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PICKING THE WINNER: MEASRUING URBAN SUSTAINABILITY IN INDIA

B.Sudhakara Reddy and Arpit Tiwari

Indira Gandhi Institute of Development Research, Mumbai
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B.Sudhakara Reddy and Arpit Tiwari

Indira Gandhi Institute of Development Research (IGIDR)
General Arun Kumar Vaidya Marg
Goregaon (E), Mumbai- 400065, INDIA
Email(corresponding author): sreddy@igidr.ac.in

Abstract

This study provides a snapshot of the sustainability of selected Indian cities by employing 57 indicators in four dimensions to develop an overall city sustainability index. In recent years, its complexity has made 'urban sustainability' a prominent concept. Urban areas propel growth and at the same time pose a lot of ecological, social and infrastructural problems and risks. High population density and continuous in-migration among developing countries created the highest risk in natural and man-made disasters. These issues and the inability of policy-makers in providing basic services make the cities unsustainable. The objective of the paper is to develop a city performance index (CPI) to measure and evaluate the urban regions in terms of sustainable performance. The paper uses benchmark approach to measure the cumulative performance of the 25 largest Indian cities based on economic, environmental, social and institutional dimensions. The CPI, consisting of four dimensions disaggregates into 12 categories and ultimately into 53 indicators. The data are obtained from public and non-governmental organizations, as also from city officials and experts. By ranking a sample of diverse cities on a set of specific dimensions the study can serve as a baseline of current conditions and a marker for referencing future results. The benchmarks and indices presented in the study provide a unique resource for the government and the city authorities to learn about the positive and negative attributes of their a city and prepare plans for sustainable urban development.

Keywords: City, Benchmark, Index, Performance, Sustainability, Urban

JEL Code: P28, Q41, Q42, Q48

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Abstract

This study provides a snapshot of the sustainability of selected Indian cities by employing 57 indicators in four dimensions to develop an overall city sustainability index. In recent years, its complexity has made 'urban sustainability' a prominent concept. Urban areas propel growth and at the same time pose a lot of ecological, social and infrastructural problems and risks. High population density and continuous in-migration among developing countries created the highest risk in natural and man-made disasters. These issues and the inability of policy-makers in providing basic services make the cities unsustainable. The objective of the paper is to develop a city performance index (CPI) to measure and evaluate the urban regions in terms of sustainable performance. The paper uses benchmark approach to measure the cumulative performance of the 25 largest Indian cities based on economic, environmental, social and institutional dimensions. The CPI, consisting of four dimensions disaggregates into 14 categories and ultimately into 57 indicators. The data are obtained from public and non-governmental organizations, as also from city officials and experts. By ranking a sample of diverse cities on a set of specific dimensions the study can serve as a baseline of current conditions and a marker for referencing future results. The benchmarks and indices presented in the study provide a unique resource for the government and the city authorities to learn about the positive and negative attributes of the city and prepare plans for sustainable urban development.

[1] Indira Gandhi Institute of Development Research, Mumbai, India
[2] Tata Institute of Social Sciences, Mumbai, India.

1. INTRODUCTION:

In 1800, only 2% of the population lived in urban areas which increased to 14% in 1900. By 2015 more than half of the world's population lives in urban regions with developing countries constituting 31% of it. As the world continues to urbanize, the issue of sustainability took the centre stage owing to challenges the cities face in relation to globalisation, resilience, equality, and infrastructure inadequacy. Therefore, the development of cities has a significant impact on the future of economic, environmental and social sustainability.

Even though the concept of sustainability has a great appeal with regard to urban regeneration, its applicability in practical decision making is hampered by the ambiguity of its meaning and the complex nature of urban systems. Indeed, the urban regeneration projects focused mainly on the physical renewal. This approach is bound to fail since economic activities, environmental improvements and social and institutional vitality are important ingredients of a sustainable urban system. To deal with the multi-faceted nature of the ambiguous term 'urban sustainability', a practical and reasonable approach is needed. Until now, its research and application have been confined to some narrowly defined issues (e.g., population, climate, energy, and water) and rarely moved beyond these issues. Since urban systems are complex in nature, they are often in constant flux, unpredictable and self-organizing, with feedbacks across time and space. A key feature of this complex system is that they can settle into a number of different domains which are intertwined. Urban sustainability cannot be achieved if their economic growth impairs the environmental quality, and human life cannot be sustained without equitable distribution of resources. Clearly, what constitutes urban sustainability needs rethinking and reformulation, taking various facets of sustainability into account.

To measure the performance of a city in terms of sustainability, establishing a system of indicators is essential. Hence, in recent years, while preparing the sustainability index, an integral approach involving indicators of different dimensions such as ‘economic’, ‘environmental’ and “social” is being used (Anon, 2015). Urban benchmarking is a tool that allows a comparative analysis of city indicators[3] against threshold values (similar indicators describing other units) (Jakub Rok, 2013). Conceptually, indicators are symptoms of behaviour in complex systems, and they are used to diagnose the underlying status of the system. The term "indicator" is used in diverse ways, according to the subject of concern and its context. In a generic sense, indicators may be defined as "variables whose purpose is to measure change in a given phenomenon or process". Indicators have been used to assess performance (for example, Gross Domestic Product is used as a measure of economic performance) or impact (for example, carbon emissions are used as a measure of environmental performance). This comparison-based method allows to evaluate one’s performance vis-à-vis the position occupied by other cities (Reddy and Balacahndra, 2013)

The performance of cities can be compared by using indicators that represent diverse aspects of urban system only with a meaningful and structured set system, and an appropriate number of relevant indicators (Mavrič and Bobek, 2015). There is still no agreement on a universal list of indicators, which enables the comparison of sustainability levels in different dimensions. This is due to the multivariate character of sustainability and the difficulty in aggregating the required data. Given the complexity of the issue, the present paper tries to provide a unified methodology to assess urban sustainability based on a number of quantitative indicators.

