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Abstract

There was a boom in the development of sustainable development indicators (SDIs) after notion of sustainability became popular through Bruntland Commission's report. Since then numerous efforts have been made worldwide in constructing SDIs at global, national and local scales, but in India not a single city has registered any initiative for indicator development . Motivated by this dearth of studies added to the prevailing sustainability risks in million plus cities in India, a research is being undertaken at the Indira Gandhi Institute of Development and Research (IGIDR), Mumbai, India, to develop a set of sustainable indicators to study the resource dynamics of the city of Mumbai. As a first step in the process, the ground for development of SDIs is prepared through the development of a framework. A multi-view black box (MVBB) framework has been constructed by eliminating the system component from the extended urban metabolism model (EUMM) and introducing three-dimensional views of economic efficiency (EE), social wellbeing (SW), and ecological acceptability (EA). Domain-based classification was adopted to facilitate a scientifically credible set of indicators. The important domain areas are identified and applying MVBB framework, a model has been developed for each domain.

Key words: Urban metabolism, Resources transformation, Economic efficiency, Society, Ecology, Monitoring and evaluation, City development, Black box, Productization of process

JEL Codes: Q01, Q56, O18

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1. Introduction

An indicator or a group of indicators is a tool that can suggest the health of any system. The United Nations defines indicators as not datasets, rather models which simplify a complex subject to a few numbers that are easy to understand and grasp by policy makers. Indicators can translate physical and social science knowledge into manageable units of information that can facilitate the decision-making process (UNCSD, 1996; UNCHS, 1997). Indicators are pieces of information, which have wider significance than their immediate meaning (Bakkes *et al*., 1994). OECD (2003) outlines two major functions of indicators. Firstly, they *reduce* the number of measurements and parameters, which normally would be required to give an exact presentation of a situation. Secondly, they *simplify* the communication process. More recently, efforts have been made to construct indicators in different dimensions and domains to keep track of sustainability i.e. the progress towards the goal of sustainable development (Dhakal, 2002). They are popularly known as sustainable development indicators (SDIs). SDIs perform functions of both proactive and reactive nature. They are like early warning systems, which, when carefully designed, closely watched, and wisely interpreted, can not only show the critical aspect of the socio-economic-environmental status of the community but also influence the policy decisions, monitor their effectiveness and facilitate community action (DEAT, 2001). In case of urban resource dynamics, SDIs guide the resource allocation and use pattern. Indicator development is an ever-evolving process. No set of indicators can be final or definitive. Indicators are adjusted over time to fit the specific conditions, priorities and capabilities (UNCSD, 1996).

Many important cities of the world like Seattle (US), Toronto (Canada), London (UK), Melbourne (Australia), Kitakyushu (Japan) have developed their own set of SDIs.

Regular tracking of these indicators helps these urban systems to monitor and evaluate the sustainability aspect of the present state and frame future strategies to ensure development with inter and intra–generational justice. China is a success story where publication of rankings of China's major cities on the basis of set of indicators has enhanced awareness to such an extent that the mayors have shown tremendous interest to take measures to increase environmental quality in their respective city so that it improves in ranking (Angel and Rock, 2001). SDIs are not limited to cities or local bodies. SDIs are developed at national level by many countries particularly the developed ones and by different international bodies like the UN, African Union and OECD. Some developing countries like Brazil, Mexico, Malaysia, and Colombia have initiated SDIs at different levels and are not far behind the developed world. Irrespective of this global popularity, 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.

Large-scale urbanization and growth of million plus cities is a global phenomenon of twenty-first century, more so in the developing world. The socio-economic and ecological footprint of mega-and million plus cities is far bigger than their actual territory. Cities take up less than 2% of the earth's surface yet use 75% of its resources (BMBF, 2004). This concentration of resources results in sustainability-risks in all dimensions: *economic*, *social* and *ecological*. India is not an exception to this global phenomenon. Motivated by this alarming situation and the dearth of studies in India, a research is being undertaken at Indira Gandhi Institute of Development and Research (IGIDR) to develop a set of SDIs to study resource dynamics of the city of Mumbai. Apart from the coincidence of its location, i.e. IGIDR is being in the same city, Mumbai has been chosen for the present research as it is the most populous city of India with migrants from all over the country making the place a

congregation of various communities and cultures. Moreover, it is the financial capital of India. Both poverty and wealth are in ample and extremities and so is the resource use pattern. This wider spectrum of socio-economic standards in people of Mumbai makes it an interesting case to study. This research will motivate researchers and civic authorities at different level to have similar initiatives for other cities, and regions of this country.

This paper has been written to disseminate the output of the initial steps in the pursuit of SDI development for the city of Mumbai to assess resource dynamics. The scope of the paper is limited to the stage of development of framework for indicators. The indicators themselves, their selection criteria and methodologies, and finally the development of report card for the city do not fall under the scope of this paper. So, the objective of this paper is to develop a framework for SDIs. The existing frameworks of indicator systems are reviewed with their pros and cons. In the process, several past indicator researches and frameworks adopted in each initiative are studied to understand their advantages, limitations, and applications. A modified version of systems framework is introduced with the paradigm of sustainable development. In the end, the major domains are identified for Mumbai urban system, and the complete skeleton for indicators is prepared with framework applied to each domain.

2. SDI Initiatives

The term ‘sustainable’ was first used in the context of people using resources, as overusing of resources cannot continue for a long term (Sustainable Seattle, 2004). Gradually, this concept had many more applications where there are limits to growth, like amount of garbage being produced or percentage of children born into poverty or number of cars on road – which when continued for ever, at a certain point, the system would simply break down. The term ‘sustainable development’ (SD) was used for the

first time by the International Union for the Conservation of Nature (IUCN) during World Conservation Strategy (IUCN, 1980) in defining equity in ecology. However, the SD concept became popular in 1987 by Brundtland Commission report, which introduced the inter-generation and intra-generation equity. SD is defined as the *development which meets the needs of the present without endangering the ability of future generation to meet their own needs* (WECD, 1987). Since then, SD became an integral consideration in policy making. For any system, to evaluate and monitor the progress towards SD a set of indicators were developed, known as SDIs. SDIs are resulted from dynamic iterative processes and dialogue among non-expert citizen participants, government bureaucrats and technical experts, and acted as a link between policy and science (IISD, 2005). Efforts were made worldwide to develop SDIs at global, national and local scale. India as a country has fallen behind in the domain of SDI research. A review of the Compendium of SDI Initiatives - possibly the most ambitious database to date to keep track of SDI efforts - showed 836 entries worldwide out of which are 250 metropolitan initiatives and 193 local or community-level initiatives (IISD, 2007). But, none of the Indian cities figures in the list.

As a part of literature review sixteen different indicator initiatives are studied the summary of which are given in Table 1 while the details of each initiative are presented in Appendix 1. The initiatives are chosen in such a way that it makes the pool as diverse as possible. Among those that are considered, one initiative is each from Africa and South America, two each from Asia and Australia, three each from Europe and North America and four are global initiatives. The scopes of indicators are not the same for all initiatives; in some cases they are local, whereas in other cases they are national. Here, *scope* is not to be confused with *coverage* of the program, as both may be different. For instance, the indicators developed under Urban Indicator Program in

China (Angel and Rock, 2001), EU Local Sustainability Initiative (Ambiente Italia, 2003) and Global Urban Indicator Program by UNCHS (2004), though local in scope, the coverage of the program is national, continental and global respectively. However, it is worth noting that with the scope of the initiatives varying, the essence of the approaches, frameworks and subject themes can potentially remain the same. This is precisely why, though the present research on indicators of Mumbai is city specific, approximately half of the indicator initiatives, considered in the literature review, are national in scope.

One of the major debates in indicator initiatives is between top-down vs. bottom-up approaches. Both the approaches have their own merits and share of criticism in indicator literature. Sustainable Seattle, which pioneered bottom-up approach, has been praised for the participatory element, but at the same time has also been criticized for having had minimal effect on policy (Levett, 1998). Similarly, strictly top-down approaches, are too weak to address local sustainability problems because of the dominance of professionala/bureaucrats. The review of past indicator initiatives shows that, with some exceptions, the national initiatives are top-down whereas local initiatives are bottom-up. The EU initiative (Ambiente Italia, 2003), though globally initiated, followed the bottom-up approach. Similarly, in case of UNCSD (1996) initiative, the consultative process with the member states was responsible for revision of framework and indicator list. Though, this kind of iterative approach makes the process lengthy, but the time spent is worth for its advantages. Multi–stakeholder approach, where the top-down and bottom-up approaches are combined involving all the stakeholders to get best results, has been demonstrated by South Africa (DEAT, 2001) Canada (NRTEE, 2003), and New Zealand (2002).

Table 1 Summary of Indicator Initiative studied

Initiative	Framework	Scope	Approach	Dimension (s) of Sustainability considered
Canada (NRTEE, 2003)	***Capital based***	Country	Multi stake holder	*social*, *economic* and *environmental*
OECD (2003)	***Causal*** framework (PSR) used in conjunction with *Sectoral* grouping	*(International)* Country	Top-down	Only *environmental*
WEF (2005)	***Causal*** framework (PSR with 2 additional components)	*(International)* Country	Top-down	Only *environmental*
South Africa (DEAT, 2001)	***Causal*** framework (DPSIR)	Country	Multi stake holder	Major focus on *environmental*
Kitakyushu (Dhakal, 2002)	***Causal*** framework (a modified version of PSR)	City	Top-down	Only *environment* dimension
UNCSD (1996)	***Thematic***	*(International)* Country	Top-down with strong feedback	*social*, *economic* and *environmental*
UK (1999, 2005)	***Objective or goal oriented***	Country	Top-down	*social*, *economic* and *environmental*
UNCHS (2002, 2004)	***Objective or goal oriented***	*(International)* City	Top-down	*social*, *economic* and *environmental*
EU Local Sustainability Indicator (Ambiente Italia, 2003)	***Thematic***	*(International)* City (Local authority)	Bottom-up	*social*, *economic* and *environmental*
UEQES (Angel and Rock, 2001)	***Target based***	City (cities of PRC)	Bottom-up	Only *environment* dimension
London QoL (LSDC, 2002)	***Objective or goal oriented***	City	Bottom-up	*social*, *economic* and *environmental*
Sustainable Seattle (2004)	***Issue based*** and sectoral classification	City	Bottom-up	*social*, *economic* and *environmental*
Winnipeg (1997)	***Issue based*** and thematic classification	City	Bottom-up	*social*, *economic* and *environmental*
New Zealand (2002)	Combination of ***Theme based*** and **capital model**	Country	Multi stake holder	*social*, *economic* and *environmental*
Argentina (UNDSD, 2005)	***Systems***	Country	Top-down	*social*, *economic* and *environmental*
Australia (1998)	***Systems*** (EUMM Model)	Country	Top-down	*social*, *economic* and *environmental*

Some of the other controversies surrounding indicator research identified are: context–specific *vs.* global common indicators, quantitative *vs*. qualitative indicators, and indicators measuring process *vs.* outcomes, aggregated index or indicator set (Dhakal, 2002). In fact, there exists horizontal link between these controversies, like; community-driven bottom-up initiatives usually follow context–specific approach and favor simple and qualitative indicators while top-down initiatives usually end up in common, complex, and quantitative indicators (McMullan, 1997). In the literature, it has also been argued that grass root participation in a higher–level indicator–making process can root out many of the aforementioned controversies (Dhakal, 2002).

