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Developing an Approach and Structural Framework for Measuring Environmental Performance of Urban Settlements in India

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ABSTRACT: The 21st century is plagued with contradictions and dilemmas associated with urban development. There is a pressing need that the planners and policy makers focus on to what extent the urbanisation could be permitted, so that either the impact on the environment stays within sustainable limits or there is a possibility of replenishing resources and recovering from impact on environment within a reasonable time frame The 'Agenda 21'adopted at Earth Summit in 1992 recognised the importance of development of indicators by countries to make informed decisions concerning sustainable urban development for protection of the natural environment and livable pollution free built environment. The present paper recommends an approach and structural framework for developing a set of simple and effective sustainability indicators in India at both macro and micro level . The careful framing, monitoring and interpreting of the indicators would help the urban areas in India to assess the present state of the sustainability, highlight critical aspect of the environmental status of the system, to devise future action plans or policies to ensure inter-generation and intra-generation equity and to inform the general public about the state of the environment and raise awareness.

I. INTRODUCTION

The world urban population is expected to increase 72 per cent by 2050, from 3.6 billion in 2011 to 6.3 billion in 2050, wherein the share of the urban population of the developing world is 2.7 billion in 2011 to around 5.3 billion by 2050. Urban growth rates are highest in the developing world and it is responsible for 95 percent of the world's urban population growth (UN-DESA, 2011; UN-HABITAT, 2008).

In India urbanisation scenario in recent decades is characterised by two significant features. First, there has been a massive growth in the absolute number of people living in urban areas. Secondly, there has been an increasing concentration of urban population in the Class I towns or 'cities' with one million or more population. (Planning Commission, GoI).

With rapid expansion of urban population around the world there has arisen a wide awareness and concern about minimizing the environmental costs of urbanisation. Population growth and environmental degradation are engaged in a complex, multi-factor relationship, where one serves to exacerbate the adverse impacts of the other (UNER, 1995).

The concentration of population in particular areas can have a particularly damaging effect on environment once critical pollution thresholds are exceeded

Several International and National agencies across the World have been working towards formulating indicator sets to measure and assess one or more aspects of 'sustainable development' for sound decision making which got a major impetus after the adoption of Agenda 21at the Rio Earth Summit in 1992 (UN,1992)

At the global level the various initiatives associated with urban environmental planning have taken a formal shape in last few decades. However none of the Indian cities figures in the IISD Compendium, the most comprehensive database to date to keep track of Indicators efforts all over the world (IISD, 2007). Irrespective of the various initiatives at global level, it is a matter of deep concern that none of the Indian cities, regions, or India as a whole has so far registered a similar initiative to tackle the urban environmental sustainability. The paper explores incorporation of urban environmental sustainability concept in the physical planning of urban settlements in India.

II. PLANNING OF URBAN SETTLEMENTS IN INDIA

The physical planning of cities and towns in India is dominated by 'Master Plan Approach', which is focused on land use and often ignores many important socio-economic and environmental aspects (Devas, 1993). There is inadequacy of research relating to the spatial planning of the cities and towns in India as the first few Five Year Plans after independence focused on country level macro-economic planning and development (Kundu, 2001). Moreover, in India after independence planning has been dominated by top-down approach. However, an effective plan or policy should be an outcome of dynamic interaction of ground reality, expert's opinion and people's perception. In reality, both the top-down approach and bottom-up approach are important for effective planning at macro level (national/city)and implementation at micro level (local/neighborhood level) (Banerjee et al., 1982; Richardson, 1982; Mathur 1984).The city planners and policy makers need a set of tools to arrive at a sequence of logical actions which could help them in making judicious resource allocation and informed decisions for continual improvement of human settlements. levels. Apart from broader indicator sets at national /city and local level, there is also a need of developing comprehensive micro-level urban ecosystem sustainability assessment indicators to overcome the hindrance of data availability and to ensure community participation.

To incorporate urban environmental sustainability concept in the physical planning of urban settlements in India there is a need to develop a set of simple and effective sustainable development indicators at various

The careful framing, monitoring and interpreting of the indicators would help the urban areas to assess the present state of the sustainability, highlight critical aspect of the socio-economic-environmental status of the system and to devise future action plans or policies to ensure inter-generation and intra-generation equity.

