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Research Article

A Framework For Assessing Smartness Of Cities – A Case Study Of Gujarat

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Abstract

Globally, over 50% of the population is urbanized as on today. As per World Bank's estimates, by 2045, the world's urban population will increase by 1.5 times to 6 billion. Cities are in focus primarily and the world has evidenced that cities are core to socio economic development of any nation. Cities also in perceived as source of threats for climate change. The attention on cities is not only for socio-economic development of any nation but also as potential to bring in disasters. Smart city concept is considered to be a novel model, to address both the issues balancing development and disaster prone characteristics of city, using technology. However, the taxonomy of smart cities varies through geographies. Government of India in 2014 selected 100 cities for transformation into smart cities in a mission mode through infrastructure development with an objective to improve quality of life of citizens, by use of technology. Many media have released ranking of smart cities but measure of smartness in a systematic & scientific approach has been limited. This study presents a framework of smart cities in India and suggests a methodology to assess smartness of cities under six broad dimensions using fuzzy multi criteria decision making (MCDM) technique. This model gives a comprehensive Smart City Index, which evaluates cities on the basis of multiple characteristics of a smart city including economy, governance, environment, mobility, living and people. The model assesses datasets across 31 factors for 4 cities of Gujarat, and smartness index was calculated for 4 cities of Gujarat state in India. The results presented gives an understanding on performance of the cities in various aspects and provides guidance to authorities to take corrective measures for improvement.

Keywords: Sustainability, Smart Cities, Smartness Index, Fuzzy logic, MCDM.

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1. Introduction:

The global urban population is likely to grow by 63 percent between 2014 and 2050 – compared to an overall global population growth of 32 percent in the same timeframe[1]. The fastest growing urban centers contain around a million inhabitants, and are located in the lower-middle-income countries in Asia and Africa[2]. Cities demand 67 percent of the global energy and consume 40 percent of world's energy overall. 70 percent of global greenhouse gas emissions are contributed by urban centres, contributing to climate change[3]. Over and above, urban centers increasingly experience natural disasters which is apparent in the last few decades. Out of the 100 cities vulnerable to environmental hazards, 44 cities are located in India[4]. Urban Centres bring in social tension due to rising inequality and unemployment, air and water pollution, traffic congestion, and urban violence and crime. On the other side, urban centres offer tremendous opportunities for socio-economic development. Eighty percent of the world's gross domestic product is generated in cities[2]. Smart Cities have emerged as one response to the challenges and opportunities created by rapid urbanization suggesting a balance approach to address the growth and challenges those are posed by these cities. However, the concept of smart cities is not clearly defined and varies across geographies and economy status of the countries and varies with countries based on their stage of development and challenges those need redressal.

As cities strive to become smarter and more sustainable, there is a need to measure their progress. Measurement and monitoring of performance of cities execution and development is relatively new, but these processes are becoming increasingly popular as an essential tool that clarifies cities mission and translates into action. In this context, primary importance is assigned to city indicators since they are an important quantitative tool for measuring performance of any type of city and may be designed to explain importance of certain services those are being delivered [5]. In the context of smart cities ISO 37120 [6] lays down core & supporting indicators for city services and quality of life assessing sustainability and ISO 37122 presents indicators to assess smartness[7].

Such indicators are characterized by low degree of aggregation and a high amount of information. Since the indicators are not homogeneous and degree of explanation of main objective varies, its imperative to assign weights to each[8]. Roscia et al. have proposed to use Fuzzy MCDM for assessing smartness of cities. Keeping in view the characteristic of indicators weighting of indicators are proposed to be done using Fuzzy Logic.