A multi-stakeholder approach will be followed for future stage of the present study to take the advantage of both approaches. The different stakeholders envisaged to participate in the process include: civic authorities, academia and experts, media, and citizen and community groups. Further details of stakeholder participation mechanism are beyond the scope of this paper. Also for the present research, context–specific indicators are more suitable as it is a singleton study. For objectivity, quantitative indicators will be preferred. Unavoidable qualitative indicators can also be considered as there are tools available to quantify the qualitative indicators if the analysis demands so. A set of optimum number of indicators will be preferred over an aggregated index. Aggregation may hide serious deficits in some sectors which threatens the health of the system. More importantly, the methodology to aggregate indicators which cannot be measured in the same units is inherently questionable (IISD, 1999). Finally, the controversy between process indicators and outcome–based indicators does not arise in the present case as the proposed framework will handle the same.

3. Sustainable Frameworks

Frameworks are the logical structures over which the indicators are developed. They promote interpretation and integration and make the indicators understandable to non-experts. They help clarify and focus what to measure, what to expect from measurement and which derived data (indicators) to use (IISD, 2005). Without a framework, indicators always remain *ad hoc* and incomplete and biased of the specific expertise and research interest of the authors, overly dense in some areas, and sparse or even empty in other important areas (IISD, 1999).

Frameworks form one of the core-distinguishing factors between different indicator researches. The main differences among frameworks are the way in which they conceptualize the main dimensions of SD, the inter-linkages between these dimensions, the way they group the issues to be measured, and the concepts by which they justify the selection and aggregation of indicators (IISD, 2005). The following sections describe commonly used guiding frameworks for SDIs development.

3.1 Capital Accounting Framework

Capital accounting–based framework has its root in economics. It was developed before the development of the concept of SD. This framework is used in Environmental Accounting where the natural resources are accounted like financial resources. The linking of mainstream accounting with indicators, improves the objectivity, quality and comparability of the later. One of the recent developments in this area is the United Nation's System of Integrated Environment and Economic Accounting (SEEA) (IISD, 2005). SEEA aims to evaluate the change in the state of environment in monetary terms by using a hybrid- physical and monetary- accounting framework. In monetary indicators, the cost of the produced and natural capital consumption is deducted form conventional economic values to measure sustainable

economic activity and growth. Green GDP (environmentally adjusted net domestic product i.e. EDP) is such an example. The physical indicators present material flows and stocks. They can be linked to economic performance indicators like GDP by ratios like material intensity (material flow or stock per unit output) or resource productivity. ***Limitation:*** The Capital Accounting framework suffers from the fact that it is not always easy to quantify environment resources, particularly the qualitative ones. In addition, the philosophy of common monetary denomination of manufacturing goods and environmental resource, which makes the later replaceable by former, is inherently debatable. Also, social indicators are yet to be included in this environmental-economic accounting framework (Lundin, 2002).

3.2 Causal Framework

The causal framework introduces the concept of cause and effect relationships among diagnostic variables (i.e. indicators). Pressure-state-response (PSR) framework is such a conceptual approach widely used in SDI initiatives. 'Pressure' indicators represent human activities, processes, and patterns that impact on SD either positively or negatively. 'State' indicators provide a reading on the present state of affairs, while 'response' indicators represent societal actions aimed at pursuing SD. The PSR framework was developed and popularized by OECD (2003).

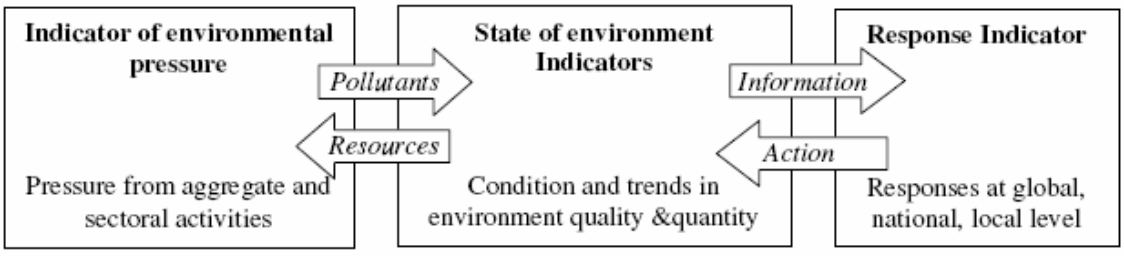

Fig 1 Pressure State Response (PSR) Framework

As shown in Fig 1, PSR framework groups indicators, related to human pressures on the environment, actual states of the environment, and the responses,

which may be undertaken to alleviate the damage. This also provides linkages among indicators through cause–effect relationships. One of the advantages of PSR framework is its attention to responses to environmental problems which are often neglected in the area in indicator studies (Australia, 1998). This model has been widely used, both locally and internationally. A modified version of PSR is used in Environment Sustainability Index (ESI), developed by the World Economic Forum (WEF) where apart from PSR two additional components were added, human vulnerability and global stewardship (WEF, 2005).

Driving force-pressure-state-impact-response (DPSIR) framework, which is an extended version of PSR framework, has been adopted by the European Environmental Agency (EEA) and the European Statistical Office (Eurostat, 1997). Driving forces are the underline causes of pressure where as impacts are the effect of the observed changes in the state of the environment.

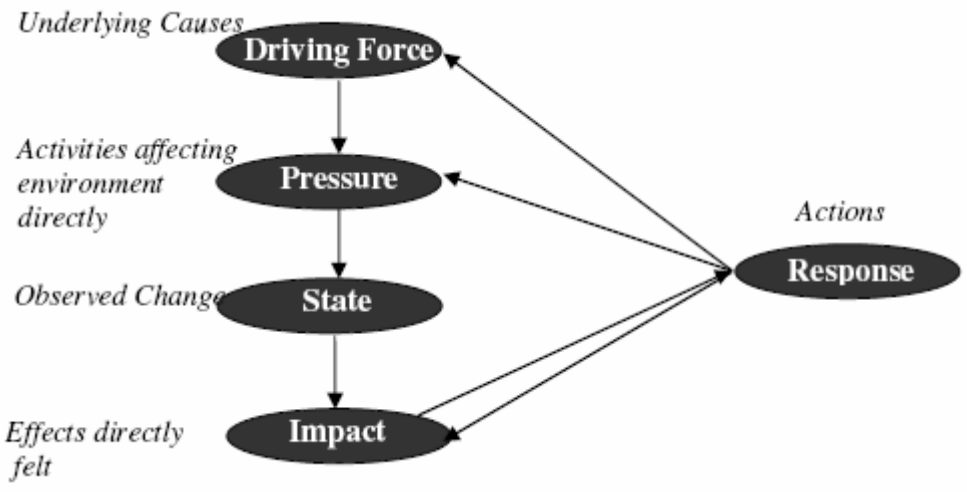

Fig 2 Driving Force-Pressure-State-Impact-Response (DPSIR) Framework

Like PSR, DPSIR framework has also been used in variety of its forms by omitting one or more components or adding components to the original. Kitakyushu initiative is one such example where the driving force has been omitted and vulnerability component has been added (Dhakal, 2002).

Limitation: There are two major limitations in the underlying foundation on which the causal framework is based. Firstly, it is difficult to categorize an indicator as a pressure or a state or a response, because the focus of the viewer may change depending on the underlying objective. 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. Similarly, CO_2 emission is a pressure to the environment, CO_2 concentration is a state, global temperature increase attributed to CO_2 emissions is an impact, whereas carbon tax imposed on the basis of CO_2 emissions is a response. Secondly, the implied cycle of cause and effect is simplistic, which neglects the systemic and dynamic nature of processes. In reality, the pressure, state and impact mechanisms are complex and can not be isolated into single cause and effect. There can be relationships between causes themselves and effects themselves. Such multi–chain linkages with non-linear relationship between components cannot be accounted for in PSR framework or its variations. Moreover, the causal model deals only with human responses and is silent about ecological ones. For instance, under a PSIR model, CO_2-emissions would not account for the facts that CO_2 concentration is only partially caused by human emissions, that global temperature is only partially determined by CO_2emissions, that a carbon tax may be introduced for other reasons, and that this tax has many other (economic and social) repercussions besides affecting CO_2 emissions (IISD, 1999).

The limitations of PSR framework are experienced in the Indicators of Sustainable Development (ISD) program by the United Nations Commission on Sustainable Development (UNCSD). Initially, indicators were structured according to DSR model. But after the testing of these indicators in several countries the framework

was abandoned as it was found to be inappropriate for economic and social indicators and it lacked focus on policy (UNCSD, 1996). The unsuitability of PSR for economic and social dimension of SD is evident from the fact that all the four SDI initiatives following PSR framework considers only environmental dimension of SD.

3.3 Issue-based, goal-oriented or thematic framework

In this framework the indicators are distinguished on the basis of different themes and issues. These frameworks usually emerge as a consequence of particular concerns at local, national and global levels (Australia, 1998). The indicators developed on this framework are goal-driven and have direct link to policy. The philosophy is *no policies without indicator and no indicator without policy* (Newton, 2001). This framework, together with the PSR, dominates the indicator literature.

UNCSD has adopted a thematic framework. The program was inspired from Agenda 21 and the chapters of this document were divided into themes and sub–themes and they are grouped into four primary dimensions of SD—social, economic, environmental, and institutional (UNCSD, 1996). The Energy Indicator for Sustainable Development (EISD), by International Atomic Energy Agency (IAEA) follows the same conceptual framework as developed by UNCSD (IAEA, 2005). The examples of goal-oriented thematic framework are many. The London quality of life indicators are based on fourteen objectives related to four themes of SD; taking responsibility, developing respect, managing resources, and getting results (LSDC, 2005). Similarly, the Canadian initiative for the city of Winnipeg quality of life indicator, which follows closely the policy document plan Winnipeg, classifies indicators into five distinct categories; individual wellbeing, urban economy, urban environment; community assets, and community leadership pride and further sub–categories and couple of issues

for each sub category (Winnipeg, 1997). Then indicators are then identified from the issues.

One of the recent and most influential goal-oriented SDI initiatives is the Millennium Development Goal Indicators (MDGIs). MDGIs follows an eight-pillar model and and are based on the specific targets listed under each MDG (UNSD, 2005). Urban metaphors are also immerged as kind of goal-based framework where an abstract representation of complex phenomena designed to deliver a message with maximum impact for a set of targeted audience (Newton, 2001). Healthy cities core indicator project of World Health Organization (WHO) is one such instance where a set of core indicators have been developed to carry out the inter-city comparison on progress toward a healthy city (WHO, 1997). Other examples of metaphors are, Livable City, Ecological City, Safe City, etc.