A good, practical and much-needed starting point in the direction of attaining urban environmental sustainability is improving the delivery of basic urban services like supply of clean drinking water, sanitation; management of municipal solid waste, efficient transport system, adequate supply of power and energy along with minimization of pollution levels to improve the quality of lives of the people. The cities should be able to produce and distribute the services in an economic, environment friendly and equitable way. Most basic indicators and the values from which they flow are common to all human beings - everyone wants better health, livelihood security, safe communities, reasonable level of educational attainment, clean air and water, etc. So the fundamentals transcend circumstance and culture.

III. ENVIRONMENTAL SUSTAINABLE DEVELOPMENT OF URBAN SETTLEMENTS IN INDIA

A) Conceptual Approach

Sustainable Development is a broad and multidimensional concept. The most popular definition of Sustainable Development as given by Brundtland Commission (WCSD, 1987) is "Sustainable development is the development that meets the needs of the present without comprising the ability of the future generations to meet their own needs". A modified version of this definition to make it applicable to the urban context is "the path of urban environmental sustainability is the one in which urban development meets the environmental needs of the present urban dwellers without compromising the ability of non-urban dwellers and the future generations to meet their own needs which are affected by the environment" (MoE Japan, 2002).Thus for environmental sustainability of an urban settlement it requires monitoring of the internal environment of the settlement and its success in fulfillment of basic needs of its inhabitants while minimizing undesirable effects; as well as the effect that the settlement has on the wider natural environment through resource use and waste outputs. Hence to achieve the aim of environmentally sustainable urban development following two major goals have been identified:

a) Ecological resilience of the Natural environment- To preserve balance of the natural resources and the restoration and renewal capacity of the natural ecosystem.
b) Sustainable development of the Built Environment- Energy efficient settlements with adequate and secure housing and efficient infrastructure.

To achieve the above goals, the present study focuses on formulating an indicator system which performs the following tasks:

- To assess the state of the environment
- To provide necessary inputs to the policy makers
- To keep track of the changes in the environment and to do a performance review of the environmental policies
- To inform the general public about the state of the environment and raise awareness

The study focuses on formulating an indicator set which can satisfy the following characteristics to the extent feasible:

a) Multilevel indicators
b) Core indicators-common set of indicators with available data at broader level and with experts opinion; and
c) Additional indicators- specific set of indicators relevant to a local area and with public participation

d) Simple and easy to understand by policy makers and the general public
e) Bottom up approach and multi stakeholders participation
f) Policy responsive and action plan oriented
g) Analytically sound
h) Mix of quantitative and qualitative indicators
i) Quantifiable with available reliable data

B) Selection of the Structural Framework

Structural Frameworks are the rational over which the indicators are outlined. Different indicator initiatives across the globe have developed various framework methods over the time which mainly differ in the way the different aspects of sustainable development are being focused, the inter-connection between the various aspects, the way they highlight the major issues to be monitored and the criteria for selection of indicators for assessment of the state of sustainability and providing necessary inputs for decision making. The distinguishing features of the reviewed sustainable development indicator initiatives are given in the table below:

Table 1: Review of Sustainable Indicator Initiatives

Indicator Initiative	Structural Framework	Key Features	Aspect of Sustainability
UNCSD (1996)	Thematic/Sub-Thematic framework	- Monitoring & implementation of AGENDA 21 - Integrated the four pillars of sustainability - Top-down approach - Scope-(International)Country (22 countries comprising developed and developing ones)	social, economic, environmental and institutional
OECD (1993)	Pressure-State-Response framework	- Several categories of measurable indicators each corresponding to a specific purpose - Top-down approach - Scope-(International)Country - (30 OECD member countries)	Only environmental
UNCHS (1996)	Policy based framework	- Implementation of HABITA AGENDA - Specific focus on Millennium Development Goals(improvement of slum dwellers) - Top-down approach - Scope-(International)City - (cities from developed, developing and under developed countries)	social, economic and environmental
EU Common Indicators, Ambiente Italia (2003)	Thematic framework	- Ready to use, self-contained set of indicators with methodologies for collection of data - Bottom-up approach - Scope-(International)City, Local level - (cities of member countries under EU)	social, economic and environmental
UECIQES, China (1989)	Target based framework	- Assessment of environmental performance of the cities through a reward based incentive mechanism - Bottom-up approach - Scope-City - (cities of Peoples Republic of China)	Only environmental
Kitakyushu, Japan (2000)	Causal Framework (a variation of PSR framework)	- Unlike PSR the framework does not isolate cause and effect relationship - Include the vulnerability of the human systems to cope with changes in the environment - Top-down approach - Scope-City (Kitakyushu, Japan)	Only environmental
Environmental Indicators Human Settlement, Australia (1998)	Systems Framework (Extended Urban Metabolism Model)	- State of the environment reporting on human settlements - Domain based classification of indicators - Goals of reducing resource input and waste output and improving livability - Top-down approach - Scope-Country (Australia)	Only environmental

A policy based framework is based on developing a comprehensive inventory of major social goals, devising indicators to measure progress towards these goals and aim at establishing urban strategies and policies. A thematic /index driven framework works by establishing broad themes and sub themes such as livability, sustainability, compact city, ecological city or good governance which are generally multidimensional, involving different aspects which have different indicators, or may be expressed as indexes such as Human Development Index, City Development Index or linear combinations of indicators.

Causal Framework (Pressure- State-Response Framework) developed and popularised by OECD (2004) for State of Environment reporting has emerged as the most widely used indicator framework for environmental reporting. It introduced the concept of cause and effect relationship amongst indicators covering human pressure on the environment, actual state of the environment, and the responses which may be undertaken to alleviate environmental damage. However limitation is that the indicator, which is a pressure in one perspective, may be a state in another and a response in a third (Australia, 1998). For example, housing, which is a pressure indicator for land use, is a state indicator for construction domain and is a response for the homelessness. Secondly, the pressure, state and response/ impact mechanisms are complex and cannot be isolated into single cause and effect. There can be relationships between causes themselves and effects themselves. Performance/Target Based Framework is based on outcome oriented indicators system capable of providing data for establishing and assessing public sector goals and targets in the context of agency management and accountability, strategic planning, economic development program evaluation, customer satisfaction and city competitiveness.

Systems Framework- The Extended Urban Metabolism Model (EUMM) developed by Newman *et al.* (1996) for State of the Environment reporting in Australia (Australian Environmental indicators human settlements,1998) interpret cities as dynamic urban system (population dynamics, economy, industry, infrastructure, transport, institution, linkages) which require inputs of key resources (Land, water, Energy, Population, Finance) which are drawn into the urban processes and transform them into desirable livability outputs or Services (Employment, Income, Health, Education, Housing, Accessibility to services, Community life) and waste (Solid waste, Sewage, Air pollutants, Noise). The desirable change for the system is improvement of livability and reduction of waste. EUMM is closely aligned with the paradigm of sustainable development where future orientation, sustainability goals and targets and linkages among different dimensions are made explicit (Australia, 1998; Newton, 2001).

A review of the major structural frameworks in use in development of sustainability indicators brings to the notice that irrespective of systems framework advantage over the causal and thematic ones, especially in development of environmental indicators, it has not been much explored. Australian Environmental indicators human settlements is the sole literature in indicator research found using EUMM model (Australia, 1998). The systems approach differs from the policy based approach in beginning with a simple but explicit physical model or systems diagram of the city or the environmental system, within which the various actors operate and in which linkages and causality between various sectors are delineated. The limitations of the PSR framework for urban indicator development have also been addressed via the Extended Urban Metabolism Model which makes explicit the notion of livability and reinforces the normative concept of improved environmental outcomes over time. EUMM is closely aligned with the paradigm of sustainable development where future orientation, sustainability goals and targets and linkages among different dimensions are made explicit (Australia, 1998; Newton, 2001).