In this study an attempt has been made to assess Smartness of Indian cities using Fuzzy MCDM. 31 factors of cities are assessed under six broad domains namely economy, governance, environment, mobility, living and people. The indicators under these domains are finalized in consultation with experts of the fields and data availability in Indian cities. The weights for factors and broad domains are computed using Fuzzy MCDM. Perceptions on importance of factors and domains are collected from 21 domain experts seven each from academic, industry and government and accordingly weights are derived. This paper prepares a framework suitable to assess smartness index of Indian cities with more than million population as per 2011 census. The model is applied to four sample cities of Gujarat which have been selected as Smart cities and ranked based on their smartness.

This paper is divided into four sections. After introduction to the overall research area, the second section discusses the smart city framework and proposed indicator framework in the context of Indian cities and the methodology of the weighting model adopted using Fuzzy MCDM and results. The third section discusses on the results and proposes measures to be taken by cities to improve their smartness. And the fourth section concludes the paper with suggestion for future work.

2. Building Smart City Framework & Evaluation framework for Indian Cities

2.1. The state of urbanization in India

a) Urban population in India will continue to grow over next few decades and by 2050, will comprise about 58% of the total global population

b) Within Class I category of cities (Population > 0.1 million), those in the 1–5 million population range are growing faster, whereas the growth rate in the bands above and below are slowing down.[9]

c) A gap of INR 1.45 lakh crore in the annual investment in infrastructure service delivery in Indian cities based on a comparison between investments made in 2011-12 and 2012-13[10]

d) Approximately 62-63% of India's Gross Domestic Product (GDP) is contributed by urban areas, and the same is estimated to reach 75% by 2030[10]

e) India is the fourth largest emitter of Green House Gases (GHG) in the world. Indian cities are becoming more vulnerable to climate change due to high share of urban poor, improper landuse, high population density in flood-prone areas, improper infrastructure and planning practices, and competing use of scarce resources, etc.

2.2. Literature on smart city definition and framework

Although there is abundant literature available on smart cities, there is no standardized, commonly accepted set of terminologies which would help to aptly describe a "Smart City".

Batty et al. [11]define smart city as a city in which ICT is merged with traditional infrastructures, coordinated and integrated using new digital technologies. Hall et al. [12] defines smart city as a city that monitors and integrates conditions of all of its critical infrastructures. Giffinger et al. [13] highlighted the performance of smart city in economy, people, governance, mobility, environment, and living. One of core mechanisms in smart city is a self-monitoring and self-response system. Nam et al. [14] states that the initiatives of making a city smart have recently emerged as a model to mitigate and remedy current urban problems and make cities better as places to live.

Government of India adopted Smart Cities development in a mission mode to drive economic growth and improve the quality of life of people by enabling local development and harnessing technology as a means to create smart outcomes for citizens. Government of India, definition for Smart City "the objective is to promote cities that provide ***core infrastructure*** and give a ***decent quality of life to its citizens***, ***a clean and sustainable environment*** and ***application of 'Smart' Solutions***. The focus is on ***sustainable and inclusive development*** and the idea is to ***look at compact areas***, create a replicable model which will act like a light house to other aspiring cities". [15]

The methodology adopted in this research comprises of three distinct stages. Firstly, to build a robust evaluation indicator framework for measuring the performance of smart city suitable for Indian cities was worked out in consultation with academicians, consultants, urban managers and bureaucrats. Secondly, the weighting technique using Fuzzy MCDM was computed and weighted scores for each city were assessed. Lastly, based on the scores, the Smartness Index for sample cities are computed and ranking has been proposed.

2.3. Stage -I Indicators to assess Indian Smart Cities

As per the literature studied, there is a wide acceptance of smart city performance assessment adopted by European Union ([16], [13] & [17] using six broad domain Living (Quality of Life), People, Environment, Economy, Mobility, and Governance which characterises a smart city. Accordingly, in the present study, these characters were selected for assessing smartness of an Indian city and 31 factors were finalised in consultation with experts to measure smart city performances. Huovila et al. [18] work has been on selecting the right indicators to have a balanced assessment of all the factors to assess smartness without foregoing sustainability aspect of the city. Based on the Smart City framework for Indian Cities the indicators were chosen to assess six broad characteristics i.e. Living (Quality of Life), People, Environment, Economy, Mobility, and Governance (presented in Table 1).