This study provides a snapshot of the sustainability of 25 cities across India employing 53 indicators in four broad dimensions (economic, environmental, social and institutional) to develop an overall city sustainability index. The cities include major cities experiencing high,

[3] Indicators are usually, but not necessarily, constructed from statistics. They are simple numbers comparable over time and space that have a clear link with policy implications.

medium and low levels of population and economic growth. The methodological framework that is developed provides a number of benchmarks against which urban sustainability can be assessed. Analytic hierarchy process (AHP), a multi-criteria judgment method, has been used to evaluate urban sustainability. The method combines the subjective as well as objective assessments in the form of combination of weights based on ratio scales derived from simple pairwise comparisons (Stam and Silva, 2003). As a result of our conceptual framework, the set of criteria we suggest is somewhat different to any already available in the literature. The scope of our analysis is intended to be broad. Although illustrated with specific examples, it should be apparent that the principles identified are relevant to any monitoring that is used to make decisions involving decision variables. These indicators are policy-relevant and, hence are useful tools for decision-makers and researchers

2. ANALYTICAL APPROACH

2.1 The Framework

The present study follows domain-based framework in which sustainability is measured according to key dimensions (i.e., economy, society, environment and institutions) (Maclaren, 1996). Each dimension is further composed of several indicators. The performance of a city is based on the following indicators: (1) economic structure (income, purchasing power and consumer price), (2) consumption (energy, electricity, water, transport, and intensity) (3) infrastructure (road length, vehicle population, internet connection, and tele-density), (4) demography (population, households below poverty line, and gender ratio), (5) housing (slum population, population living in pucca (permanent) houses), (6) equity (access to water, sanitation, and electricity), (7) education (no. of educational institutions, students completing primary, secondary and college education), (8) employment (working population and unemployment rate), (9) health (health infrastructure, infant mortality and life expectancy),

(10) emissions (CO_2, NO_x, SO_x and SPM levels), (11) land (share of green spaces, solid waste generated), (12) institutional capacity (city competitiveness), (13) institutional framework (voter turnout and work participation), and (14) urban planning and design (planning of acts and their spatial development).

Detailed information on urban land-use, population and density, socio-economic characteristics and other urban dynamics which describe urban changes and developments is obtained. The identification and selection of indicators is based on three kinds of information sources: interviews with key stakeholders, review of documents obtained from censuses, national household surveys, demographics, family health surveys, statistics registries from the city corporations and data from public or private companies in charge of services. The census and the National Sample Survey are the most important sources of data at the city-level. However, due to their high cost it is usually collected with long lags (NSSO every 5 years and census every 10 years). Information has also been obtained from books, academic journals, government and institutional reports, sustainable urban development plans and websites (World Bank. 2008; Chaudhuri and Gupta, 2009; Anon, 2010; Kundu, 2011; Kumar, 2012; NSSO 2012**;** Sreekumar, and Josey, 2012; UNHABITAT, 2012; UNDESA/PD, 2012; Sudhakara Reddy and Balachnadra, 2013; and Govindarajulu, 2014).

This study adopted analytical method by using the analytic hierarchy process (AHP) which helps the decision-maker in evaluating complicated problems and issues. Further, it contributes to identifying numerical values for the objective stimuli related to the given problem through comparisons among various criteria that affect the problem directly. This method is crucial since it assists the decision-makers in observing the continuous interaction between the elements of a complicated problem. This in turn assists them in defining the problem's elements and setting its priorities depending on their relevant knowledge and experiences as well as the desired goals (Silva, 2003).

For the present study, we have used AHP to obtain the relative importance of the criteria under analysis (in our case, dimensions of sustainability and their categories) based on expert opinions using pair-wise comparison system. AHP is the most effective way to obtain solid judgment by pairing indicators and compares them with single property without the need for other criteria. It is used to assign weights to the dimensions of sustainability and their categories. Each decision matrix has four parts, namely: (a) alternatives (b) attributes (c) weight or relative importance of each attribute, and (d) measures of performance of alternatives with respect to the attributes. It shows alternatives, Aj (for j = 1, 2,….., n), criteria attributes Ci (for i = 1, 2,….., m), weights of attributes, Wi (for i=1, 2,….., m) and the measures of performance of alternatives, aij (for i= 1, 2,….., m; j=1, 2,….., n). It may be added here that all the elements in the decision table must be normalized to the same units so that all the possible attributes in the decision problem can be considered. In the present study, two sets of matrices have been developed to compare the defined indicators (one set for comparing the indicators at dimension level and the other at category level). The relative preference of each indicator with respect to the other is estimated by using a nine-point unit-free scale—the larger the number, the greater is the importance (Saaty, 1997). Appendix 1 shows the decision matrix.

A questionnaire is developed and administered to a group of experts comprising specialists, working in the field of urban sustainability development. Experts are selected on the basis of their position, competence and work experience. A survey form is filled by the experts A total of 9 responses have been received. Keeney and Raiffa [1976] find that "there are no universally agreed criteria for the selection of experts", and hence we have decided the number and qualifications of the experts based on our judgement. It was the pair wise comparison and the experts were asked to rate, on a 9-point scale, the level of importance of each item, with 1 indicating equally important, and 9 suggesting extremely important. The results are compiled and the geometric mean value of each criterion is determined. Irrespective of the method applied, the assessment logic is simple. The most important indicator should have the highest value and the sum of weights must be equal to one. To develop the weights of the criteria, a single pair-wise comparison matrix is developed for the criteria and then the Eigenvector is calculated. Eigenvector solution is the best approach, demonstrated mathematically by Thomas Saaty (1990). Then the aforementioned Eigenvector is normalised to get the appropriate weight. After getting the weights, the consistency ratio (CR) is checked which informs the decision-makers how consistent they are, while making pair-wise comparison. A higher number means the decision-maker has been less consistent and a lower number more consistent ($CR \leq 0.10$).

The weights were assigned to dimensions of sustainability and their categories but for the indicator weights we use an equal weighting (EW) system, which is the most common approach used to weigh composite indicators. This approach assumes that all of the base indicators have equal weights, i.e., the same relative importance (Gallego-Ayala, 2014).