Thus, for the present study, system framework based on Extended Urban Metabolism Model (EUMM) developed by Newman et al. (1996) has been adopted with modifications relevant to context of the study. The components of the EUMM and their relationship have been explained in the Fig.1.

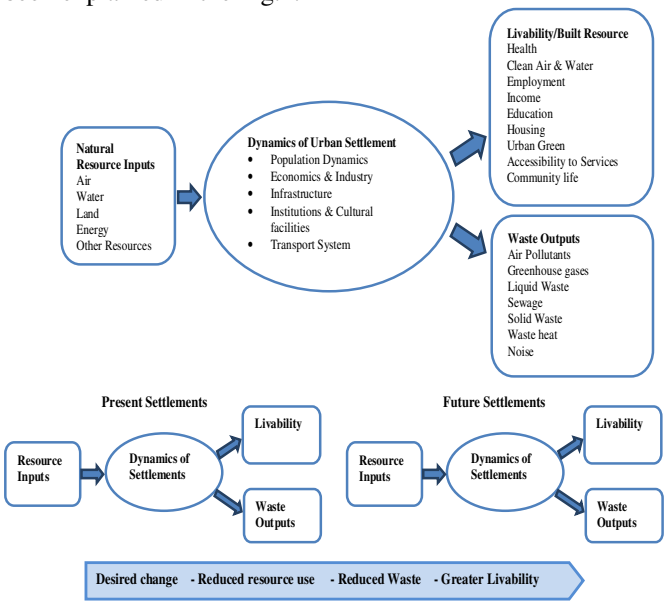

Fig. 1. Extended Urban Metabolism Model of Human Settlements.

C) Identification of Domains

For this study, five domains have been identified based on the essential natural and built in resources: air, water, land, energy, housing and infrastructure which are required for the sustenance of population and the urban system and quality of life. Since population growth and density affects natural and built environment by exerting consumption pressure and by generation of waste, population has been chosen as the sixth domain. For greater livability of the settlements following urban environmental sustainability determinants have been elucidated for the above identified domains with the goal of achieving healthy and resilient natural environment and sustainable built environment.

1. Population- Sustainable population growth and density for reducing the consumption pressure on resources and generation of waste
2. Air- Maintaining air quality and reducing pressure on the atmosphere
3. Water- Maintaining water quality and reducing pressure on the water systems
4. Land- Balanced built land use and urban green and reducing demographic pressure for development
5. Housing- Access to proper and durable housing for satisfaction of basic need of Shelter
6. Infrastructure- Access to infrastructure for satisfaction of basic needs of clean and adequate water and sanitation
7. Energy- Efficient energy use by sensible use of resources and minimization of waste

D) Formulation of Indicators

Formulation of indictors should reflect a thorough understanding of the systems they are going to monitor. A set of domain models have been developed for the above identified resource based six domains: air, water, land, energy, housing and infrastructure structured on EUMM model for providing the framework within which the core indicators at the macro level and additional indicators at micro level could be developed (Refer Fig.2,3,4,5,6,7). The seventh domain population has been treated as one of the major underlying force determining the intensity of resources usage and environmental impact through various urban activities.

In developing the models for the identified domains the focus is on explicating the observable parameters i.e. the resource input, livability and waste output and the unobservable complex parameters i.e various forces at work in urban settlement for conversion of resources to the various outputs have not been enumerated. This approach satisfies the property of an indicator. For example health of a human body is tested through various indicators like temperature, blood sugar etc. without going in to the complexities of what happens inside the human body. The selection of indicators under each identified domain has been made keeping in mind the sustainability determinants along with data availability at macro level and scope of collecting data for that parameter at micro level. Care has been taken to choose a set of concise, simple, easily understandable and interpretable indicators which are also analytically and scientifically sound.