***Limitation*:** Idea of linking indicators to goals and targets enables their use in tracking performance and helps link them to policy priorities. But some of the goal-oriented frameworks are too specific and pay no attention to the multi dimensional holistic nature of SD except as already accepted within the policy process. Hence they are neither complete nor consistent (IISD, 1999).

3.4 Systems Framework

System framework has been developed by Newman *et al.* (1996). It is based on extended urban metabolism model (EUMM).

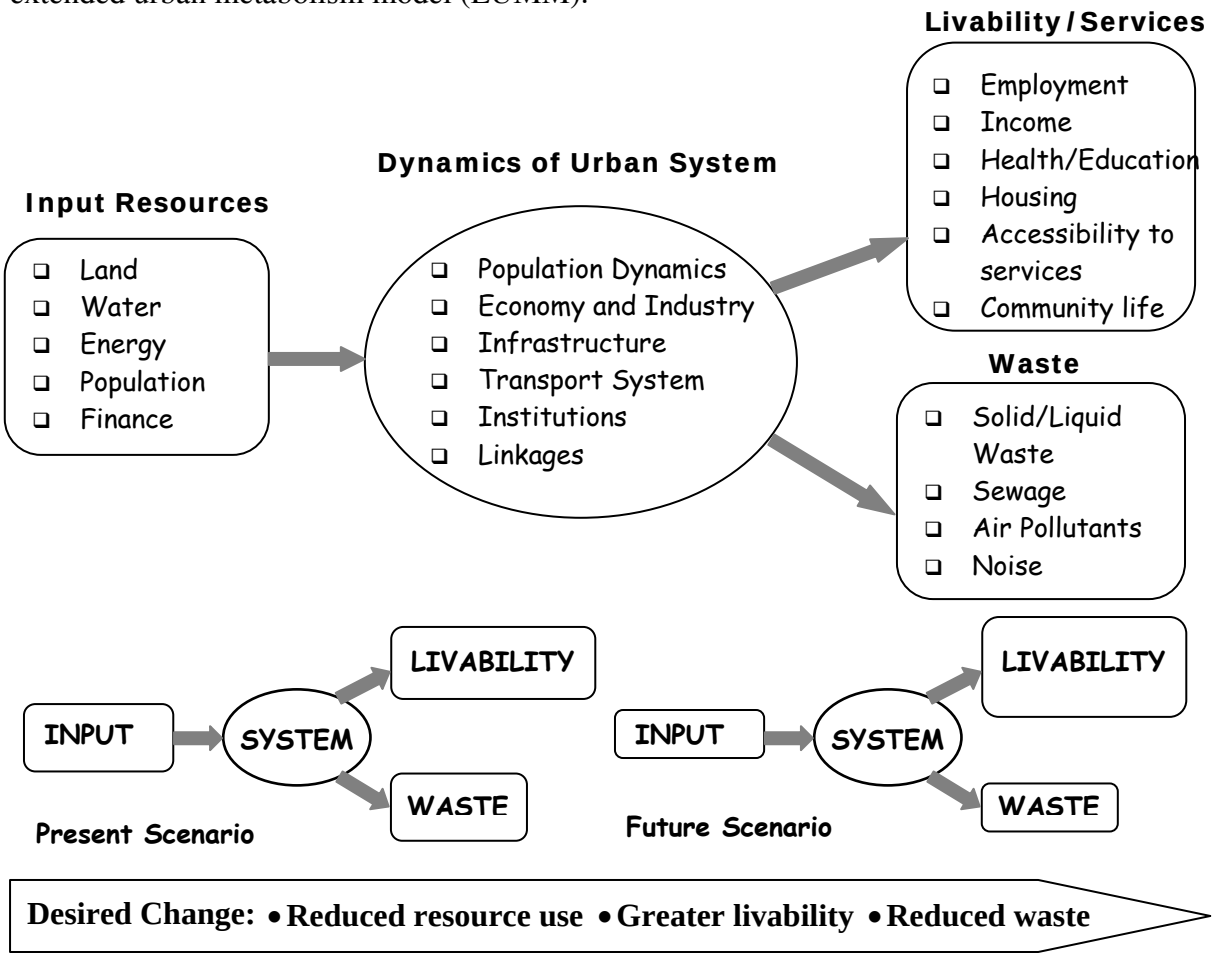

Fig 3 Extended Urban Metabolism Model (EUMM)

EUMM views cities as systems which require inputs of key resources which are drawn into the urban processes and transform them into desirable livability outputs and waste. 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). Irrespective of its advantages over other frameworks, system framework is not much in the use like causal

and thematic ones. Australian Environmental indicators in human settlements is the sole literature in indicator research found using EUMM model (Australia, 1998).

3.5 Sectoral or domain framework

This is not a framework by itself but is used mostly in conjunction with other frameworks. Indicators structured under capital accounting, or causal or thematic or system framework can be grouped into different domains or sectors before finally listed. Under sectors, transport, domestic, commercial and industry are considered; which mostly corresponds to the departments of civic bodies. In case of domain, the division is like land, water, energy etc, which are specific disciplinary areas or areas of expertise.

Sustainable Seattle program followed a sectoral approach where citizens from ten different sectors of society such as education, transportation, health, culture and recreation, population, and community participation contributed to the process of developing SDIs (Sustainable Seattle, 2004) whereas, in Australian model (Australia, 1998) indicators are classified into domains: energy, water, urban design, transport and accessibility, population, housing, indoor air, health, noise and waste. South Africa is another example where domain-based classification is used over DPSIR framework (South Africa, 2004).

4. A modified Systems Framework – *Black Box Framework*

A black box framework (Fig 4) has been adopted for the present analysis which is similar to system framework with some modifications. In this framework no attention is paid to the inside of the system which behaves as black box, and focus is only on the boundary. Boundary signifies observable parameters. This approach is in line with property of indicator. For example health of a human body is tested through indicators like temperature and blood pressure without going into the complexities of what

happens inside the body. Similarly, this framework is silent about the hidden complexities of urban system, hence the name, black box.

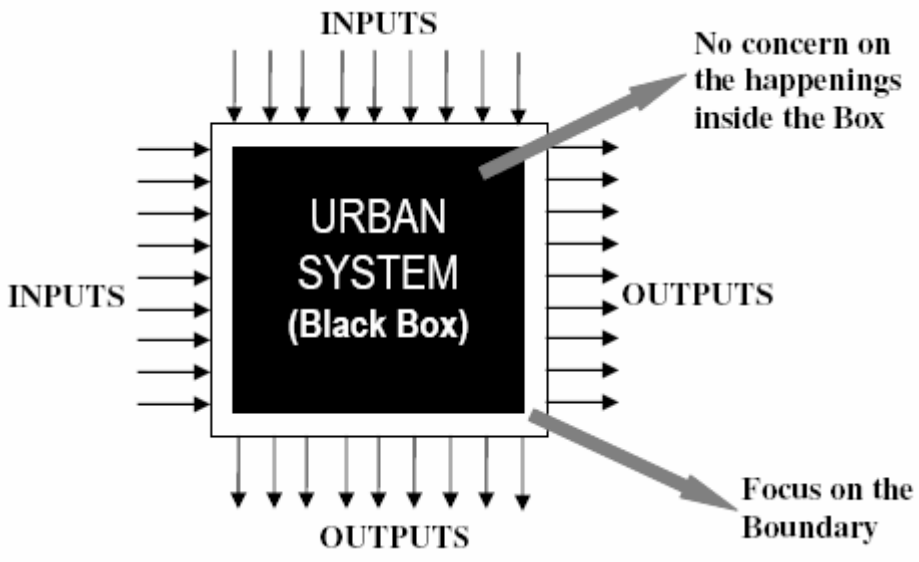

Fig 4 Black box Model

In the debate between process-based and outcome-based indicators, black box framework clearly is tuned for later[2]. The outcome parameters that are observed depend on the view that is adopted to examine the black box. For instance, an efficiency point of view would consider the productive output per unit input of resources; where as a viewpoint of equity would consider parameter specifying distribution of outputted benefits. Hence, views, which are the intensions behind observations, are critical as they can potentially expose or hide any outcome.

4.1 Sustainable Development Paradigm

Any system, taking input and producing output, to act more efficiently the desired output to input ratio of a system must increase and/or undesired output to input ratio must decrease. The urban system constitutes of sub systems and each sub system

[2] But that does not mean processes are totally out question here. The processes which can be parameterized and can be visualized as outcome under a certain viewpoint can be handled in this framework. This concept can be termed as 'productization of process'. This is similar to the concept of quantification of quality where industries and corporate houses sell their processes by having an ISO or

can be further disintegrated into some economic activities which transform the raw input to desired services or products and in the process wastes get generated. For example, in a domestic energy sub system where activities like cooking, water hating, lighting, air conditioning convert fuels like firewood, LPG, and kerosene and electricity into the desired services and waste is generated in the form of pollution at different levels. For an efficient urban system, these economic activities need to be efficient. This desirable characteristic of urban system can be termed as 'economic-efficiency'.

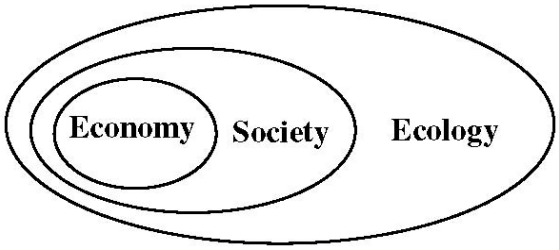

Fig 5 Sustainability Paradigm

An efficient urban system need not be sustainable. All the economic activities of urban system are parts of a larger social system, and the society, is in turn inside a larger ecological sphere (Figure 5). Economic activities, depending upon their dynamics, have positive or negative impacts on society and ecology. In fact, the social issues like inequality and environmental issues like increase in air pollutants are the side-effects of some mainstream economic activities as nobody *per se* take wealth from poor and give the same to rich or pour buckets of pollutants into the atmosphere. So, under this paradigm, an *economic-efficient* urban system is sustainable only when the activities in economic sphere result in *social-wellbeing* and have *ecological-acceptability*.

So, urban sustainability has three components, *economic-efficiency* (EE), *social-wellbeing* (SW) and *ecological-acceptability* (EA). Accordingly, the

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CMM level certification. If the process is desirable it is considered as positive outcome (livability); if undesirable considered as negative (waste).

performance of the urban system would be gauged based on EE, SW, and EA indicators.

Figure 6 shows the application of above sustainable paradigm to Black Box Framework. Three simultaneous views are given to the same system to have complete understanding. This is similar to the concept of, front-view, side-view and top-view of any component in engineering drawing to have the complete view. Different outcomes are observable in different views. For instance, for domestic energy subsystem, EE-view will capture the efficiency of technologies and practices, SW-view will capture the accessibility and affordability across income groups, whereas the pollutants are considered in EA-view. The processes which are missed in one view can get captured in other view(s). Inequity and ecological liability, which are missed in EE-view, will be captured in SW-view and EA-view respectively. So, the throughput, the social impacts and environmental effects of the system are examined respectively from EE-view, SW-view and EA-view. The desirable outcome under EE, SW and EA views indicate increases in livability; and undesirables are considered as waste.

