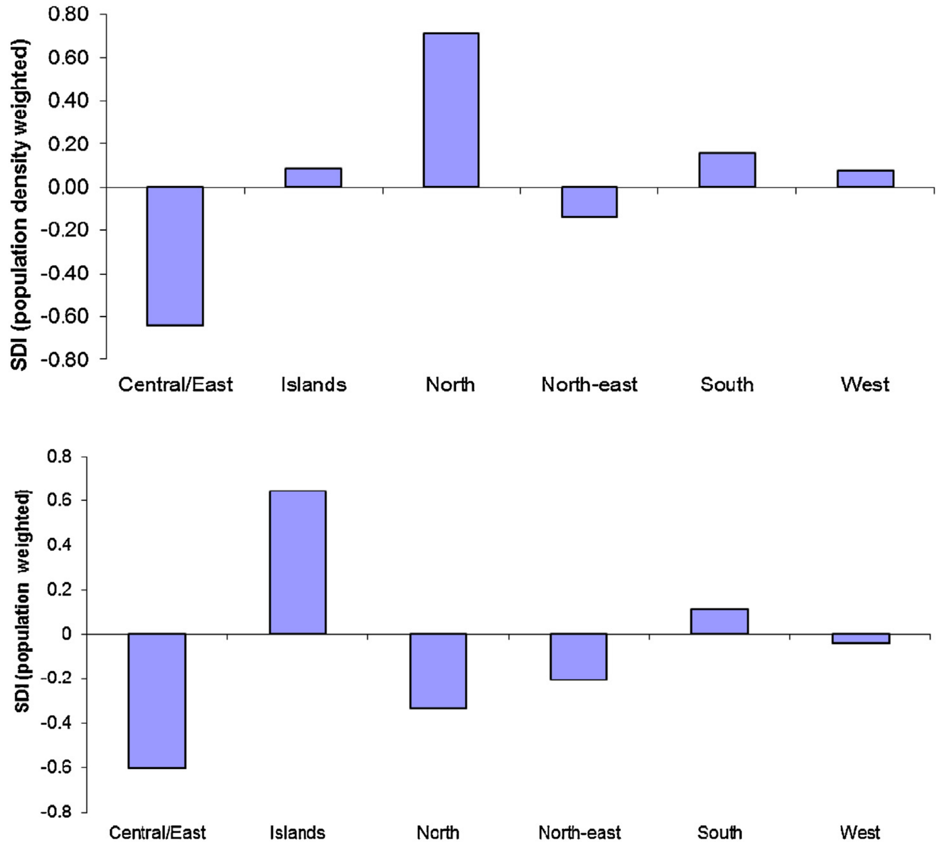

Fig. 6. Average SDI (population/population density weighted) for 6 geographical regions of India (north, south, central/east, west, north-east and islands).

improve the state of the environment while maintaining the other sub-indicators scores.

Table 4 and Fig. 3 provide a summary of sustainability indices for various States/UTs. It is evident from the analysis that on a comparative scale, the States/UTs of Chandigarh, Sikkim, A&N islands, Delhi and Goa are more sustainable than the rest. However, States/UTs of Jharkhand, Bihar, Uttar Pradesh, Rajasthan and Madhya Pradesh are not performing well in all the three themes consistently, and therefore showing low index values.

Sustainability of a region hugely depends upon the economic resources available in the region. Economic sustainability is important not only for socio-economic development but also for environmental preservation. Kuznet curves also demonstrate the fact that most pollution problems appear to begin improving before countries' per capita incomes reach $800 (Grossman and Krueger, 1995). SDI values estimated for different States/UTs were interpreted by exploring its linkages with these important parameters. A positive correlation has been observed between SDI and per capita income across various States and UTs of India (Fig. 4). The States/UTs with higher incomes have shown better SDI values. This shows that India is following the Kuznets curve where after reaching a certain economic level, the quality of life improves and community awareness to preserve the environment is also enhanced. When the income grows high, people tend to think beyond their basic needs. They look forward for better surroundings – better air, water, land, health facilities, and better institutions for higher education. In these conditions, environmental conservation takes the priorities not only for the individuals of the society but also for policy makers. If the basic level of living– food, shelter, and clothing is achieved then government can also direct the finances for better technologies for environmental protection, higher education, and infrastructural support. Enhanced economy will also help people buying green products which may initially require a little higher investment but a quick payback with environmental and health benefits.

Fig. 5 shows the decrement in SDI values with growing population in Indian States and UTs. This clearly identifies population control is a major driver for improving sustainability in a region. The States with large populations have been found to perform poorly on environmental fronts, except for the UTs where better management has resulted in higher SDI scores.