2.2 Normalisation of Indicators

Indicators are not measured in the same units nor have the same direction. Higher values do not always reflect better performance, i.e., a higher value in an indicator may represents a worse performance (there might be a positive indicator in which case it would be the reverse). Therefore, data transformation is required prior to the next analysis and its goal is to adjust for different ranges, variances and outliers. This is being done using normalisation process. There is a wide range of normalization methods. Choosing the most appropriate method for normalization depends on the type of data and on weighting and aggregation. We have used external benchmarks (threshold values), which are defined by norms for a specific indicators. This paper deals with the min–max normalization method which re-scales the base indicators, i.e., the base indicators are measured on a scale ranging from 0 (the worst performance) to 1 (the best performance). We have obtained these benchmark values for each indicator through literature survey (Reddy and Balachnadra, 2013). These can be referred to as the performance boundaries to evaluate the sustainability of a city. The mathematical formulation of the min–max technique is as follows, depending on whether the indicator has a positive (more is better) or negative (less is better) value.

$$I_k = \frac{(\mathrm{Xk} \ - \mathrm{min}\ (Xk)}{\mathrm{max}(Xk)\text{-}\mathrm{min}(\mathrm{Xk})}$$

$$I_k = \frac{Max\ (\mathrm{Xk}) - Xk}{\mathrm{max}(Xk)\text{-}\mathrm{min}(\mathrm{Xk})}$$

where:

Ik refers to the normalised value of the indicator *k*

Xk is the value of indicator *k* without being normalised

Max(xk) is the maximum value of *k* without being normalised

Min(xk) is the minimum value of *k* before the normalisation

After normalization, the indicators do not have any dimension, and they range between 0 and 1, with 0 being the worst and 1 the best. The advantage of this method is that a wide range of raw data is lying within a small interval.

2.4. Development of composite index

To assess the sustainability performance of cities, the sustainability sub-indices for various categories are calculated based on Krajnc and Glavic (2005). In this method, the normalized value of each indicator in the aggregated matrix is multiplied to the related priority weight. The closer the values of sub-indices and final index of the case study to the values of the benchmark, the more successful the case study is in sustainability development (Yazdi, 2014). This linear aggregation of the indicators to obtain dimension index is done by using the following formula:

$$\mathrm{Cj} = \sum_{i}^{n} \mathrm{Wi} * \mathrm{X}_i$$

where:

Cj = Sustainability index of dimension j

Wi = Weight of indicator i

n = Number of indicators for dimension j

Xi = Normalised value of indicator i

The following equation is used to calculate the sustainability index of a city based on various dimensions.

$$CSI = \sum_{j}^{n} Cj \times Wj$$

where CSI is the city sustainability index based on various dimensions

Cj = sustainability index of dimension j

W_j = Relative weight of dimension j

n = number of dimensions.

The sum of the result is the sustainability performance sub-indices which reflect the importance of Economic, Environmental, Social and Institutional indicator performances in sustainability assessment of a given city

3. CITY CHARACTERISTICS

Over half of the world's population lives in urban areas; 80% in developed countries and 51% in developing countries. In 1950, it was 30% and by 2011, it rose to 52.1%. At 34%, India remains mostly rural. Its population residing in urban regions has increased nearly ten-fold (from 0.30 billion in 1950 to 2.88 billion in 2014), which is expected to exceed 64% by 2050 implying that the global population growth over the next four decades will occur in urban areas of developing countries like India (UNDESA/PD, 2015). As a consequence, developing countries are considered to be at the crossroads of urban transition, with significant migration of poor from rural to urban areas with damaging consequences to sustainable development

(Alkire & Santos, 2011) meaning a translocation of poverty from rural to urban areas with over one third of urban residents in developing countries living below the poverty line.

In India, one in three inhabitants lives in urban area in 2015 compared with one in six in 1950. The urban population has doubled every twenty-five years, while the number of urban agglomerations has doubled in fifty years. In 1950, there were 5 cities with more than 1 million populations, which increased to 60 by 2015. However, the share of these ’cities’ in the total population has increased from 3.3 to 15% indicating a strong process of metropolitan concentration during the post-independence period. The so-called ’megacities’ were absent in 1950 and today, it has three which are home to 42 million people representing 12% of the total urban dwellers. The total population of million plus cities constitutes 42% of the urban population (Census, 2015, Indiastat.com).

In 2015, there were 60 million plus cities in India of which 25 are selected for the study. The final selection of cities was based on the following criteria: location (North, South, East and West), database (availability of required information), comparability in terms of size (comparable population size with more than one million population), and regional significance (state capital region or important regional centre). Actually, the sample is not representative of a scientifically drawn sample and there is wide variation, incorporating mega cities (e.g. Delhi and Mumbai), large cities (e.g., Bangalore and Chennai) and smaller cities (e.g., Kochi and Agra). Table 1 shows the city characteristics.

The population value enables us to know the size of the city and the opportunity to compare cities with each other. Area data enables city comparisons (measured in square kilometres) since land availability is an important component of urban planning. Population density gives a measure of how urbanised a city is. Data on income enables the affordability comparisons across cities. Among the metropolitan regions, Delhi is the largest city with an agglomeration of 14.5 million inhabitants, followed by Mumbai with 14.3 million, Kolkata with 13.5 million, and Bangalore, Chennai and Hyderabad each with around eight million inhabitants. The indicators included in city characteristics are used as input for other indicators and to distinguish the type of city being studied. Kolkata is the city with the densest in our sample of 25 cities, at about 25,000 persons per sq.km while Patna has less than 2,000 persons per sq.km. Delhi is not very dense, with about half of Mumbai's density. This has potentially strong implications for the possibility of increasing green space. In general, larger cities tend to be denser.

As the data show, mega cities saw their populations increase at a growth rate of 3 to 4% between 1951 and 91 (except Kolkata) but declined post-1991. Large cities experienced growth of more than 3% (except Hyderabad). But the real increase occurred in medium cities which is around 3% (except Surat which grew by 5.5%). In case of small cities, except Bhopal, the growth rate was about 2%. The population as well as the area of cities grow over time, but the rate of growth is not uniform. As the data show, Delhi, Mumbai and Kolakata are mega cities of roughly 15 million people. These cities possess the highest population density with the concentration of industry and service sectors. The large population base is due to large labour and consumer market which makes transactions cost low resulting in the prosperity of the economy. Lack of spatial structure increases the length of the city infrastructure network thereby increasing its operating costs. This also results in increasing the time spent over transport, increasing air pollution, thus resulting in decrease in quality of life. The negative side of urbanisation in India is that the high spatial and demographic growth is characterized by change of land use and consumption of land for settlement purposes. This results in large slums built up by the migrants which do not possess public transportation, garbage removal and sewage systems and hence no sanitation facilities. Since these slums are located in disaster-prone areas, they are vulnerable to natural and man-made disasters.

Appendix 2 lists the indicators that are included on which we perform quantitative assessment. The choice of indicators is based on the availability and measurement capability of modeling tools and quantitative approaches available. We have grouped the indicators in four domains.