Parameters & Factors	
A. Economy Eco 1- Entrepreneurship Eco 2- Equity Eco 3- Employment Eco 4- Gender equality Eco 5- Income B. Environment Env 1- Sustainability practices Env 2- Air Pollution C. Governance Gov 1- Finance Gov 2- Efficiency Gov 3- E-Gov Gov 4- Urban Planning D. Mobility Mob 1 -Safety Mob 2- Efficiency Mob 3-Sustainable mode	E. People Peo 1- Inclusiveness Peo 2-Participation Peo 3-Education Peo 4-Technology F. Living Liv 1 -Sewage Liv 2 -Solid waste Liv 3 -Emergency Liv 4 -Safety & security Liv 5 -Energy Liv 6 -Sanitation Liv 7 -Health Liv 8 -Shelter Liv 9-Water Supply Liv10-Drainage Liv11-Recreation Liv12-Education Liv13- Heritage

Table 1: Indicator framework for Indian Smart Cities

Step 1 : - Formation of the decision matrix

$$X = \left[X_{ij}\right]_{m\times n} = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} (i = 1,2,3,\dots,m,; j = \quad 1,2,3,\dots,n) \qquad (1)$$

Where x_{ij} presents the crisp value of criteria for measuring smartness on j^{th} criterion of i^{th} city. The crisp values for the indicators stated in the Table 1 are collected for the sample cities and the decision matrix is formed.

Step 2: The decision matrix is to be normalized. The factors those are beneficial (maximization) and those non-beneficial (minimization) criteria are normalized by equation 2 and equation 3 respectively. To have the performance measures comparable and dimensionless, all the entries of the decision matrix are linear normalized using the following two equations:

$$r_{ij} = \frac{x_{ij} - min\, x_{ij}}{max\, x_{ij} - min\, x_{ij} x_{ij}} \qquad i = 1,2,3,\dots.m, j = 1,2,3,\dots.,n \qquad (2)$$

$$r_{ij} = \frac{max\, x_{ij} - x_{ij}}{max\, x_{ij} - min\, x_{ij} x_{ij}} \qquad i = 1,2,3, \dots .m, j = 1,2,3, \dots ., n \tag{3}$$

The crisp data were collected for each indicators are normalized and the decision matrix X_{ij}^{k} $(where\ i\ is\ the\ city, j\ is\ the\ indicator\ and\ k\ is\ the\ characteristics\ to\ which\ the\ indicator\ belongs\ t$ was prepared for the four sample cities.

2.4. Stage-II Weighting using Fuzzy MCDM:

One of the key issues in the construction of composite indicators is the choice of the weighting and aggregation model. Weighting is one of the most criticised characteristics of composite indicators. Hence, special attention to avoid internal contradictions and mistakes when dealing with weighting and aggregating individual indicators[19]. An International agreement on smart city indicators has not been found, because smartness is not always easily measurable [16]. Gagliardi et al. [8] states that, the indicators arranged by the scientific community are commonly characterized by a low degree of aggregation and a high amount of information. Since the different indicators are not homogeneous, as a result of their various structures, it is possible to assign a weight to each indicator to allow for possible aggregation. This assignment can be made by means of a combination of values assigned from different judges and different criteria, calculated using a procedure based on the "fuzzy logic". Khambete et al. [20] states that a decision problem is said to be complex and difficult, if there exist multiple criteria-both qualitative and quantitative in nature, multiple decision makers, uncertainty, risk and vagueness surrounding the decision-making. They have used Fuzzy MCDM (multi criteria decision making) to assess integrated efficiency of waste water treatment plants. Lad et al. [21] state that vagueness in the perception of experts for ranking the techno- scientific parameters in linguistic terms for the specific usage, coupled with imprecision in parametric data calls for the application of fuzzy modelling. Anaokar et al. [22] suggests that multiple parameter comprehensive index by fuzzy logic is an innovative approach toward environmental indexing. Ordinary aggregated indices method allows overall estimation of multi-attribute based quality. Smart city being a multi-attribute based composite index, ordinary aggregation may suppress some important parameters. The weighting and aggregation of index components are critically important steps in any sustainability assessment [23]. In this research, Gan et al. state that the weighting and aggregation methods utilized in Sustainability Index formulation define whether dimensions can compensate or substitute for each other. Weights of such indices reflect the relative importance of different dimensions in their contributions to the performance of a system, while aggregation essentially reflects the substitutability of different dimensions. Smartness composite index very similar to sustainability index and therefore use of suitable weighting and aggregation techniques is crucial for reliable results.