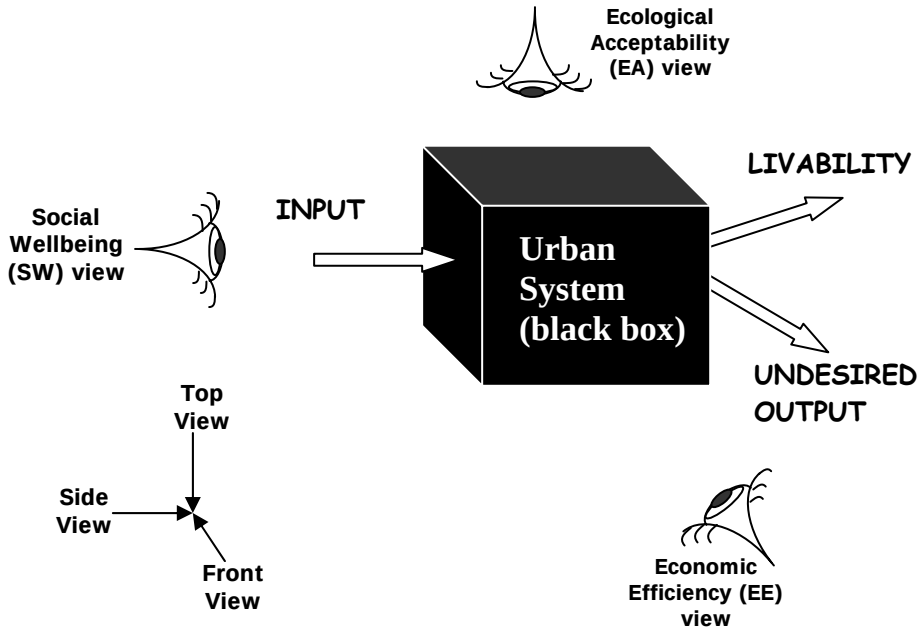

Fig 6 Sustainable paradigm applied to Black box framework

5. Identification of Domains

The objective of the research is to develop scientifically credible set of indicators on urban resource dynamics. For this, *domain*-based classification becomes appropriate as this ensures experts involvement which leads to development of credible indicators with the required scientific or disciplinary backing.

Domain identification closely follows the Australian model with the difference in approach that the Australian model is designed for human settlements, whereas the present focus is on resources. The nine domains identified are based on natural resources: energy, water, land and atmosphere which support the urban system, human resource: populace; and capital resource: finance; both labour and capital are required to transform the natural resources to desirable services/outputs; built in resources: housing and finance and waste, it is also a resource when recycled. Technology, and institutions though important resources to the urban system are not considered as separate domains, as the same would be implicitly considered under each resource. For flexibility, a tenth domain miscellaneous is kept to capture something which fails to get classified under the domains mentioned above.

5.1 Energy

Energy is central to social and economic well-being, and is indispensable in achieving human progress. It is a key element for poverty reduction, improving human health and raising living standards. However, there are large disparities in the level of energy consumption, not only among different regions (urban and rural), but also among various sections of the society in the same region. Urban regions enjoying wealth and consumption have become massive fossil fuel users thereby providing a dangerous greenhouse gas emissions surplus. There is no issue of accessibility, but

there are question marks on affordability and long term availability. Thus the provision of adequate energy services at affordable prices, in an environmentally benign manner, and in conformity with social and economic developmental needs, is an essential element of SD.

Energy is not an end in itself, but only a means to an end. Energy, whatever may be the form, coal, solar, nuclear, or biomass is not good or bad in itself, as far as it can deliver this end. At present, much of the energy in transformation, from source to end use, goes as waste. Along the energy chain - from resource extraction to the provision of energy services - pollutants are produced, emitted or disposed of, often with severe health and environmental impacts. Even if a technology does not emit harmful substances at the point of use, emissions and wastes may be associated with its manufacture or other parts of its life cycle. Hence it is important to use energy efficiently with appropriate fuel choice to avoid crisis in future. This can be done by substituting efficient technologies for inefficient ones and renewable energy in place of non-renewable resources.

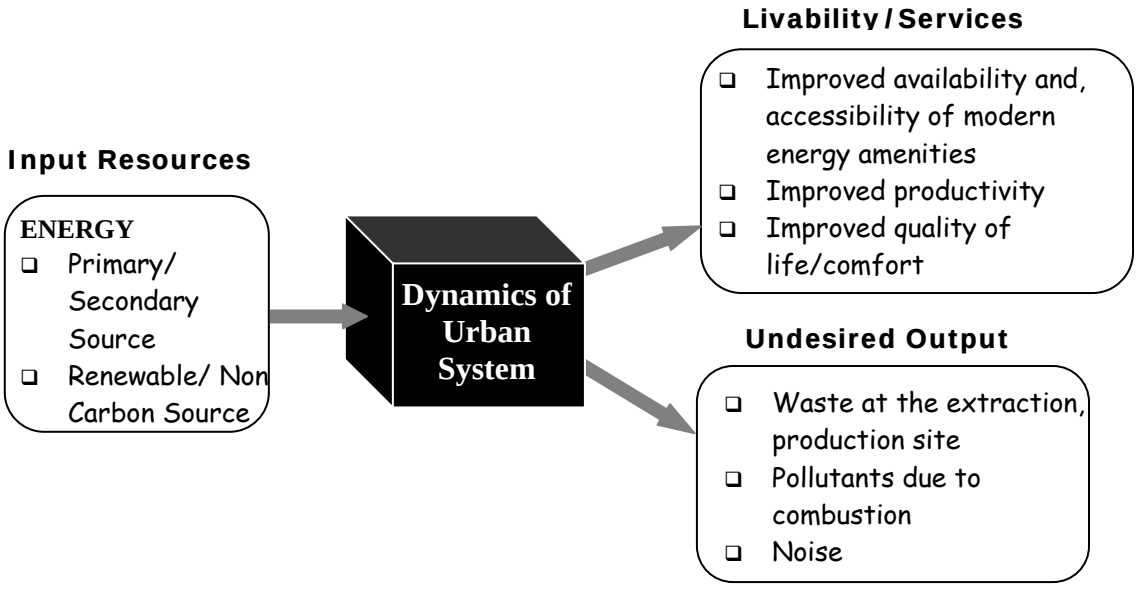

Fig 7 Domain model for energy

Fig 7 illustrates MVBB applied to energy domain. The EE-view of the urban energy system would signify the efficiency at all stages -transformation, transmission and distribution, and conversion of final useful energy to services. Efficiency of all major sub systems for all sectors in urban system will be analyzed. The SW-view would take inequality in distribution, consumption (i.e. energy usage pattern), and affordability i.e. cost of energy into consideration. From EA-viewpoint, availability, the renewable and non-carbon sources and energy pollutants would be parameterized.

5.2 Water

Water is one of the basic resources for urban system as it is essential for the very existence of human, plant and animal life. Water is used for various purposes in domestic, industry and recreational and aesthetics services. As water is a common factor that cuts across all sectors of development, development is not possible without water. Because of the strong linkage water with development, monitoring the sustainability of water resources can effectively provide an indication of SD in the region. The main functions of an urban water system are to produce and deliver affordable drinking water and to manage and treat wastewater. These are vital functions in any society, hence securing them for current and future generations should be an important part of SD. All households need to be connected with piped water and sewerage system without losses and pilferage. The storage of water in the household and round the clock availability of water through taps represents higher quality of life. Another aspect of urban water systems that make it interesting from a sustainability point of view is water quality. Drinking water increasingly fails to meet standards due to pollution, poor operation of treatment facilities, lack of disinfection and the poor condition of supply systems and sewerage systems. Supplying safe drinking water is therefore an important issue for SD which requires explicit emphasis on quality. The

problems are complicated by the inability to ensure maintenance and investment in the existing systems. Also, there is equity issue where a section of society does not get water for basic usage, where as another section make wasteful usage of water in bathtub and gardening. Apart from households, water being an essential input to agriculture, industry and commercial purposes like aesthetics and recreation, the efficiency, equity and sustainability aspects would be studied.

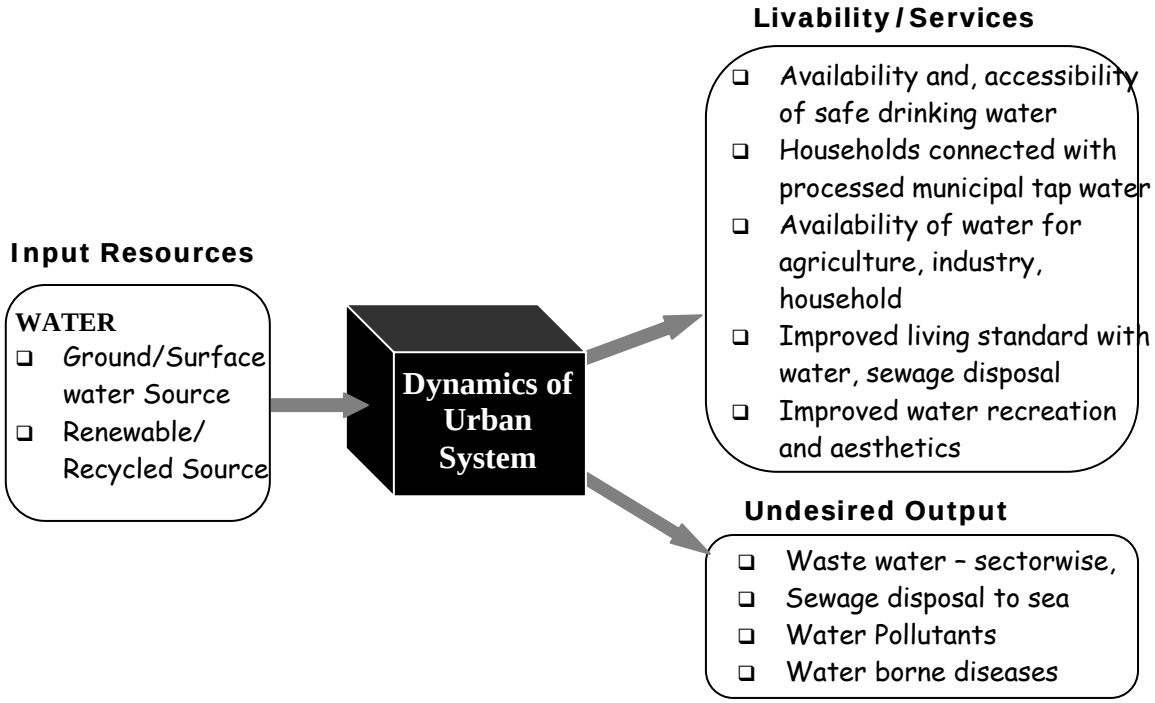

Fig 8 Domain model for water

Fig 8 illustrates MVBB applied to water domain. Efficiency of the distribution system, sewage disposal and recycling of wastewater will be taken into consideration in the EE-view. The SW-view would deal with affordability, inequality in distribution and consumption pattern and hygiene. From the EA-viewpoint, water pollution, long term water availability would be checked to assess environmental compatibility.