A total of 57 indicators, which are quantitative in nature is selected to characterize the urban sustainability in the study. These belong to four dimensions, viz., 15 indicators in the economic dimension, 24 in social, 7 in environment and 11 in institutional. The normalized scores are used to generate an aggregate index for each dimension—economic vitality (economic), smart growth (environment), well-balanced society (social), and competitiveness (institutional). Finally, all four dimensions are combined creating a composite City Sustainability Index — a single index of sustainability for each city

3.1 Economic Development

Economic development is the backbone of city's sustainability. The raw data are used to estimate the economic sustainability of various cities. To achieve a good economic development index (EDI), a city must perform well, in most, if not in all categories. For evaluating economic sustainability, the variables economic structure, consumption pattern and infrastructure/growth are selected. Income/GDP, consumer price and purchasing power indices are considered here. Delhi enjoys an income of about 9982 (US$) per household, high purchasing power index, and a good infrastructure. Ranchi's household income is $2,012 is the lowest. Of the 25 assessed cities, ten enjoy a fair household income (more than US$4000). Income is not the only building block to achieve high economic development. Infrastructure also plays an important role. In the select cities, most deny themselves a decent score by subpar showings in infrastructure category. While the target or the benchmark (max. value) for road length/1000 population is 12.3 and most cities score around 1 except for Coimbatore (3.4) while Patna has the lowest score of 0.2. Out of 25 cities with the lowest scores (less than 0.5), no less than seven are found in this region This is because they have low GDP which plays a crucial role in paying for infrastructure services and material necessities and communication. The stellar economy of Mumbai is offset by the lack of adequate infrastructure. Of all the categories, equity is unique in having no city with a good index (Gini coefficient) and the fewest with a bad index and range from 0.29 to 0.44.

3.2 Social Development

Social development covers five categories represented by 19 indicators. The progress away from poverty and towards equality needs to be addressed by the issues represented by these five categories. The health dimension includes life expectancy at birth (average number of years that a child could expect to live in good health), infant mortality and the number of hospitals per one lakh population. The total life expectancy at birth (both sexes combined) was the highest for Chennai (81 years, and the lowest for Bhopal, Raipur and Ranchi (58 years). There are significant disparities in infant mortality rates among cities. Kochi has the lowest with 17 followed by Bangalore with 31. Among those with good hospital index, Jaipur tops the list with 59 hospitals per one lakh population. In most cities, fewer people have access to basic services such as sanitation clean fuels and pucca (permanent) housing. Among basic services, sanitation is more neglected than safe water supply. Eight cities have a bad score for clean fuel for cooking and six for pucca housing. These numbers indicate the need to improve the conditions for basic services. Among the select cities, at least one third of the population is poor in four cities, viz., Agra, Bhubaneswar, Bhopal and Raipur.

3.3 Environmental Development

To achieve a good sustainable development index, the city should perform well both in land as well as in atmosphere. Green spaces play an important role in sustaining bio-diversity. Most cities do not have enough green spaces and their air quality is also poor. If they had met these two criteria, many would have been included in the environmentally sustainable cities list. Cites with a fair land diversity index (green space per person) are Bangalore and Ranchi with a value of 17.3. One explanation may be population pressure: 90% of them (all except Bhopal and Lucknow) have a land availability (land area divided by population) of 0.02 hectares or more per person, compared with 10% of those with a poor or bad land diversity index. Surprisingly, 14 cities score of 1 or lesser value in the category of per-capita carbon emissions. However, for others, most of them are highest-scoring cities, except the dramatically low scores for Chennai.

3.4 Institutional Development

To achieve institutional sustainability responsible participation of civil society actors in decision-making processes is essential. Civic institutions should be accountable, achieve greater efficiency and there should be equity in the provision of public services such as health, education and housing. Urban planning and institutional capacity are important and among the 25 cities, Delhi and Mumbai score well due to high scores for both. Raipur occupies the last place. In general, institutional sustainability worldwide is anything but sustainable. The 10 cities receive the lowest scores (except Pune), often due to very low scores for all three indicators.

4. RESULTS

4.1 Dimension weighting

The rankings evaluate a city's overall performance based on a set of indicators that serve as individual data points, grouped into categories and dimensions. The weighting of the indicators leads to variance in rankings and reflects assumptions about the importance of individual criteria. Differences among these criteria mean that a city may score well on some indexes while lagging behind in others. In all, 53indicators in four dimensions provide heft to academic analysis. In comprehensive rankings, economic dimension is widely considered a compulsory element of cities, which is weighted higher than other dimensions.

To determine the weights of the dimensions selected, pair-wise comparisons according to their impact on overall sustainability have been carried out. The value of 1 indicated equality between the two indicators while for example, a preference of 7 indicates that one indicator is 7 times better in comparison to the one to which it is being compared. The results of calculating the priority weight of the dimensions are shown in Table 2. Comparing the priority weight of the four dimensions, Environment dimension has the highest weight with 0.33 followed by Social dimension with 0.26. Institutional dimension has the lowest priority after Economic dimension, based on expert judgments. So, according to experts' opinion, Environment is the most significant in the sustainability of a city while Institution has the lowest importance. This result complies with what has been perceived to be the important criteria for sustainability.

The results of the category weightage are summarized in Table 3. Based on the pair-wise comparison, average factors of preference have been calculated. Finally, the relative weights of indicators in each group have been estimated following the model of AHP. Through the calculation of category weights, the performance of economic, environmental, social and institutional performances of various cities have been evaluated.

4.2 Performance

As mentioned earlier, the four-dimensional framework provides the ability to evaluate the performance of each city in terms of sustainability. As four pieces of a system, the dimensions represent rough approximations of the overall performance of the complex idea that is "urban system". In this analysis, cities with high dimension values are sustainable, while those with low value are unsustainable

4.2.1 Economic vitality: The economic vitality of a city can be described as its ability to absorb future shocks and adapt to emerging pressures, which are essential elements of an economic sustainability. Surprisingly, most of the wealthiest economies find themselves lagging behind the top performers. Mumbai (0.56) is ranked at 8, due to poor performance on the demography (high population density and high share of slum population) and energy intensity. Better, but also not among the top five are Ahmedabad (0.564, rank 6) and Bangalore (0.562, rank 7). Again, the problem areas for these cities are high personal transport resulting in high motorisation index, and, in the case of Bangalore, lack of proper infrastructure. Of the 25 cities Kochi turns out to be the most sustainable city while the second place is shared by no less than three different cities, all in Tamil Nadu (Chennai, Coimbatore and Madurai). Similarly, six cities—Lucknow, Kanpur, Bhubaneswar, Ranchi, Raipur and Agra—are at the bottom of the table with scores lesser than 0.5. Incidentally, all these cities belong to north and eastern India. The lowest-scoring ones do not include a single highly industrialised city (Table 4).