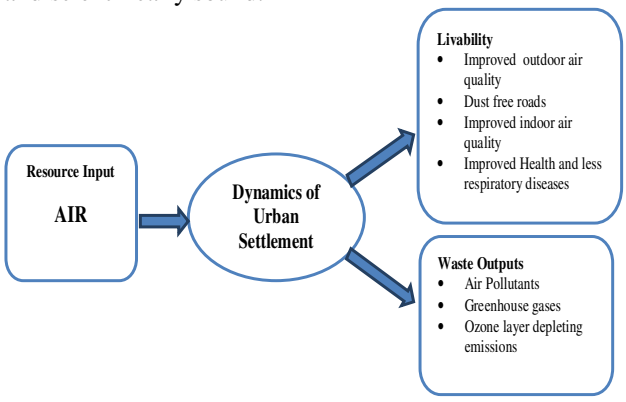

Fig. 2. Domain Model for Air.

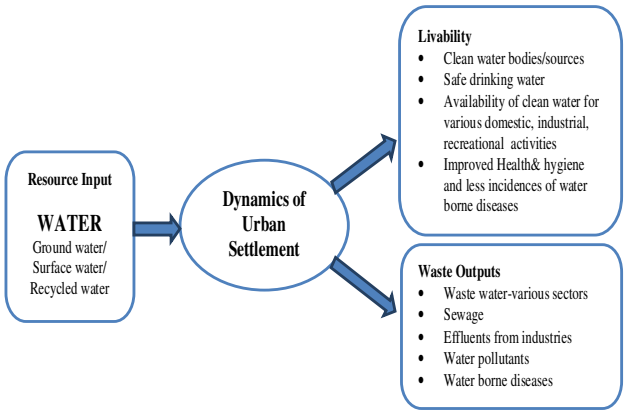

Fig. 3. Domain Model for Water.

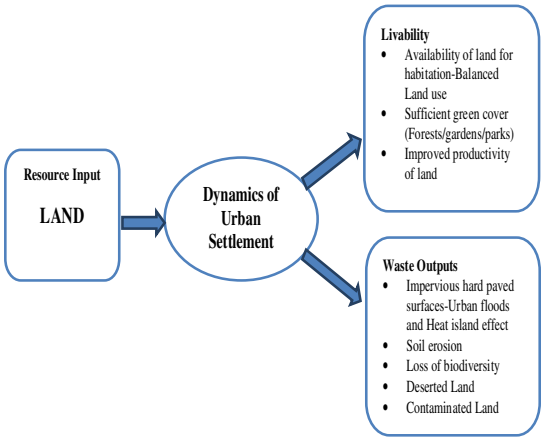

Fig. 4. Domain Model for Land.

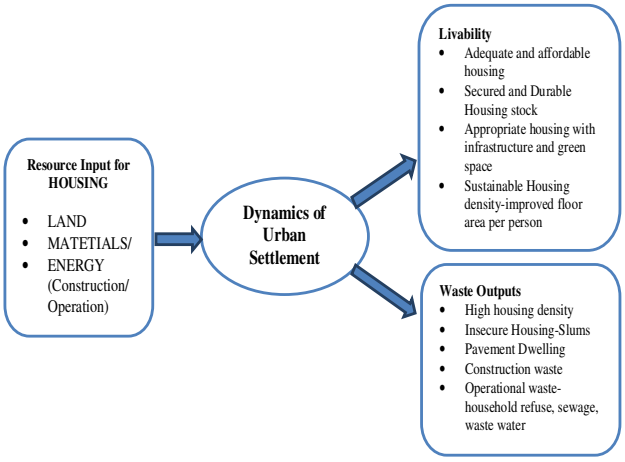

Fig. 5. Domain Model for Housing.

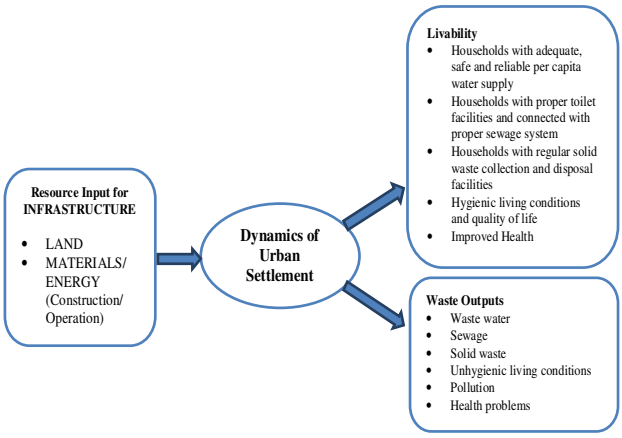

Fig. 6. Domain Model for Infrastructure.