In the current study, it has also been observed that smaller administrative regions are easier to manage and hence perform better on all three legs of sustainability. States/UTs which have an area of less than 10,000 km^2 show positive SDI values. All the larger Indian States i.e. Uttar Pradesh, Andhra Pradesh, Madhya Pradesh, Rajasthan show negative SDI values. However, probably due to better governance, some States/UTs are exceptions (Gujarat, Maharashtra, Karnataka and Tamil Nadu show positive values.)

Geographically, when we weight the SDI values by population in the States/UTs, southern States/UTs have been found to be more sustainable followed by western states. The regions in central and eastern parts of the country are lagging behind (Fig. 6). However, by weighing the sustainability scores by population densities show better scores of North because of presence of densely populated UTs of Delhi and Chandigarh.

4. Discussions and conclusions

The assessment carried out in the study provides a platform to measure and compare the progress of different regions in the country towards sustainable development. It is an attempt to build knowledge towards the measurement of sustainability – an extremely complex parameter. Year-wise trends of the proposed index can prove to be useful to analyze the comparative progress of a region. The index clearly points out the States/UTs of Chandigarh, Sikkim, A&N islands, Delhi and Goa, are more sustainable than the rest. Moreover, with growing economy the SDI has shown an increase. This also suggests that smaller regions are better managed compared to bigger ones.

The results could prove useful for the decisions makers and provide insights into the areas of concern which need special attention. Results could also help in balancing the three legs of sustainable development. The proposed index can be used by the policy makers to compare various regions in the country on the sustainability scales. Also, there are State/UTs which show better performance for one or two legs of sustainable development, but still depict an unsustainable scenario due to one of the strained leg. The capital city of Delhi is a classic example which scores high on socioeconomic fronts but at the cost of severe degradation of environmental resources. There is clearly a need for policy interventions for reducing the environmental footprints of socioeconomic activities in the city. The index also highlighted the least sustainable regions (central and eastern) in the country which show strains on all the three legs of sustainability. There is a need to put special emphasis on overall development of these regions and developmental projects should be planned without degrading the environmental quality.

Based on SDI scores, policy instruments based on fiscal incentives and disincentives can be designed to promote sustainable initiatives across the country. For an example, the annual central budgetary allocations made to the different States/UTs for various developmental works can be allocated based on sustainability indices of the respective regions. Trends of SDI can be assessed by the policy makers for assessing the impacts of various interventions for sustainable development. The index can also be used for future planning exercise and assessing sustainability of different regions under different future growth scenarios. Finally, this tool could also be used to generate awareness among the public towards sustainable development issues.

Major limitation of the study is the absence of weights for different themes/indicators that defines sustainability. Limitations of datasets all across the country is another important issue. Availability of more reliable and consistent data sets will further help analyzing the trends of the indicators and thereby measuring sustainable development. Moreover, the index although presents comparative assessment of sustainability across different regions, it does not provides details of region-specific issues that could have a significant impact on a particular region. Measuring sustainability at regional scale is hence very important to assess the region specific aspects and allows to make informed decisions for improving the three main dimensions of sustainable development. The methods developed to measure sustainability at national scale generally fail at the regional scale to effectively measure progress towards sustainability, hence highlighting the need for methodologies for assessing regional sustainability (Graymore et al., 2008). Riley (2001) also concluded data availability at regional scale is also an important issue. Attempts have been made in the past to conduct sustainability assessments at regional scales. Coelho et al. (2010) worked on a framework for regional sustainability assessment for a Portuguese region. Bao et al. (2011) conducted the regional sustainability assessment for Zhejiang province in China based on long periods of ecological footprint and demonstrated that the rapid economic growth of Zhejiang Province relies on the capitalization of environment and resources. Some work has also been carried out on methodological improvement of regional sustainability assessments. Wallis et al. (2007) provided insights into the challenges encountered and the lessons learned during a regional sustainability assessment project. Munda and Saisana (2011) worked on the methodological considerations on regional sustainability assessment based on multi-criteria and sensitivity analysis. Future work should focus on developing regional scale sustainability indices based on bottom up approaches assessing the region-specific issues.

References

AC, 2005. Local quality of life indicators – supporting local communities to become sustainable. Audit Commission, London.

Bao, H., Chen, H., Jiang, S., Ma, Y., 2011. Regional sustainability assessment based on long periods of ecological footprint: a case study of Zhejiang Province, China. Afr. J. Bus. Manag. 5 (5), 1774–1780.

Calder, I., Hofer, T., Vermont, S., Warren, P., 2007. Towards a new understanding of forests and water. Unisylva 229 (8), 3–10.