4.2.2 Well-balanced Society: In this dimension**,** the pressure of large populations, rapidly growing vehicle population, and histories of pollution and resource mismanagement prevent the authorities from providing basic amenities. Thus, many cities score poorly on the social objectives, and their education and health care systems are not able to offset the stressors that contribute to low scores on the social burden count. Actually, the social problems of Indian cities are vastly different from those of the developed countries. They are diverse and require all-encompassing strategies to set right, with regulatory overhaul, more efficient and transparent institutions, and more effective enforcement of laws and regulations. Table 5 illustrates the position of the 25 cities with Chennai topping the list in this category. Kochi and Pune are among the top three positions while Mumbai, Bangalore and Delhi take 4^{th}, 5^{th} and 6^{th} places. The high overall scores are due to good scores for employment and equity, although they may possibly be overestimated. At the rear are Agra and Bhubaneswar due to very high unemployment and extremely unequal income distribution.

4.2.4 Environmental resilience: In environmental sustainability, Kochi comes out best, thanks to a high score for both atmosphere and land. Delhi takes the last position with a score of 0.65. There is negligible difference among cities in this index and in many cases two cities have an equal score. For instance, Bhubaneswar and Chennai tops the list with a score of 0.78 despite markedly different performances in economic and social dimensions. Bhubaneswar has performed well despite a comparatively bad performance in other dimensions. Meanwhile the performance of other cities such as Raipur, or Lucknow is very similar to what is seen in the overall rating. These cities are among the poorest in India, lack resources for health care or basic environmental investments, and have weak policy capacity (Table 6).

4.2.5 Institutional competitiveness: Institutional capacity and urban governance are the strongest in Delhi, Kolkata and Mumbai, closely followed by Surat and Mysore. However, all the cities have a poor or bad score. Some wealthy cities like Bangalore make it to the bottom, owing largely to a lack of governance and poor urban planning. This is owing to lack of policies in some cities (Table 7).

4.3 City Sustainability index

The City Sustainability index (CSI) combining the economic, environmental, social and institutional dimensions is shown in spider web without submerging one in the other (Figure 1). The closer a city is to the top of the barometer, the nearer it is to achieving sustainability. The CSI comprises 25 cities with sufficient data for inclusion. As expected, economically well-off cities with sufficient financial resources, a commitment to social inclusion, and policy instruments in place make up a large portion of top performers. Exceptions exist, however; Kochi, a city with middle-level income outperforms most wealthy cities and Madurai, with strong health and educational scores and low levels of pollution ranks third. This illustrates the great differences in development towards sustainability among various cities. Delhi scores relatively high on institutional dimension, rather low on social and clean environment. Kolkata scores lower than Delhi and Mumbai in all categories, apart from environment. Compared to Bangalore, Chennai scores much higher on social and institutional dimensions. Available data suggest that all the three cities have increased the supply of basic services, emit little CO_2 per capita, and have a small resource footprint. With rapidly growing economies and increasing personal transport, particularly Delhi and Bangalore, the cities may not achieve long-term sustainability. Rich cities such as Ahmedabad scores badly with respect to sustainability. At the bottom of the list are three poor cities, viz., Patna, Lucknow and Bhubaneswar. The lower scores present only half the picture: either the state of people or that of the environment. For example, Pune, Mumbai, and Ahmedabad end up with identical scores of 56, despite Pune's much higher rating on human wellbeing and Bangalore's superior ecosystem wellbeing. However, one thing is certain; sustainability is an expression of interdependence of domains and unless all the four indices increase, the city may not move towards sustainability. As the figure shows all the cities that are studied fall short of being sustainable compared to benchmarks from developed countries. As the results show, economic prosperity (the money people earn or the vehicles they own) alone does not make a city sustainable. It also depends on the equitable distribution of resources and the capabilities to transform the city.

5. DISCUSSION

5.1 Snapshot of performance

On the economic dimension, five of India's largest financial centers—Delhi, Bangalore, Hyderabad, Chennai and Mumbai—take the lead.. India's largest financial center, Mumbai, ranks relatively low in social and environmental dimensions due to insufficient infrastructure growth, losing out to a new entrant, Hyderabad. Kolkata's score is harmed by relatively poor infrastructure and low per-capita GDP. Transport infrastructure consists of public transport availability (including suburban rail system), commuting time and ease of getting private transport (taxi or auto rickshaw). While many Indian cities face challenges in these areas, significant amount of resources is not being invested to improve urban mobility.

It is important to consider the performance of a city at present and in future. Since the time to achieve results even with the best executed plans take years, if not decades; long-term planning supported by credible analysis is an important exercise. By emphasizing how factors such as business investment, sustainability, and environmental degradation can change the viability of cities, these rankings can help planners to determine which strengths might take on added importance in the future. This index measures the likelihood that cities with low- and middle incomes will improve sustainability rankings over the next one or two decades. These different analyses of the data offer an even more textured perspective on city performance.

5.2 Indicators, dimensions and integration

It is futile to pay too much attention to overall rankings to overtake one's competitor. Instead, there is a need for a well-considered comparison with bench mark cities and debate how a sustainable city should perform in various dimensions and where exactly it falls. At the data level, the indicators included in these categories deviate significantly from one index to another—even among categories that are similar. The selection of indicators themselves and what constitutes each dimension reflect a researcher's individual perspective. The most useful rankings are those that provide not just an overall score but also a second or third layer of information which throws light on the city's ability to perform. As a result of differences in the inclusion/exclusion of indicators, the rankings often disagree on the criteria about the improvement or lagging of cities over time.