5.3 Land

Urban land use is mainly to satisfy residential, commercial and industrial requirements and also to improve public facilities, which in turn enhance quality of life.

The land usage pattern in urban regions changes due to the interaction of demographic, political, economic, societal, environmental, and cultural reasons. However, this change usually makes a direct and serious impact to the natural environment. Land, being a limited resource, needs to be utilized in a sustainable manner. There is a tremendous land pressure as most of the land is possessed by handful of wealthy people. The concrete surfaces are on the rise, and the dissipation spaces like wetlands, and mangrove lands are on the decline leading to rain-fed floods. More of soil erosion, deserted and contaminated land is considered inefficient utilization of urban land system. Sustainable land use requires strategies which optimize economic development, enhance social welfare and minimize the environmental impacts of human activity. Such strategies include improved integration of land use and transport planning, redevelopment of slums and industrial sites and the regeneration of waste lands.

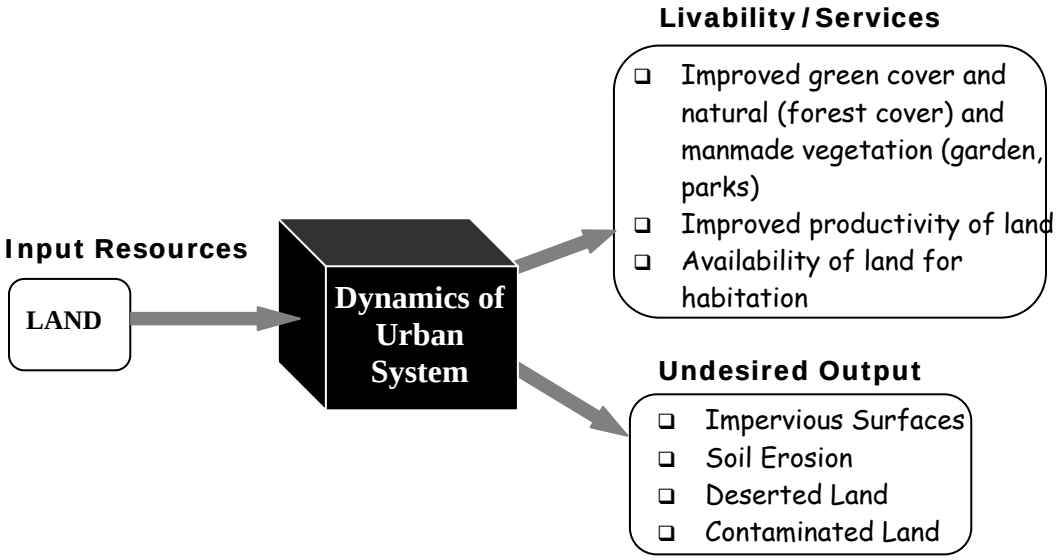

Fig 9 Domain model for land

Fig 9 illustrates MVBB applied to land domain. The EE-viewpoint, will look into how efficiently land is being utilized while the SW-view would show the land distribution and affordability. From EA-viewpoint the availability, the forest and vegetation cover, soil pollution would be parameterized.

5.4 Air

The quality of air directly affects the socio-economic condition of a society. As a result of the rapid economic growth in India over the past two decades, commercial and industrial activity is increasing resulting in significant air pollution. There is a relation between air pollution and sickness rate. The increasing number of vehicle remains the main cause of the deterioration of air quality in urban regions causing respiratory diseases. The impact of air pollution on the market value of real estate is significant. The indoor air pollution at workplace (factories) also needs to be parameterized.

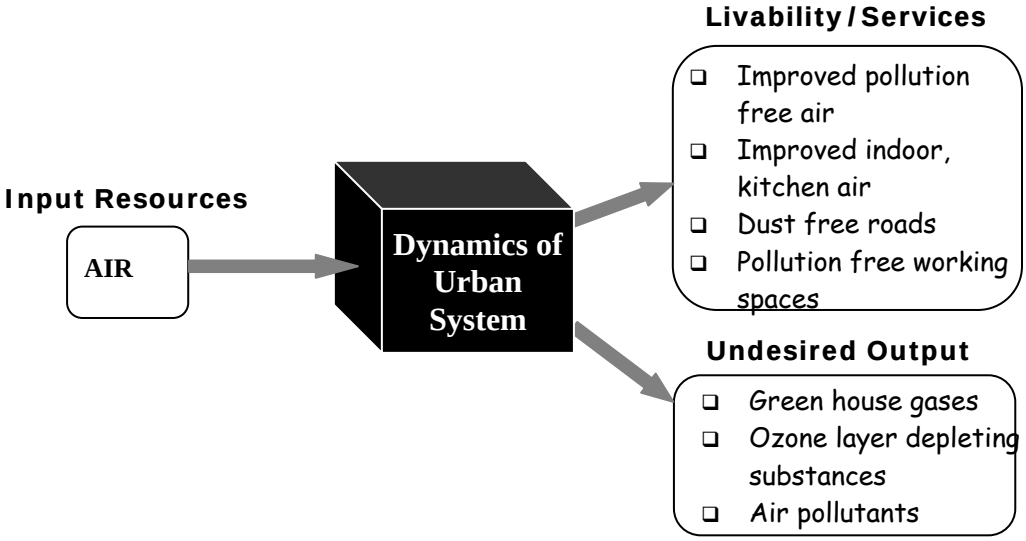

Fig 10 Domain model for air

Fig 10 illustrates MVBB applied to air domain. Under this both outdoor and indoor air quality would be considered. Here the model assumes that the city-dynamics makes the air polluted and hence has the responsibility to maintain clean air. The cleaner the air the more efficient is the system in EE-dimension. The SW-viewpoint looks into the social effects of air pollution. The quantum of green house gases, ozone layer depleting substances, and other pollutants would indicate the EA dimension.

5.5 Population

In the early 1990s, approximately half of the countries of the world, mostly developing ones, considered the patterns of population distribution in their regions to be unsatisfactory and wished to modify them. A key issue was the rapid growth of urban areas, which started housing more than half of the world population since mid 2007. The process of urbanization is an intrinsic dimension of economic and social development and, in consequence, developing countries are going through the process of shifting from predominantly rural to predominantly urban societies. Cities are centres of economic growth and hence migration from rural to urban regions takes place which has economic, social and environmental implications - both positive and negative - for the places of origin and destination.

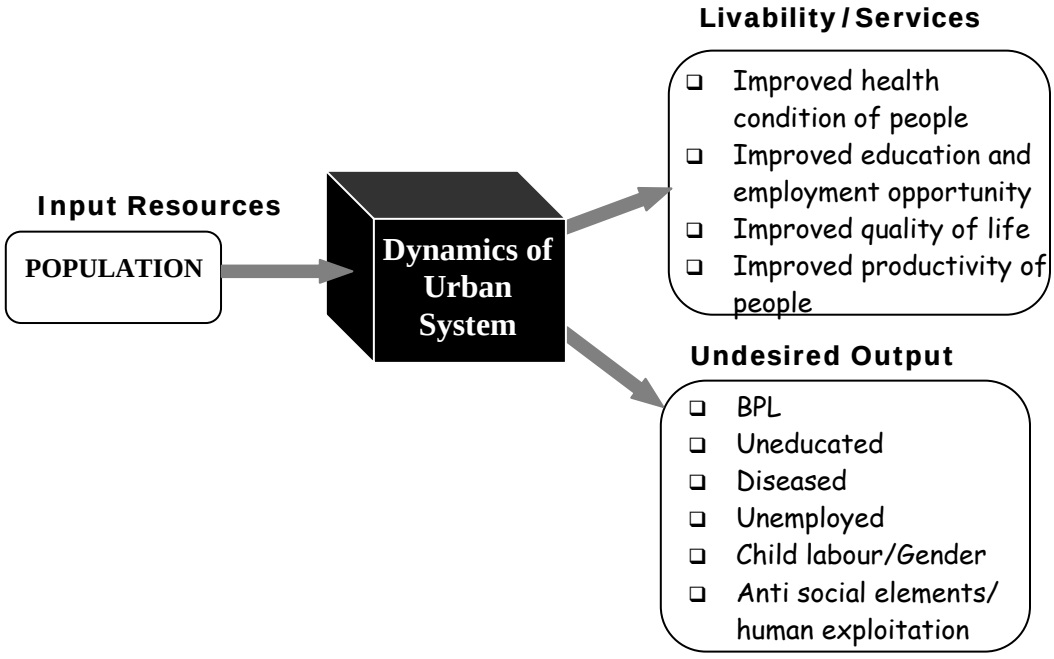

Fig 11 Domain model for population

Fig 11 illustrates MVBB applied to population domain. The huge urban populations become assets for the city when productive. This domain accounts for the health, education and employment opportunities in the system. From EE-view point, educated employed and healthy people are desirable output of the system; where as the unemployed, uneducated, diseased people are undesirable. Crimes, gender, child labor

and quality of community life are considered in SW-view. The EA-viewpoint will look into growth rate, density.

5.6 Financial Resource

The gigantic increase in urban population in recent decades has brought heavy pressure on urban services, housing and infrastructure. Traditionally, the management of urban areas has been primary responsibility of local governments. However, many local governments have been facing scarcity of financial resources for providing basic services such as infrastructure, water, sanitation and health. As a consequence living conditions of majority of urbanites have been deteriorating and instances of poor urban services and inadequate urban infrastructure have become common features.

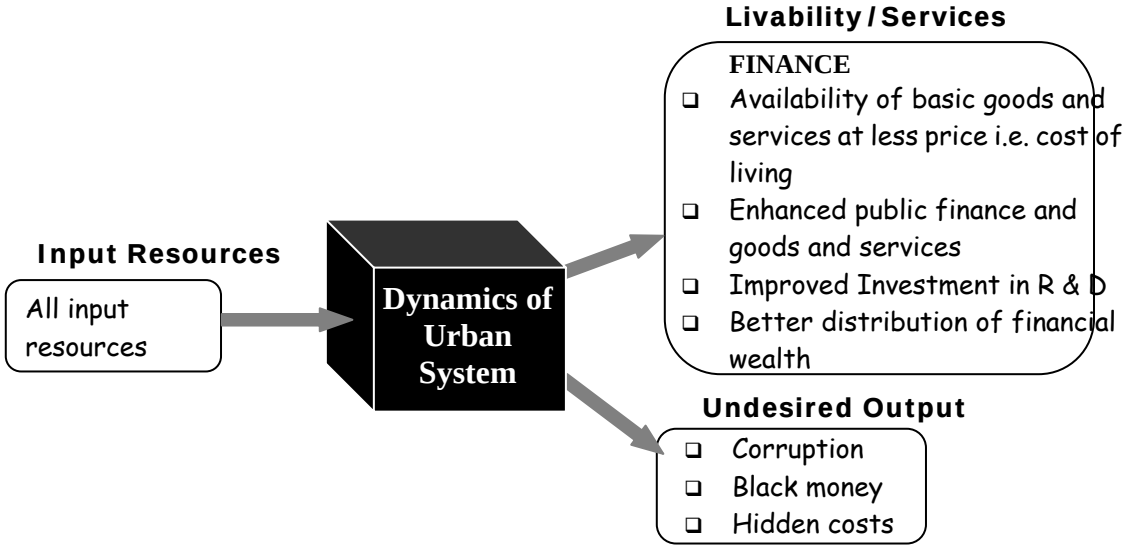

Fig 12 Domain model for finance

Fig 12 illustrates MVBB applied to finance domain. Under this model, the city's economy would be gauged from EE and SW point of view. A high GDP of the city and per capita income of the people may indicate highly efficient economy, but parameters like distribution of income, corruption, black money, cost of living would bring in the social perspective. The domain has a very high significance as Mumbai is the financial capital of India.