CGWB, 2010. Ground Water Scenario of India 2009–10. Central Ground Water Board Ministry of Water Resources, Government of India, Faridabad.

Coelho, P., Mascarenhas, A., Vaz, P., Dores, A., Ramos, T.B., 2010. A framework for regional sustainability assessment: developing indicators for a Portuguese region. Sust. Dev. (18), 211–219.

CDF, 2011. Environmental Sustainability index for India States – Informing Environmental Actions. Centre for Development Finance, Chennai, India, Available from: http://www.greenindiastandards.com/index.php.

Chandrasekharan, I., Kumar, R.S., Raghunathan, S., Chandrasekaran, S., 2013. Construction of environmental performance index and ranking of states. Curr. Sci. 104 (4), 435–439.

CPCB, 2009. Status Of Water Supply, Wastewater Generation And Treatment In Class-I Cities & Class-II Towns Of India, Control Of Urban Pollution Series: Cups/70/2009-10. Central Pollution Control Board, New Delhi.

CPCB, 2011a. National Ambient Air Quality Status 2010, NAAQMS/30/2006-07. Central Pollution Control Board, New Delhi.

CPCB, 2011b. Status of Water Quality in India – 2010, Monitoring of Indian National Aquatic Resources Series: MINARS//2010-11. Central Pollution Control Board, New Delhi.

CPCB, 2013. Status Report on Municipal Solid Waste Management, Available from: http://www.cpcb.nic.in/divisionsofheadoffice/pcp/MSW_Report.pdf.

Dinda, S., 2004. Environmental Kuznets curve hypothesis: a survey. Ecol. Econ. 49 (4), 431–455 http://www.sciencedirect.com/science/article/pii/S0921800904001570.

ECHO, 2012. ECHO Best Practices Notes No. 1, Improving Degraded Land. ECHOcommunity.org, USA, Available from: http://c.ymcdn.com/sites/www.echocommunity.org/resource/collection/85B5FF35-55F1-4A7A-95D2-CAA98D032F45/BPN_1_Improving_Degraded_Land.pdf.

EEB, 2001. EU Headline Indicators. European Environmental Bureau (EEB), UK.

FSI, 2011. State of Forest Report 2010. Forest Survey of India, Dehradun.

Graymore, M.L.M., Sipe, N.G., Rickson, R.E., 2008. Regional sustainability: how useful are current tools of sustainability assessment at the regional scale? Ecol. Econ. 67, 362–372.

Grossman, G., Krueger, A., 1995. Economic growth and the environment. Q. J. Econ. 110 (2), 353–377.

Hanley, N., Moffatt, I., Faichney, R., Wilson, M.D., 1998. Measuring sustainable development: a time series of alternative indicators for Scotland. Ecol. Econ. 28 (1), 53–73.

IAEA, 2005. Energy Indicators for Sustainable Development: guidelines and methodologies. International Atomic Energy Agency, Vienna, Austria, 171 pp.

Jackson, T., Bride, N.M., Abdallah, S., 2007. Beyond G D P measuring Progress, True wealth & the well being of Nations, New Economic Foundation. In: International Conference, 19–20 November 2007, Brussels.

Lee, Y.J., 2007. Sustainability index for Taipei. Environ. Impact Assess. Rev. 27 (6), 505–552.

Lim, S.S., et al., 2012. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet 380 (9859), 2224–2260, http://dx.doi.org/10.1016/S0140-6736(12)61766-8.

LS, 2011. Lok Sabha Starred Question No. 270, Available from: http://envis.tropmet.res.in/Data_depository/Agriculture_Data/Degraded_Land.htm (accessed 15.03.11).

Minium, E.W., King, B.M., Bear, G., 2001. Statistical Reasoning in Psychology and Education. John Wiley & Sons (Asia), Singapore.

MLE, 2010. Report on Employment & Unemployment Survey (2009–10). Ministry of Labour & Employment, Government of India, New Delhi.

MoEF, 1988. National Forest Policy. Ministry of Environment and Forests, Government of India, New Delhi.

MoEF, 2009. State of Environment Report India – 2009. Ministry of Environment and Forest, New Delhi.

MoEF, 2010. Towards Sustainable Growth- Transport, Chemicals, Waste Management, Mining, SCP. Ministry of Environment and Forest, New Delhi.

MoEF, 2013. Ministry of Environment and Forests, Government of India, New Delhi, Available from: http://envfor.nic.in/downloads/public-information/protected-area-network.pdf.

MoF, 2011. Economic Survey 2010–2011. Ministry of Finance, Government of India, New Delhi.

MoF, 2013. Report of the committee for evolving a composite development index of states. Government of India, Ministry of Finance, New Delhi, Available from: finmin.nic.in/reports/Report_CompDevState.pdf.