Literature survey section above has highlighted the fact that, most of the composite indicators built on the smart city subject have been using z transformation and equal weighting which is a subjective way giving equal importance to all the indicators. In this paper, Fuzzy MCDM approach has been used to assess weights of factors as well as broad domains.

The framework is shown in Figure 1.

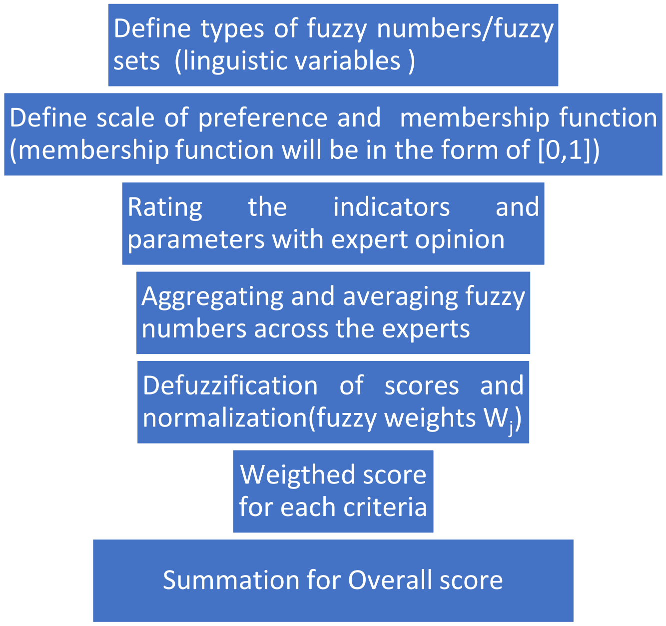

Figure 1: Fuzzy Methodology

Fuzzy MCDM method was used to find out the subjective weights through expert opinion from 21 different experts from different fields. Seven each from academics, consulting (industry) and urban practitioners (Government). To describe the level of importance on decision criteria, in the present study, five linguistic terms have been selected to describe the level of performance, of decision criteria, in evaluation of Smartness Index of cities[22].The significance of using linguistic terms is for convenience of the expert to distinguish subjectively between parametric criterions. Linguistic terms used were: Very Significant (VS), Significant (S), Average Significant (AS), Low Significant (LS), and Not Significant (NS) for assessing the alternatives and the criteria. Five linguistic variables are used because it is convenient for an expert to distinguish subjectively between them. Each was defined with four fuzzy numbers average of the numbers assigned by experts presented in Table 2.

Questionnaires were sent to all these experts to give their opinion on individual indicators with the 31 factors under each of the six broad domains mentioned in Table 1 and also on the domains Living, People, Governance, Mobility, Economy & Environment. The perception of experts about the importance of sub indicators were taken. Perceptions from experts were obtained and tabulated for analysis. Perception of experts on the importance of each characteristics are shown in Table 3, Table 4, and Table 5.