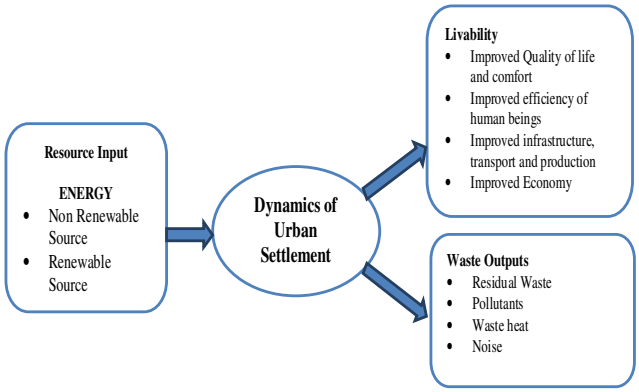

Fig. 7. Domain Model for Energy.

List of Indicators

A set of core indicators for state of the environment reporting at the national/city level and a set of additional indicators for assessing the urban ecosystem at micro level has been identified under each prioritized domain of study with focus on major urban environmental issues of the urban settlements in India. The list of indicators along with the identified data sources are given in the Table 2 below:

Table 2: List of Indicators at the Macro and Micro level along with identified Data Source.

DOMAIN	MACRO INDICATORS (A)	MICRO INDICATORS (B)	DATA SOURCE
POPULATION Sustainable population growth and density for reducing the consumption pressure on resources and generation of waste	City Population (in Millions)	Population of the Area (in absolute numbers)	(A) Census of India (B) Municipality
	Population growth rate (% / annum)	Floating Population (Residential Characteristics)	
	Population density (person/ sq km)	Population Density (person/ sq km)	
AIR Maintaining air quality and reducing pressure on the atmosphere	SO_2 emission (ug/m³)	SO_2 emission (ug/m³)	(A) CPCB (B) • CPCB data of nearest air quality monitoring station • Reconnaissance Survey • Stakeholders/Community feedback • Aerial Image/local maps
	NO_2 emission (ug/m³)	NO_2 emission (ug/m³)	
	PM10 emission (ug/m³)	PM10 emission (ug/m³)	
	CO_2 emissions per person (tonne per capita)	Air emissions from residential energy use	
	GHG emission/city GDP	Air emissions from commercial energy use	
		Air emissions from industrial energy use	
		Air emissions from vehicles	
		Air emissions from burning of solid waste/dry leaves	
		% of paved(black topped)road length/area of total road	
		% of road with road-side green/plantation	

WATER Maintaining water quality and reducing pressure on the water systems	Average BOD/DO concentration in water sources	Mode of Sewage disposal (municipal connection/ pit/septic tanks/open defecation/storm water drains)	(A) CPCB (B) • Municipality • Public Health Department • Reconnaissance Survey • Stakeholders/Community feedback
	Average COD concentration in sea or marine environment	Solid waste disposal open dumping /dumping in storm water drains)	
		Contamination of storm water runoff (agricultural fields,/landfills/chemical working sites/others)	
		Incidences of water borne diseases.	
LAND Balanced built land use and urban green and reducing demographic pressure for development	Share of residential area (%)	Share of residential area %	(A) CDP/Master Plans (B) • Zonal Plans/Local Area Plans • Aerial Images • Reconnaissance Survey • Stakeholders/Community feedback
	Share of area under roads (%)	Share of area under roads (%)	
	Share of green area (%)	Mixed Landuse ratio (%)	
	Green spaces/person (m^2)	Share of green space in the total land area (%)	
	Area of green cover (sq.m/1000 population)	Surface runoff based on the % of different types of surfaces	
	Contaminated/deserted land- under sanitary landfills, hazardous dumping etc (%)	Impervious surface ratio in the total land area (%)	
		Measurement of Albedo of different surfaces by their area percentages	
		Contamination of land- dumping of hazardous waste/chemicals	