Moffatt, L., 1996. Sustainable Development: Principles Analysis and Policies. Parthenon Press, New York.
MoHA, 2011. Crime in India 2001, National Crime Records Bureau Ministry of Home Affairs. Government of India, New Delhi.
MoHFW, 2010. National Health Profile (NHP) of India – 2010. Ministry of Health and Family Welfare, Government of India, New Delhi.
MoHFW, 2011. Family Welfare Statistics in India 2011, Statistics Division, Ministry of Health and Family Welfare. Government of India, New Delhi.
MoHUPA, 2009. India: Urban Poverty Report. Ministry of Housing and Urban Poverty Alleviation, Government of India, New Delhi.
Munda, G., Saisana, M., 2011. Methodological Considerations on Regional Sustainability Assessment Based on Multicriteria and Sensitivity Analysis, 2011. Reg. Stud. 45 (2) http://rsa.informaworld.com/10.1080/00343401003713316.
Neumayer, E., 2001. The human development index and sustainability—a constructive proposal. Ecol. Econ. 39, 101–114.
OECD, 2001. Sustainable Development: critical issues. Organisation for Economic Co-operation and Development, Paris, France, 487 pp.
Parris, T.M., Kates, R.W., 2003. Characterizing and measuring sustainable development. Annu. Rev. Environ. Resour. 28 (13), 1–28.
PC, 2013. Data tables. Planning Commission, Government of India, New Delhi, Available from: http://planningcommission.nic.in/data/datatable/0904/tab_45.pdf.
RGCC, 2011. Census of India – 2011. Registrar General and Census Commissioner, New Delhi, Available from: http://www.educationforallinindia.com/chapter6-state-of-literacy-2011-census.pdf.
Riley, J., 2001. Multidisciplinary indicators of impact and change: key issues for identification and summary. Agric. Ecosyst. Environ. 87 (2), 245–259.
SOPAC, 2005. South Pacific Applied Geoscience Commission. Building Resilience in SIDS. The Environmental Vulnerability Index (EVI) 2005. SOPAC Technical Report, Suva, Fiji Islands.
TERI, 1997. Looking Back to Change Track GREEN India 2047. The Energy and Resources Institute, New Delhi.
TERI, 2001. DISHA (Directions, Innovations, and Strategies for Harnessing Action). The Energy and Resources Institute, New Delhi.
TERI, 2010. Looking Back to Change Track. The Energy and Resources Institute, New Delhi.
UN, 1987. Report of the World Commission on Environment and Development Our Common Future. United Nations, Available from: http://conspect.nl/pdf/Our_Common_Future-Brundtland_Report_1987.pdf.
UN, 1992. Earth Summit Agenda 21 – The United Nations Programme of Action from Rio. UN Department of Economic and Social Affairs.
UN, 2002. Plan of Implementation of the World Summit on Sustainable Development. United Nations.
UN, 2006. CSD Indicators of Sustainable Development, 3rd ed. United Nations, Available from: http://www.un.org/esa/sustdev/natlinfo/indicators/factsheet.pdf.
UNCSD, 2007. Indicators of Sustainable Development: Guidelines and Methodologies, 3rd ed. United Nations Publication, New York.
UNDP, 2013. Human Development Report 2013, The Rise of the South: Human Progress in a Diverse World, 2013. United Nations Development Programme, Available from: http://hdrstats.undp.org/en/countries/profiles/IND.html.
UN-HABITAT, 2001. City development Index. www.un.org/ga/Istanbul+5/116.pdf, http://ww2.unhabitat.org/istanbul+5/116.pdf.
Wallis, A., Richards, A., Toole, K.O., Mitchell, B., 2007. Measuring regional sustainability: lessons to be learned. Int. J. Environ. Sustain. Dev. 6 (2), 193–207.
Wamba, N.G., 2011. Poverty and Literacy, Routledge. Taylor & Francis Group, London, Available from: http://eric.ed.gov/?id=ED527756.
Weiss, B.D., Hart, G., Pust, R.E., 1991. The relationship between literacy and health. J. Health Care Poor Underserved 1 (4), 315–363.
Xiao, G., Xue, L., Woetzel, J., 2010. The Urban Sustainability Index: A New Tool for Measuring China's Cities. The Urban China Initiative, Available from: http://www.urbanchinainitiative.org/wp-content/uploads/2012/04/2010-USI-Report.pdf.
YU, 2012. EPI methodology. Yale University, USA, Available from: http://epi.yale.edu/epi2012/methodology.
YU, 2014. Environment Performance Index 2014. Yale University, USA, Available from: http://epi.yale.edu/epi.