5.3 City priorities

The priorities of various cities differ significantly based on their goals. A city's profile shows which areas in it are lagging behind and where they can take the lead to improve its standards. Hence, overarching development strategies must be complemented with city-specific goals. Such city-specific priorities can be identified in an evidence-based manner, for instance, by examining the trade-off between sustainability and people's satisfaction. Thus, instead of pursuing all goals to the same extent all the time, one should prioritise them for allocation of resources (Kroll, 2011)

5.3 Lack of credible Data

Unlike country-level data, which is widely available thanks to organizations such as the World Bank and United Nations, the collection of city-level data is extremely difficult, if not impossible. For example, the most fundamental definition of a city—land area—differs from one source to another and from one city to another. Most studies adapt available data using approximation. No matter how rigorous research has gone into data collection and analysis, the lack of a reliable, and comparable data source is a problem that one has to contend with. Even in an advanced city like Mumbai, data on crime and unemployment vary wildly across the sources.

Due to both a lack of data and the labor-intensive gathering effort, many rankings may be compendiums of other rankings. Such indicators are essentially a snapshot of performance-based on trailing data, meaning that a city's progress might not register on these indexes for several years. As the balance of economic power shifts from north to west and southern India at an increasingly rapid pace, the most valuable indexes will reflect these macro trends and what they portend for the Indian metropolitan regions.

6. CONCLUSIONS

The data show that not a single city in India has performed well on the human index probably because of inherent difficulties. Hence, we should find ways to achieve the tasks that are desirable, equitable, and sustainable. Prescott-Alien (2001) rightly said that a goal that is measurable is attainable. Using the indices developed here a city can measure the condition of its people and that of the environment. This information available can be used to achieve the goal of sustainability in all dimensions. Each city can set the targets for itself and decide how to achieve them.

Cities play an important role in shaping the future of a country. They house industries which act as magnets for the brightest young minds. Hence it is critical to take advantage of their dynamism and vast resources they possess. In this task, selecting indicators for sustainability and ranking them based on their performance provide a valuable insight. Since the city sustainability index (CSI) has been developed based on a limited number of indicators, it is easy to use and implement as it is a practical tool for defining targets to achieve sustainability and for monitoring the progress over time. Given the persistent nature of scale of urbanisation and the lack of access to basic services, deterioration of the natural environment, growing informal economic activities, urban sprawl and informal settlements, the purpose of sustainable urban development in developing countries seems to be a lost case. In a sense, sustainable urban development remains unrealistic, until issues of economic, environmental and social issues are addressed holistically. The underlying data offer the opportunity to analyze differences among cities and thus provide additional stimuli for improvement. It is also important that cities should conduct their own analysis and identify their strengths and weaknesses compared with their peers. Cities that are lower in ranking should begin introspection on the reasons for their poor ranking and address the issues plaguing them. By conducting a detailed analysis officials can get a sense of where they need to improve and the impact of their plan. Whenever possible, policymakers should reach out to their counterparts in other relevant cities to learn more about strategies and efforts that have paid dividends. Since a city's performance in various dimensions is measured continuously (years and sometimes over decades), urban officials should identify various indexes to gauge the city's future prospects.

The CSI presented here is a simple instrument for assessing a city' sustainability which provides a snapshot of the present level of sustainability. The advantage of CSI over the many existing indexes lies in its transparency, its limited number of indicators and therefore its ease of use

Cities should not perceive their position on an index as a definitive and objective assessment of their performance. It provides useful information for city officials and policymakers with important insights into the city metabolism. The nature of city rankings is comparative; as such a city must go beyond looking at its own performance and expand its analysis to include peer cities. For example, Mumbai may compare itself with highly industrialised cities like London but it should also be looking at cities of comparable size, GDP, and geography —a group that could include a wide range of cities such as Tokyo and Shanghai (Leff and Petersen, 2015).

An in-depth look at the performance of the select cities among various categories and dimensions suggests that the cities vary greatly in their capacity to meet the sustainability goals. It is evident that not all cities are fit to achieve the objective, and indeed no city has shown a stellar performance in all dimensions. This means that each city has its own particular lessons to learn from the others.

The indexes that are provided here give a snapshot of a city's performance which can be incorporated into long-term strategic-planning initiative. To improve ranking, one has to fine-tune approaches, improve data collection and analysis and develop city performance indices. This helps in effective urban strategies and promote knowledge exchange and collaboration among various cities.

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Table 1: City Characteristics

Type	City	Area (sq.km)	Population (million)			Rank	Exponential Growth Rate/y (%)		Household income ($)	Rank
			1950	1991	2011		51 - 91	91 - 2011	Value	
Mega	Mumbai	621	3.2	12.6	18.2	1	3.4	1.9	6326	2
	Delhi	1295	1.44	8.4	16.3	2	4.4	3.3	9982	1
	Kolkata	531	4.67	11	14.1	3	2.1	1.2	3744	12
Large	Chennai	414	1.42	3.84	8.70	4	2.5	4	4797	3
	Bangalore	534	0.79	4.13	8.44	5	4.1	3.6	4502	6
	Hyderabad	583	1.13	4.34	7.75	6	3.4	2.9	4434	7
	Ahmedabad	466	0.88	3.3	6.35	7	3.3	3.3	4192	9
Medium	Pune	700	0.61	2.45	5.05	8	3.5	3.5	4277	8
	Surat	326	0.24	1.51	4.59	9	4.6	5.5	4737	4
	Jaipur	645	0.3	1.51	3.70	10	4	3.5	3272	14
	Kanpur	312	0.1	2.03	2.92	11	2.6	1.8	2792	19
	Lucknow	976	0.5	1.67	2.90	12	3	2.8	3158	15
	Nagpur	218	0.45	1.66	2.51	13	3.3	2	4142	10
	Indore	530	0.31	1.1	2.21	14	3.2	3.4	2891	16
	Coimbatore	642	0.29	1.1	2.14	15	3.4	3.4	4644	5
	Patna	943	0.33	1.1	2.04	16	3	3.1	2540	21
	Vizag	681	0.11	1.06	2.02	17	5.1	3.5	3687	13
	Kochi	95	0.2	1.14	2.02	18	4.2	3.1	3965	11
Small	Agra	179	0.94	1.75	1.92	19	2.3	3.1	2328	22
	Bhopal	782	0.1	1.06	1.88	20	5.9	2.9	2782	20
	Madurai	243	0.37	1.09	1.46	21	2.7	1.5	2848	17
	Raipur	226	0.09	0.46	1.21	22	4.1	4.4	2228	23
	Ranchi	175	0.11	0.61	1.18	23	4.4	3	2012	25
	Bhubaneswar	175		0.07	1.08	24			2138	24
	Mysore	129	0.024	0.07	1.06	25			2825	18