DOMAIN	MACRO INDICATORS (A)	MICRO INDICATORS (B)	DATA SOURCE
HOUSING Access to proper and durable housing for satisfaction of basic need of Shelter	Housing density (No. of houses/1000 population)	Housing density (No. of houses/1000 population)	(A) Census of India (B) • Municipality • Zonal Plans/Local Area Plans • Aerial Images • Reconnaissance Survey • Stakeholders/Community feedback
	Average household size (no.)	Average Household size(no.)	
	Share of population living in pucca(durable) houses (%)	Durability & Condition of Housing Stock(Pucca/Kuttcha; Good/Bad/Dilapidated)	
	Share of population living in slums (%)		
	Share of population as Pavement dwellers (%)		
INFRASTRUCTURE Access to infrastructure for satisfaction of basic needs of clean and adequate water and sanitation	Water supply per capita (MLD)	Source of water supply(municipal supply/handpumps/well/community taps/water tankers/others)	(A) • Census of India • CPCB • CDP/Master Plan (B) • Municipality • Zonal Plans/Local Area Plans • Reconnaissance Survey • Stakeholders/Community feedback
	Population with potable water supply service (%)	Piped water supply reliability (no. of hours of supply /day)	
	Water demand met with piped water supply (%)	Households with source of water within premises (%)	
	Households with source of water within premises (%)	Mode of Sewage disposal(municipal connection/ pit/septic tanks/open defecation)	
	Waste water generation per capita (litre/cap)	Households with Toilets within premises (%)	
	Households with sewage connection (%)	Type of solid waste generation(domestic/commercial/industrial/hospital/hazardous)	
	Households with access to proper toilet facilities within premises (%)	Frequency of solid waste collection(regular/irregular)	
	Solid waste generation Per capita (kg/cap/year)	Solid waste segregation	
	Solid waste collected (%)	Solid waste disposal (open dumping/bins/dalaos)	
		Frequency of solid waste transportation from dalaos (regular/irregular)	

ENERGY Efficient energy use by sensible use of resources and minimization of waste	Total energy consumption per capita	Built form adhering to passive solar design principles	(A) • Census of India • Ministry of Statistics and Programme Implementation, Govt. of India (B) • Municipality • Zonal Plans/Local Area Plans • Aerial Images • Reconnaissance Survey • Stakeholders/Community feedback
	Share of renewable energy in the total energy use(%)	Rain water harvesting provision	
	Households with electricity connection (%)	Waste water recycling provision	
	Households with LPG connection (%)	Design of pedestrians paths	
		Access to public services and transport stops within 800m walking distance	

IV. WAY FORWARD

Evaluation of Indicators. Composite indicators or an index are increasingly been recognised as useful tools in policy analysis and public communication. Normalisation is required prior to any data aggregation as an index as the indicators in a data set often have different measurement units (OECD Handbook, 2008).

It is suggested to develop an Environmental Performance Index (EPI) for each city at national level in India, where each indicator under the identified domains at macro level shall be compared with a threshold value .i.e the national permissible or desirable standards set by various Government agencies for that particular indicator to arrive at the performance gap or adherence.

The threshold value shall be assigned a value'0' on the graph and the indicator values are judged from their distance above or below the threshold value. Thus the environmental performance of each indicator shall be judged from the deviation from the threshold value. The advantage of developing an EPI for each city is that it helps in monitoring indicator wise environmental performance, identifying the issues over time and developing clear and transparent domain based policies at national level.

Similarly a Composite Environmental Performance Index for each city can be developed at National level to rank the cities according to their environmental performance and to introduce a reward based incentive mechanism to make them perform better and encourage them to include environmental management dimension in their decision making at all levels.

The list of identified micro level indicators comprise of both qualitative and quantitative indicators. An Environmental Performance Matrix shall be developed assigning a categorical qualitative score such as 'poor', 'moderate', 'good', 'very good' to each indicator under the identified domains based on the national standard threshold values wherever applicable and taking stakeholders and community opinion and feedback. A detailed action plan at local level for improvement of the critical areas shall be prepared with strong participation of the community and Residents Welfare Association and the concerned Municipalities.

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