5.7 Housing

Housing, one of the basic-necessities of life, is an important part of economy as a major component of personal capital investment goes into housing. Indian cities, like their counterparts in other developing countries have been struggling through a housing crisis with high property prices at one end and a significant migrant slum population at another. The tremendous influx of people to cities on account of rural urban migration often undermines the local government's best efforts to provide adequate services to the inhabitants of the city. The unplanned growth of the city leads to decline of open space.

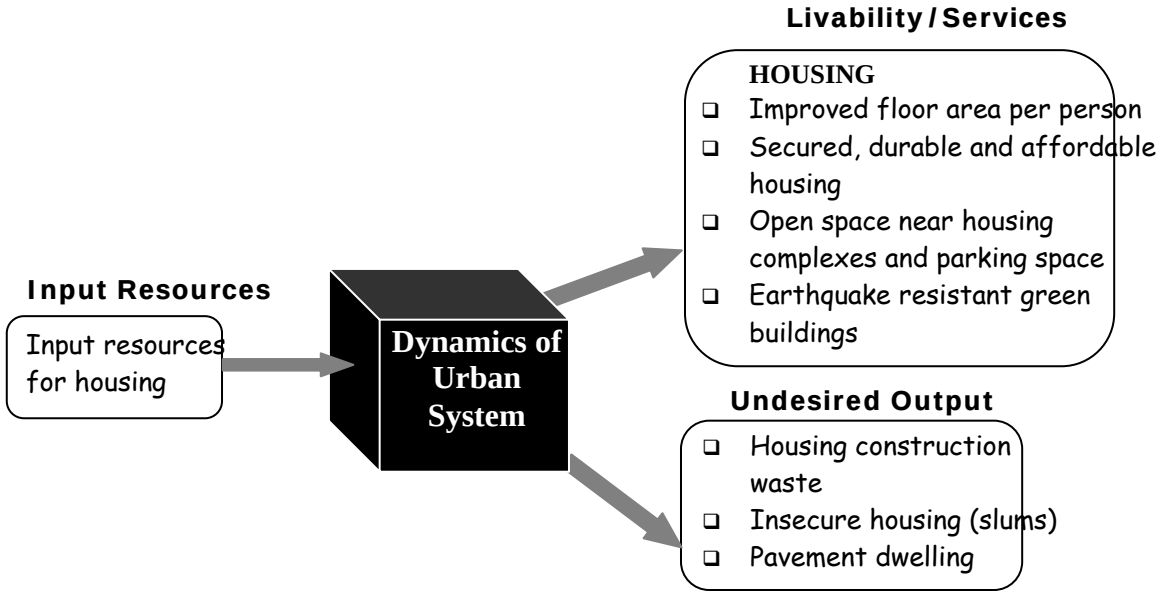

Fig 13 Domain model for housing

Fig 13 illustrates MVBB applied to housing domain. The EE-viewpoint of the system judges how efficient the system is in providing adequate and appropriate housing for the city-dwellers. Appropriate housing means secured housing with basic amenities and open space. SW-view considers the affordability aspect. High rise building, green building, and construction waste are parameterized under EA.

5.8 Infrastructure

The rail, road, air and telecom keep the urban system connected, and hence lively. There is a linkage between economic development and infrastructure

investment resulting in increased regional and national output, employment growth, and firms' performance. This may imply more than generic calls for increased investments across broad categories of public capital; infrastructure research and planning need to be differentiated by type (e.g., water vs. sanitation, public vs. private transport, industrial vs. residential and so forth). The evidence thus far suggests that urban infrastructure issues be completely incorporated into comprehensive economic development planning at all levels of government.

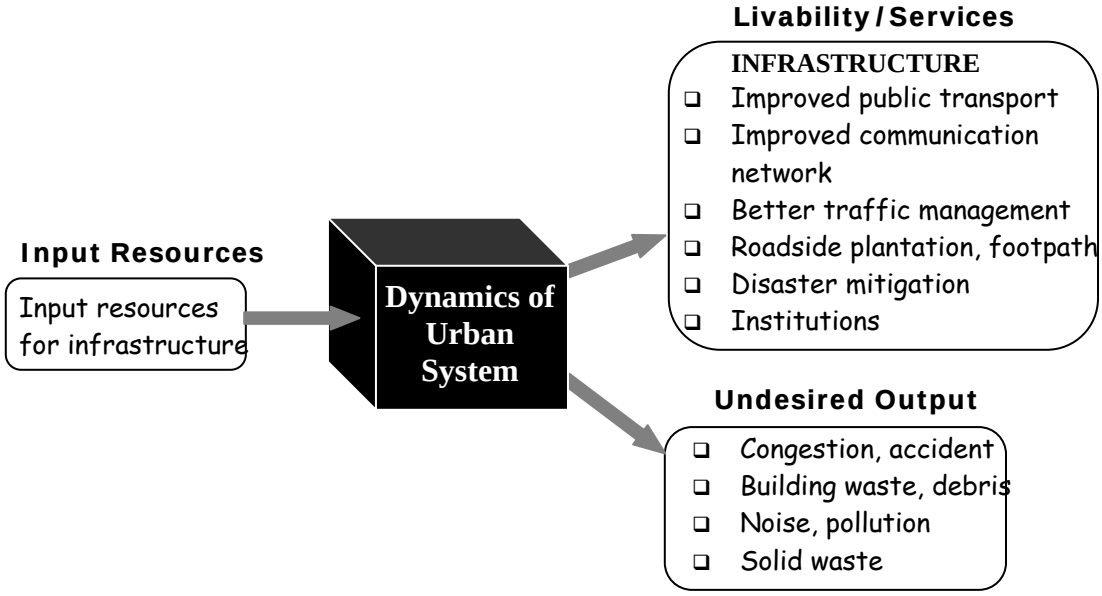

Fig 14 Domain model for infrastructure

Fig 14 illustrates MVBB applied to infrastructure domain. The EE-view of the urban infrastructure system deals with the quantity and quality of the infrastructure. The issues of accessibility, social cost of congestion, access by disabled would be considered from SW point of view. From EA-viewpoint noise, pollution and impacts on flora and fauna would be evaluated.

5.9 Waste

Waste is the undesirable output any system produces. But it is considered undesirable in the form and location where it is produced. Waste in the previous domains has been used differently as waste production must be minimized, but here it

has been used in the context of, once produced, it needs to be processed for better use. In countries like India it is a key source of livelihood and social capital, particularly for the urban poor like waste and rag pickers. Piles of waste left uncollected in the streets, blocking drainage channels or dumped in watercourses, are a major cause of public health risk, and uncontrolled disposal of waste can threaten water resources and place significant environmental health risks on those living nearby. Cities are now facing complex wastes like hospital waste, computer waste which are difficult to process. Occupational health and safety risk to solid waste workers and is also a major concern. However, when recycled to a different form or location it may turn to be useful. Waste management is one of the most visible of urban services. Effective and sustainable waste management goes hand-in-hand with good local governance and sound municipal management. Waste management is critical to the protection of public heath, safety and the environment. The recycling of waste to develop useful products indicates the city's concern for resources. Also energy can be generated from waste. Waste is inevitable in any process, but they can be minimized by reduce-recycle-reuse dictum so that waste is generated at a rate which earth can carry and assimilate.

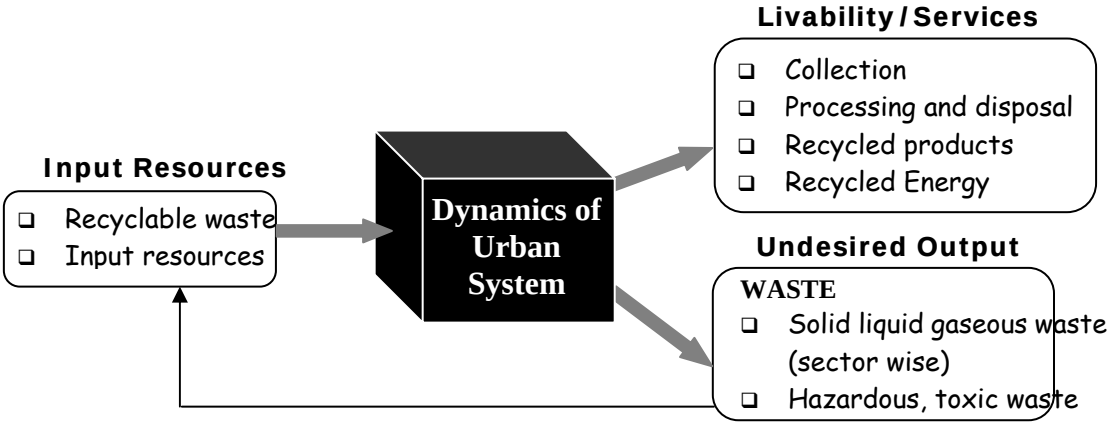

Fig 15 Domain model for waste

Fig 15 illustrates MVBB applied to infrastructure domain. A part of the waste produced the system goes as an input resource. The EE-viewpoint would look into the

efficiency of garbage collection, processing, recycling and disposal where as the SW-view takes into account the social impact of waste. Generation of waste, non-biodegradable, hazardous and toxic, is taken into consideration in EA-view.

6 Characteristics of *domain-based* multi-view black box (MVBB) framework

Domain-based multi-view black box framework (MVBB) has been constructed by eliminating the system component from the system model (EUMM) and introducing three-dimensional views of economic efficiency (EE), social wellbeing (SW), and ecological acceptability (EA) and adopting a domain based classification. This framework is *simple* as it attempts to characterize the system by focusing at only at the boundary and all the aspects of the system are addressed without peeping into the complex inside of urban system. The complexities or subjectivities of causal analysis of PSR model are out of question here. Moreover this framework is *flexible* as it is not limited to certain goals and objectives, and has a holistic agenda. By using a black box (where focus is on outcomes, and processes are productized) and different views on it (views are intentions behind the observations and are motivated by the sustainable paradigm in question) there is a direct *link* between the objectives and the system outputs, hence indicators. Moreover, the use of domain-based classification, gives a *stepwise* approach to develop indicators. Indicator development can start with energy domain, and then move to water, so on and so forth. It is worth noting that domains are not also fixed and can be adjusted as new ideas and understandings are developed. The characteristics of the framework are in accordance with Bellagio principle- Guidelines for Practical Assessment of Progress toward Sustainable Development- which calls for a framework to act as a linkage between vision and goals and indicators and is adjustable as new insights are gained.