Source: Census Bureau, NCAER data, TSMG Estimates, 2010
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Table 2: Dimension weights based on AHP

Dimension	Weight
Economic	0.24
Social	0.26
Environment	0.33
Institutional	0.18

Table: 3 Category weights based on AHP

Dimension	Category	Weight
Economic	Economic Structure	0.25
	Consumption Pattern	0.32
	Infrastructure/ growth	0.44
Social	Demography	0.1
	Housing	0.1
	Education	0.2
	Health	0.15
	Employment	0.25
	Equity	0.2
Environmental	Atmosphere	0.57
	Land	0.43
Institutional	Institutional Capacity	0.27
	Institutional Framework	0.33
	Urban Planning & Design	0.41

Table 4: Economic Sustainability Index

City	Rank	Score	Category scorees		
			Economic Structure	Consumption Pattern	Infrastructure/ Growth
Kochi	1	0.61	0.67	0.65	0.43
Chennai	2	0.58	0.73	0.63	0.39
Coimbatore	3	0.58	0.7	0.57	0.36
Madurai	4	0.58	0.71	0.66	0.44
Surat	5	0.57	0.74	0.6	0.46
Ahmedabad	6	0.56	0.73	0.61	0.42
Bangalore	7	0.56	0.71	0.64	0.41
Mumbai	8	0.56	0.68	0.6	0.55
Pune	9	0.56	0.72	0.66	0.46
Hyderabad	10	0.55	0.73	0.61	0.45
Mysore	11	0.55	0.62	0.66	0.43
Nagpur	12	0.55	0.73	0.67	0.39
Delhi	13	0.54	0.69	0.54	0.41
Kolkata	14	0.54	0.66	0.67	0.54
Vizag	15	0.54	0.68	0.65	0.41
Bhopal	16	0.53	0.65	0.68	0.42
Jaipur	17	0.53	0.7	0.63	0.42
Indore	18	0.52	0.64	0.63	0.39
Patna	19	0.52	0.71	0.68	0.47
Lucknow	20	0.5	0.65	0.66	0.45
Bhubaneswar	21	0.49	0.69	0.61	0.48
Kanpur	22	0.49	0.64	0.54	0.49
Raipur	23	0.49	0.71	0.64	0.45
Ranchi	24	0.47	0.69	0.6	0.45
Agra	25	0.46	0.66	0.67	0.5

Table 5: Social Sustainability Index

City	Rank	Score	Category score					
			Demography	Housing	Education	Health	Employment	Equity
Chennai	1	0.69	0.7	0.57	0.66	0.59	0.73	0.8
Pune	2	0.68	0.66	0.76	0.68	0.44	0.74	0.76
Kochi	3	0.68	0.81	0.83	0.76	0.57	0.61	0.63
Mumbai	4	0.68	0.56	0.66	0.68	0.46	0.74	0.81
Bangalore	5	0.68	0.66	0.69	0.65	0.45	0.72	0.82
Delhi	6	0.67	0.6	0.63	0.66	0.38	0.77	0.86
Coimbatore	7	0.67	0.76	0.74	0.67	0.43	0.7	0.74
Ahmedabad	8	0.66	0.66	0.72	0.61	0.36	0.69	0.86
Surat	9	0.65	0.64	0.74	0.61	0.3	0.75	0.79
Kolkata	10	0.63	0.7	0.48	0.57	0.51	0.69	0.76
Madurai	11	0.63	0.76	0.65	0.68	0.27	0.68	0.73
Nagpur	12	0.62	0.73	0.51	0.7	0.3	0.69	0.7
Hyderabad	13	0.61	0.49	0.57	0.61	0.34	0.68	0.83
Mysore	14	0.61	0.76	0.7	0.62	0.25	0.64	0.72
Patna	15	0.6	0.67	0.59	0.47	0.3	0.92	0.51
Bhopal	16	0.58	0.66	0.64	0.59	0.24	0.62	0.74
Vizag	17	0.56	0.77	0.57	0.59	0.35	0.6	0.55
Jaipur	18	0.56	0.64	0.62	0.59	0.37	0.52	0.66
Lucknow	19	0.55	0.69	0.56	0.54	0.25	0.61	0.64
Kanpur	20	0.53	0.67	0.54	0.56	0.29	0.57	0.59
Indore	21	0.52	0.68	0.59	0.37	0.28	0.65	0.58
Raipur	22	0.51	0.65	0.38	0.59	0.29	0.54	0.55
Ranchi	23	0.44	0.71	0.61	0.55	0.24	0.51	0.15
Bhubaneswar	24	0.42	0.7	0.54	0.63	0.25	0.26	0.34
Agra	25	0.42	0.66	0.39	0.46	0.17	0.36	0.53

Table 6: Environmental Sustainability index

City	Rank	Score	Category scores	
			Atmosphere	Land
Kochi	1	0.84	0.95	0.70
Coimbatore	2	0.80	0.90	0.66
Madurai	3	0.79	0.89	0.65
Bhubaneswar	4	0.78	0.91	0.62
Chennai	5	0.78	0.91	0.62
Vizag	6	0.75	0.87	0.63
Surat	7	0.75	0.81	0.66
Ahmedabad	8	0.74	0.83	0.62
Hyderabad	9	0.74	0.87	0.58
Nagpur	10	0.73	0.79	0.66
Bhopal	11	0.73	0.80	0.65
Mysore	12	0.73	0.78	0.66
Indore	13	0.72	0.78	0.65
Pune	14	0.72	0.76	0.66
Bangalore	15	0.72	0.82	0.58
Mumbai	16	0.71	0.77	0.64
Jaipur	17	0.71	0.73	0.68
Ranchi	18	0.68	0.70	0.65
Patna	19	0.67	0.73	0.59
Kanpur	20	0.67	0.70	0.62
Lucknow	21	0.66	0.72	0.59
Agra	22	0.66	0.70	0.61
Raipur	23	0.66	0.64	0.68
Kolkata	24	0.66	0.66	0.66
Delhi	25	0.65	0.68	0.62

Table 7: Institutional Sustainability index

	Rank	Score	Category scores		
			Institutional Capacity	Institutional framework	Urban Planning and Design
Delhi	1	0.43	0.61	0.35	0.36
Kolkata	2	0.42	0.53	0.41	0.35
Mumbai	3	0.40	0.68	0.34	0.27
Kochi	4	0.40	0.51	0.45	0.28
Surat	5	0.37	0.51	0.40	0.25
Mysore	6	0.37	0.44	0.41	0.28
Madurai	7	0.36	0.45	0.43	0.25
Hyderabad	8	0.36	0.51	0.35	0.26
Indore	9	0.35	0.53	0.32	0.25
Pune	10	0.35	0.57	0.36	0.19
Ahmedabad	11	0.35	0.52	0.32	0.26
Vizag	12	0.34	0.39	0.46	0.22
Chennai	13	0.34	0.52	0.34	0.22
Nagpur	14	0.34	0.52	0.35	0.21
Bangalore	15	0.34	0.50	0.35	0.23
Jaipur	16	0.33	0.43	0.36	0.26
Kanpur	17	0.32	0.48	0.27	0.24
Lucknow	18	0.31	0.49	0.25	0.24
Coimbatore	19	0.30	0.34	0.43	0.16
Raipur	20	0.29	0.33	0.41	0.15
Ranchi	21	0.29	0.42	0.36	0.14
Patna	22	0.28	0.49	0.23	0.19
Agra	23	0.28	0.47	0.29	0.15
Bhopal	24	0.28	0.53	0.28	0.10
Bhubaneswar	25	0.23	0.38	0.27	0.11

Table 8: City Sustainability Index

City	Final score	Rank	Dimensional Ranks			
			Economic	Social	Environment	Institutional.
Kochi	0.607	1	2	19	1	4
Chennai	0.578	2	19	16	5	11
Madurai	0.570	3	7	18	2	6
Mumbai	0.561	4	14	10	16	3
Coimbatore	0.561	5	24	1	3	17
Surat	0.560	6	6	22	7	8
Pune	0.556	7	1	15	14	14
Ahmedabad	0.556	8	12	25	8	13
Bangalore	0.554	9	9	7	15	10
Hyderabad	0.547	10	22	6	9	7
Mysore	0.547	11	4	4	12	5
Delhi	0.544	12	20	8	25	1
Nagpur	0.543	13	3	14	10	15
Vizag	0.536	14	16	9	6	9
Kolkata	0.532	15	11	3	24	2
Bhopal	0.522	16	17	23	11	21
Jaipur	0.515	17	18	20	17	16
Indore	0.512	18	23	13	13	12
Patna	0.503	19	13	12	19	22
Lucknow	0.496	20	5	11	21	19
Bhubaneswar	0.487	21	21	5	4	25
Kanpur	0.483	22	25	17	20	18
Raipur	0.481	23	8	2	23	20
Ranchi	0.466	24	10	21	18	23
Agra	0.454	25	15	25	22	24

Appendix 1: Decision Matrix

Preference	Definition
1	Equally important
3	Moderately important
5	Strongly important
7	Very strongly important
9	Extremely important

Appendix 2: Dimension, category, indicator and their contribution to sustainabi

Dimensions of sustainability	Categories	Indicators of Urban Sustainability	Unit	
Economic	Economic Structure	City GDP	US $ (PPP)	This is a maximisat
		Consumer price + rent index	No.	This is a minimizi
		Local purchasing power Index	No.	This is a maximisat
		City product as a % of country's GDP	%	This is a maximisat
	Consumption Pattern	Per capita water consumption	litres/day	This is a maximisat
		Per capita electricity consumption	J/day	This is a maximisat
		Energy intensity	J/$ GDP	This is a minimizi
		Transport fuel consumption	(GJ/capita/y)	This is a minimizi
	Infrastructur e/Growth	Households with internet connection	%	This is a maximisat
		households with access to telephones	%	This is a maximisat
		Population with access to mobile phones	%	This is a maximisat
		Motorisation index	Vehicles/1,000, 000 population	This is a minimisati
		HH using banking facility	%.	This is a maximisat
		Share of non-motorized transport	No.	This is a maximisat
		Road length	(km/1000 population)	This is a maximisat
Social	Demography	City population (million)	No.	This is a minimizi
		Population density	(persons/sq.km)	This is a minimizi
		Population growth (decennial)	%	This is a minimizi
		Gender ratio	(Females/1000 males)	This is a maximisat
		Child sex ratio	No	This is a maximisat
		Households below poverty line	%	This is a minimizi
	Housing	Number of houses/1000 population	No.	This is a maximisat
		Slum population	%	This is a minimizi
		Population living in pucca houses	%	This is a maximisat
	Education	Literacy rate	%	This is a maximisat
		Colleges/100,000 population	No.	This is a maximisat
		Schools/1000 population	No.	This is a maximisat

		Students completing secondary education	%	This is a maximisat
		Students completing primary education	%	This is a maximisat
	Health	Hospitals	No/100,000 pop.	This is a maximisat
		Number of hospital beds	No/10,000 population	This is a maximisat
		Life expectancy at birth	Years	This is a minimizi
		Infant mortality rate	No/1000 population	This is a minimizi
	Employment	Non-working population of the city	%	This is a minimizi
		Marginal working population of the city	%	This is a minimisati
	Basic needs	Household access to clean water	%	This is a maximisat
		Household access to sanitation	%	This is a maximisat
		Households with electricity connection	%	This is a maximisat
		Household with LPG connection	%	This is a maximisat
Environment	Atmosphere	CO_2 Emissions per person	ton/capita	This is a minimizi
		SO_2 emissions	µg/m0	This is a minimizi
		NO_2 emission	µg/m1	This is a minimizi
		PM10 emission	µg/m2	This is a minimizi
		SPM levels	µg/m3	This is a minimizi
	Land	Per capita Solid waste	kg/cap/year	This is a minimizi
		Share of Green spaces	M^2/person	This is a maximisat
Institutional	Institutional Capacity	City competitiveness	No.	This is a maximisat
		Bank branches	No/10,000 population	This is a maximisat
		Financial Management	No	This is a maximisat
		Staffing	No	This is a maximisat
		Transparency	No	This is a maximisat
		Accountability	No	This is a maximisat
	Institutional framework	Voter turnout	%	This is a maximisat
		Citizen Participation	No	This is a maximisat
		Work participation	%	This is a maximisat
	Urban Planning and Design	Planning Acts	No	This is a maximisat
		Urban capacity	No	This is a maximisat