7 Future directions

Once the concept is developed, the next step is to select a final set of indicators from a potential list of proto indicators. For indicators to be relevant, scientific and useful it must satisfy a set of criteria. The criteria set will be developed to assist with selection process will be based on discussion with experts, government agencies and other stakeholders. The stakeholders also participate in actual selection of the indicators. Transparency built through multi stakeholder participation is of crucial importance in indicator research as finally the indices are to be used to inform public policy decisions. However, the framework for criteria and tool to evaluate indicators are dealt in a companion paper(s) where each criterion will be assigned a measurement and integrated into a model to determine a core set of indicators for inclusion in the three dimensions for all domains. An illustrative example of indicators is given for the energy domain in the following Table.

Table 2 Sustainability Indicators

Economic Efficiency	Social Wellbeing	Ecological Acceptability
• Energy use per capita • Energy use per unit of GDP • Energy Intensity of different Sectors • Efficiency of energy conversion and distribution • Efficiency of energy device/technology	• Share of household or population without electricity or commercial energy and heavily dependent on non commercial energy • Energy affordability (energy prices versus income) of various income groups • Energy use pattern for each income group (basic use or luxurious use) and fuel mix • Accident fatalities or short tem and long term effect on health	• Proven Reserves-to production ratio • Resources-to production ratio • Renewable share in total production • Non-carbon fuel share in total production • Energy dependency • GHG Emissions per unit use of energy • Pollutants (air, water and soil) from energy systems • Non bio degradable Hazardous, pollutants share from energy systems

Urban regions in India, like in many other countries, collect a variety of data and compile them in some regularly maintained format. While looking at individual data types for trends over time is useful and instructive in gauging the current state of affairs, such analysis is usually done independently of an overarching, long-term strategic goal like that incorporated in the tenet of sustainability. Moreover, characterizing such data along three different dimensions of sustainability can further help inform policy makers and the public about the state and progress of sustainability issues. The most promising aspect of the domain-based framework is that it provides the ability to evaluate the performance of each domain of resource relative to others; hence the attention of the authorities can be proportioned accordingly. As various pieces of a whole system, the domain indices represent rough approximations of the overall performance of the complex idea that is the state of urban system. Based on the selected indicators, the indices show the performance, in terms of sustainability, over time. The simple structure of the indices is also convenient for communicating with policy makers who have multiple demands on their time. The only drawback here is that the framework does not adequately address the complexities of the interconnections between each domain and the benchmarking of individual indicators included in each domain is a challenge. A more prescriptive model that seeks to illuminate the linkages between phenomena represented by the indicators could become a more useful instrument in terms of crafting policy for sustainable development. This is left for future explorations.

8. Conclusion

The present paper is the starting point of indicator research, where the need is to establish a framework for development of SDIs. After reviewing the strengths and

weaknesses of the existing sustainable frameworks, a black box framework has been introduced by eliminating the system dynamics component from conventional EUMM model and focusing only on the boundary. To incorporate the sustainable development paradigm a three-dimensional view; economic efficiency (EE), social well-being (SW) and ecological acceptability (EA) is introduced. Major domains of urban system are identified and the framework is developed on each domain area.

The domain-based MVBB framework allows final set of indicators developed for each domain under the three dimensions of sustainable development: economic efficiency, social well-being and environmental acceptability. A detailed analysis of each indicator will signal where the city is and where it is heading to. That is how an integrated sustainability measure informs policy makers and the public about the overall path toward sustainability without masking individual trend lines that may represent unsustainable activities.

Appendix 1

1. Canada (NRTEE, 2003)

Title	Environment and Sustainable Development Indicators for Canada
Lead Organization (s)	National Round Table on the Environment and Economy (NRTEE) (http://www.nrtee-trnee.ca/)
Scope (*geographic*)	Country (Canada)
Subject focus	All the three dimensions of SD; environment, social, and economic are considered.
Approach	This follows top-down approach with a multi stake holder involvement which not only included scientists, researchers, academia but also, govt. officers from all levels, NGOs, representatives of business and financial organizations.
Framework	This follows a *capital* framework. The 'capital model' proposed by NRTEE identifies four types of capital – *produced* capital which consists of machinery, building, transportation networks; *natural* capital, which provides space to live, raw materials to utilize, and clean environment to function, *human* capital which make most of the knowledge and abilities, and *social* capital which involves human interactions. The model intends to figure out the trends in the stocks of and investment in different forms of capital and understand the linkages between them.
Distinctive feature and relevance for Mumbai	The initiative attempts to integrate the sustainability into national capital by including natural, human and social capital. The approach and subject area are relevant to Mumbai initiative.

2. OECD (2003)

Title	OECD core set of Indicators for Environment Performance and Reviews
Lead Organization(s)	Organization for Economic Cooperation and Development (OECD) (https://www.oecd.org)
Scope (*geographic*)	Country (There are 30 OECD member countries, all are *developed*)
Subject focus	The subject focus is primarily environment related.
Approach	The approach followed here is a top-down approach. The five step approach is the following a) arriving in agreement between member countries on a common conceptual framework, and b) selection of criteria to help in selecting indicators and validating the choice and c) identification of definition of indicators, d) provision of guidance for the use of indicators and e) adapting to the national circumstances. The experiences obtained from the member countries are feedback to OECD to refine the indicators in a dynamic process.
Framework	This is based on the Pressure-State-Response (PSR) model. In fact, the PSR model, is based on a concept of 'causality' has been initially developed by OECD.
Distinctive feature and relevance for Mumbai	OECD is the father of causal framework. The issues considered have relevance for environment dimension of Mumbai initiative expecting at certain places where the same has to be contextualized in developing country's perspective and they are to tailored to city level.

3. WEF (2005)

Title	Environmental Sustainability Index (ESI)
Lead Organization (s)	World Economic Forum (www.weforum.org) with Yale Center for Environmental Law and Policy and Columbia University Center for International Earth Science Information Network
Scope (*geographic*)	Country (146 countries – countries of all kinds, *developed*, *developing* and *under-developed*)
Subject focus	The focus is on environmental sustainability NOT overall sustainability.
Approach	This follows a top-down approach.
Framework	This uses PSR framework. The two additional components considered along with the conventional three components of pressure, state and response components are 'human vulnerability' and 'global stewardship'. Thus, the indicators are classified into five core components *Environmental Systems*, *Reducing Environmental Stresses*, *Reducing Human Vulnerability*, *Social and Institutional Capacity*, *Global Stewardship*. Here the indicators are *aggregated* to form a single Index i.e. ESI to facilitate comparison among countries.
Distinctive feature and relevance for Mumbai	ESI encapsulates the measure of protection and management of environmental resources, but for overall sustainability it has to be coupled with equivalent economic and social indices. The distinctive feature of this is index is it includes two important components of human vulnerability and global stewardship. This clear and concise nationally targeted composite index has limited relevance as far as scope is concerned. But the environmental dimension is well explored in this initiative and can be made applicable for Mumbai after local mapping.

4. South Africa (DEAT, 2001)

Title	National Core Set of Environment Indicators
Lead Organization (s)	National Department of Environmental Affairs and Tourism (DEAT) (http://www.environment.gov.za)
Scope (*geographic*)	Country (South Africa)
Subject focus	The focus is on natural systems, with human system as a part of it. Though socio-economic dimension is touched the maximum attention is on environmental aspect.
Approach	This follows a top-down approach which is flexible enough to accommodate the input of both specialists and stakeholders.
Framework	This uses DPSIR framework which is a form of 'causal' framework. A domain based classification was adapted to group indicators.
Distinctive feature and relevance for Mumbai	South Africa initiative is a well documented, scientifically and systematically developed research. Here, the focus differs that from Mumbai as in human system forms the centre in the later case, where as the same is just part of the bigger natural system in the case of former. The domain based classification and the approach has relevance for Mumbai.

5. Kitakyushu (Dhakal, 2002)

Title	Kitakyushu Initiative
Lead Organization (s)	Institute for Global Environmental Strategy (IGES) (http://www.iges.or.jp/en/)
Scope (*geographic*)	City (Kitakyushu, Japan)
Subject focus	The focus is on urban environmental sustainability
Approach	This follows a top-down/expert-driven approach.
Framework	This system uses PSR framework with the inclusion exposure and vulnerability concepts for urban analysis. Traditionally the PSR framework does not explicitly include the vulnerability of the human systems to cope with the change in the environmental system. Unlike PSR, this framework does not isolate causes and effect explicitly and the framework is more in frames of *system's approach*.
Distinctive feature and relevance for Mumbai	Like the case of South Africa (DEAT, 2001), Kitakyushu initiative has been taken up after thorough study on existing indicator literature. Though it uses a variation of PSR framework it recognizes the limitations isolation of causes and effects and adopts the fashion of system's approach. The scope of the initiative tallies with Mumbai's. The issues considered are relevant for environment dimension of SD.

6. UNCSD (1996)

Title	Indicators of Sustainable Development
Lead Organization(s)	United Nations Commission for Sustainable Development (www.un.org/esa/sustdev/publications/indisd-mg2001.pdf)
Scope (*geographic*)	Country (22 countries initially participated which comprised of both developed and developing ones)
Subject focus	The focus is *sustainable development* with four aspects *social*, *economic*, *environmental* and *institutional*.
Approach	Definition wise, the approach is top-down. But it has a strong and thorough feedback mechanism incorporated. The participating nations have a major say in terms of influencing the entire framework and indicator set. Though the indicator development started with an expert group at international level, on the feedback of the testing nations the complete redesigning of the framework and indicator list was done.
Framework	This follows *thematic* framework. As a starting point indicators were developed on the basis of the chapters of Agenda 21, and they were grouped into the four primary dimensions of SD; *social*, *economic*, *environmental* and *institutional*. They followed a DSR framework where 'pressure' in conventional PSR framework has been substituted by 'driving force'. But after these indicators were tested in member countries, on the basis of the feedback, the framework was revised to *thematic* one; the indicators were made *policy oriented*. Under this adopted framework of themes and sub themes, the indicator list was shortened to 58 indicators which was grouped into different themes and sub themes under the same four dimensions of SD.

Distinctive feature and relevance for Mumbai	This is an ambitious initiative to have SDIs in all countries of world. This is one initiative, where the framework has been changed from *causal* model to *thematic* model. In the process, it has exposed the limitations of causal framework very distinctly and this goes as a lesson. The approach has relevance to Mumbai initiative and the scope has to be tailored to city's context.

7. UK (1999, 2005)

Title	UK Govt. SD Strategy indicators
Lead Organization(s)	Department of Environment, Food, and Rural Affairs (DEFRA) (http://www.sustainable-development.gov.uk/)
Scope (*geographic*)	England,Scotland, Wales and Northern Ireland
Subject focus	The focus is *inter* and *intra generation* 'quality of life' with all the social, economic and environmental dimensions considered
Approach	This follows a top down approach where UK government has identified the indicators. For revision of the strategy, community consultation was done.
Framework	The framework is *objective* or *goal-based*. It uses priority areas and objectives mentioned in the UK Strategy document for Sustainable Development. There are five principles and 4 shared priorities i) Sustainable consumption and production ii) Climate change iii) Natural Resource Protection iv) Sustainable Communities
Distinctive feature and relevance for Mumbai	This indicator set has undergone many changes. In 1999, it started with more than 150 indicators, but got revised subsequently. The *objective based* framework, though flexible, is unstable. Being the subject focus area same, the issues and themes considered holds relevance for Mumbai

8. UNCHS (2002, 2004)

Title	Global Urban Indicator Program
Lead Organization(s)	United Nations Human Settlement Program (UNCHS) (http://www.unhabitat.org)
Scope (*geographic*)	237 cities in 1993 and 232 cities of 113 countries in 1998 (cities from developed, developing and under developed countries are chosen)
Subject focus	Since, the program originated from Housing Indicator Program of 1988, and was established to monitor progress in the implementation of Habitat Agenda, the greater emphasis was on housing and shelter related issues. But with Habitat II conference in 1996, the program moved towards the broader issue sustainable urban development with all its three dimensions, *social*, *economic* and *environmental*.
Approach	A top-down approach has been followed
Framework	The Habitat Agenda Indicators follow a *goal oriented* framework, where they correspond to different objectives or goals mentioned in Habitat Agenda. The indicators are grouped according to the chapters of Habitat Agenda.
Distinctive feature and relevance for Mumbai	This is one of the ambitious programs to encompass cities from all the regions of the world. The subject areas and issues considered are applicable to Mumbai.

9. EU Local Sustainability Indicator (Ambiente Italia, 2003)

Title	European Common Indicators
Lead Organization(s)	European Commission (http://euronet.uwe.ac.uk/www.sustainable-cities.org/)
Scope (*geographic*)	City (cities of member countries under European Union)
Subject focus	All the three dimensions economic, social and environmental are considered.
Approach	The indicators are developed as per 'bottom up' approach. From the very beginning the local authorities are involved as main actors in the process of developing indicator set. Starting with over 1000 indicators, through various rounds of consultations and discussions the indicator set was finalized.
Framework	This uses a *thematic* framework. The themes and sub themes were adopted from European Commission SD Strategy documents. The indicators The indicators are divided into two groups; core and voluntary. The framework facilitated integrated and harmonized approach across community policies ensuring local appropriateness.
Distinctive feature and relevance for Mumbai	This relatively small set of Indicators are complementary with respect to existing local and national indicators as it was defined not to displace or compete with any such initiative. This is at attempt to represent local action across EU in an integrated way.

10. UEQES (Angel and Rock, 2001)

Title	Urban Environment Quantitative Examination System (UEQES)
Lead Organization(s)	State Environment Protection Administration (SEPA) (http://english.sepa.gov.cn/)
Scope (*geographic*)	City (cities of Peoples Republic of China)
Subject focus	Only 'environment' aspect of sustainability has been considered.
Approach	The indicators were arrived at as through 'bottom up' planning process where local line agencies identify the environmental problems, and proposes a target based on the performance of last year.
Framework	This adopts a *target based* framework where cities are evaluated against a set of annual negotiated environment performance targets agreed by Mayor of cities and SEPA. The indicators are grouped under three categories: a) environmental quality b) environmental infrastructure and c) environmental management including pollution control
Distinctive feature and relevance for Mumbai	This is a very successful initiative which led to the rise of a more integrated approach to urban environmental management and the difference is visible. The success is

11. London QoL (LSDC, 2002)

Title	London Quality of Life Indicator
Lead Organization(s)	Commission of Sustainable Development (CSD), London Mayor office (www.london.gov.uk)
Scope (*geographic*)	City (London, UK)
Subject focus	The focus is on 'quality of life' which touch all socio, economic and environmental aspects of citizen life.
Approach	This is though initiated from top, citizens were the agents who instrumented the potential indicators which later had an expert review. As per (LSDC, 2004), the Commission of Sustainable Development launched by London Mayor in 2003 undertook a 12-week consultation with Londoners during Spring 2003. The results of the consultation were analyzed by Professor Yvonne Rydin at the London School of Economics, a renowned expert in the field of urban sustainability indicators.
Framework	This initiative follows an objective or goal oriented framework. The commission published a sustainable development framework for London to provide decision and policy makers with a list of fourteen overarching objectives that they should seek to achieve with any strategy, policy or project they wish to progress. These fourteen objectives related to the four areas of sustainable development: 1. taking *responsibility* for the impact of ones actions on other people and the environment and thinking longer term. 2. Developing *respect* for London's diverse communities and for London's environment 3. Managing *resources* more prudently to reduce the London's environmental impact 4. Getting *results* which achieve social, economic, and environmental objectives simultaneously to improve the quality of life of Londoners now and in the future.
Distinctive feature and relevance for Mumbai	This is an action oriented and objective driven framework. The citizen participation is an essential feature of this initiative. The scope of the study resembles Mumbai, looking at the commonality of diversity both cities share.

12. Seattle (Sustainable Seattle, 2004)

Title	Indicators of Sustainable Community
Lead Organization(s)	Sustainable Seattle (www.sustainableseattle.org)
Scope (*geographic*)	City (Seattle/King County, Washington, USA)
Subject focus	The focus is *community life* with the *cultural, economic, environmental* and *social* dimensions considered.
Approach	This follows *'bottom-up'* approach where community leaders from all facets of Seattle city life came together around the idea of citizens choosing their own ways of measuring long-term community well-being and met in several workshops to develop, review, debate, form consensus and propose SDIs.
Framework	This follows *issue based* framework, where the indicators were further grouped into five different sectors: *environment, population and resources, economy, youth and education,* and *health and community*.

Distinctive feature and relevance for Mumbai	This is a pioneering work in participatory approach. The geographic scope is same as Mumbai with the only difference that the issues are to be dealt in developing city's context. The subject focus is relevant as all the three dimensions of sustainability, economic, social, and ecological are inclusive. The participatory approach is not relevant for Mumbai as a whole, yet for certain aspects, where public participation is required, Seattle approach can be followed.

13. Winnipeg (1997)

Title	City of Winnipeg Quality of life Indicators
Lead Organization(s)	Strategic Planning Division of City of Winnipeg, International Institute of Sustainable Development (IISD) (www.iisd.org)
Scope (*geographic*)	City (Winnipeg, Canada)
Subject focus	The focus is 'quality of life' with all its aspects, social, psychological, economic and environmental
Approach	It adopted the top-down approach with complete participation of citizens. There was participation from relatively broader group of citizens that included representatives from labor, public, private and civil society. The groups were chosen wherever possible from members of neighborhood communities, the business community, professional associations, unions, educational organizations, indigenous groups, and non-governmental organizations (NGOs).
Framework	This follows *issue based* framework blend with the theme of 'quality of life'. The quality of life is categorized into five areas: individual well being, urban economy, urban environment, community assets, and community leadership and pride. These categories are divided into numerous subcategories and the top two issues within each sub-category were identified by participants driven from different facets of Winnipeg city life. Then as the last step, the indicators representative of the issues were identified. Here the categorization and sub-categorization followed closely the Plan Winnipeg.
Distinctive feature and relevance for Mumbai	Though this initiative was initiated from the top, the participation of citizens in the process is exemplary. Both the geographic and subject scopes are highly relevant to Mumbai.

14. New Zealand (2002)

Title	Monitoring progress towards Sustainable Newzland.
Lead Organization(s)	Statistics New Zealand (www.stats.govt.nz)
Scope (*geographic*)	Country (New Zealand)
Subject focus	The integration of economic, social and environmental dimensions that forms the heart of any assessment to the sustainable development.
Approach	As per New Zealand (2003), the approach was a blend of a top-down and a bottom-up approach. The bottom-up approach involved the communities who can see the progress in the local area, and how to fit that to the national strategy. Equally important was the top-down approach, where bureaucrats and ministers are the part and parcel of monitoring progress towards sustainable development. Media, community groups and NGOs who have an influence through the lobbying were considered as other users.

Framework	The selection and development of indicators follows the capital model proposed by OECD and theme based approach used in UNCSD (1996). The themes and sub themes specified in the UN framework were grouped into seven main themes that are considered relevant to SD. They are *New Zealand's changing population*, *environment and ecosystem resilience*, *economic growth and Innovation*, *peoples' skill and knowledge*, *living standard and health*, *consumption and resources use*, and *social cohesion*. The connection between the themes and SD has been established through capital theory approach - recognizing that sustainability requires maintaining or enhancing the stock of natural, physical and financial, human, social and cultural capital.
Distinctive feature and relevance for Mumbai	This is an example of framework where both the thematic and capital based approaches were intertwined. The combination of top-down and bottom-up approach are consolation and coordination among different stake holders at all levels. This holistic approach can be followed in Mumbai's case.

15. Argentina (UNDSD, 2005)

Title	Indicators of Sustainable Development
Lead Organization(s)	Environmental and Sustainable Development Secretary (http://www.ambiente.gov.ar/?idseccion=60)
Scope (*geographic*)	Country (Argentina)
Subject focus	The focus is 'sustainable development' with all three aspects of sustainability; *social*, *economic* and *environmental*.
Approach	Top down approach has been followed
Framework	This follows *sysytem's* approach, which is based on the idea of socio-ecological system embodying four sub systems, social, economic, institutional, and environmental –making use of four dimensions of sustainability proposed by UNCSD. Indicators were identified both for the stock of the sub system and flow in between systems. Indicators per sub system are again grouped as 'performance' indicators and 'sustainability' indicators.
Distinctive feature and relevance for Mumbai	There are limited literature available on this in language of English. This is flexible framework as it does not force any theoretical position. It follows an integrated approach with the subsystems identified are unique of its kind. The indicators are applicable for both national and provincial scale. The subject areas hold relevance for Mumbai.

16. Australia (1998)

Title	Environmental Indicators Human Settlement
Lead Organization(s)	Department of the Environment, Commonwealth of Australia (www.environment.gov.au)
Scope (*geographic*)	Country (Australia)
Subject focus	Monitoring of 'human settlement' with all three aspects of sustainability; *social*, *economic* and *environmental*.
Approach	Top down approach has been followed

Framework	This follows *sysytem's* approach, which makes use of *Extended Urban Metabolism ModeI* (EUMM). This considers the throughput of materials in human settlements from raw input to waste outputs, and the transformation of these through the dynamics of urban settlement processes into desirable livability outputs. This model is normative, having explicit goals of reducing resource input, reducing waste output and improving livability for future generation. The indicators are further classified into different domains.
Distinctive feature and relevance for Mumbai	This is the only literature found adopting *system's framework*. The subject areas have high relevance for Mumbai with the difference that the scope has to be limited to city's context. The domain based classification can also be made useful.

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