Linguistic Variables	**Fuzzy Numbers**
Very Significant (VS)	(0.7,0.8,0.9,1.0)
Significant (S)	(0.5,0.6,0.7,0.8)
Average Significant(AS)	(0.3,0.4,0.5,0.6)
Low Significant (LS)	(0.1,0.2,0.3,0.4)
Not Significant(NS)	(0.0,0.0,0.1,0.2)

Table 2: Fuzzy Numbers assigned to linguistic variables

Referring to above tables, a fuzzy decision matrices were constructed, which provides the basic framework for the collection and organization of information. A decision matrix contains the data for comparing the decision alternatives in accordance with the linguistic variables and corresponding fuzzy numbers.
The average fuzzy numbers for all the experts' are expressed as $A_{i,j}^{k}$ as shown below

$$A_{i,j}^{k} = \left(1/_{p}\right)\left(a_{i1}^{k} + a_{i2}^{k} + a_{i3}^{k} + \cdots \ldots .. + a_{p}^{k}\right) for\ j = 1, 2, \ldots . p \qquad (4)$$

where, a_{i1}^{k} be the fuzzy number or weight assigned to an alternative A_i by a Decision Maker I; DM_i for the decision criteria C_k and p is the number of experts involved in the evaluation process. The expert opinion for each criterion were converted into fuzzy numbers using **Error! Reference source not found.** and with usual notations average fuzzy numbers were calculated.

The normalized weight for each criteria was obtained by dividing the scores of each sub criterion by the total of all sub-criterions.
Average Fuzzy Numbers and crisp score (defuzzified value) for each of the factors of the Smart City were calculated for the opinion provided by Academic Experts, Industrial Experts & Urban Experts are presented in the Table 6, Table 7 and Table 8 respectively.

Characteristics	**AE-1**	**AE-2**	**AE-3**	**AE-4**	**AE-5**	**AE-6**	**AE-7**
Economy	S	S	S	LS	AS	LS	S
Living	VS	VS	VS	VS	VS	VS	VS
Environment	VS	S	VS	S	VS	VS	VS
Governance	S	S	S	S	S	VS	LS
Mobility	VS	VS	S	S	VS	S	S
People	LS	LS	LS	LS	LS	LS	LS

Table 3: Opinion of Academic Experts

Characteristics	**IE-1**	**IE-2**	**IE-3**	**IE-4**	**IE-5**	**IE-6**	**IE-7**
Economy	S	S	LS	AS	S	S	S
Living	VS	S	S	VS	VS	VS	VS
Environment	VS	VS	VS	VS	VS	S	VS
Governance	S	S	S	S	S	VS	S
Mobility	S	S	S	S	VS	VS	S
People	LS	LS	AS	LS	LS	LS	LS

Table 4: Opinion of Experts from Industry

Characteristics	**UE-1**	**UE-2**	**UE-3**	**UE-4**	**UE-5**	**UE-6**	**UE-7**
Economy	S	S	LS	S	S	S	S
Living	VS	VS	VS	VS	VS	VS	VS
Environment	VS	VS	S	VS	S	S	VS
Governance	S	LS	S	S	S	VS	VS
Mobility	S	VS	S	S	S	S	VS
People	LS	LS	LS	LS	LS	LS	LS

Table 5: Opinion from Urban Managers (Government)

Characteristics	**AE-1**	**AE-2**	**AE-3**	**AE-4**	**AE-5**	**AE-6**	**AE-7**	∑	**Final Weight**
Economy	0.65	0.65	0.65	0.25	0.45	0.25	0.65	3.55	0.1350
Living	0.85	0.85	0.85	0.85	0.85	0.85	0.85	5.95	0.2262
Environment	0.85	0.65	0.85	0.65	0.85	0.85	0.85	5.55	0.2110
Governance	0.65	0.65	0.65	0.65	0.65	0.85	0.25	4.35	0.1654
Mobility	0.85	0.85	0.65	0.65	0.85	0.65	0.65	5.15	0.1958
People	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1.75	0.0665
$\sum C_{wk}$								26.3	

Table 6 Average Fuzzy Numbers & Final Weights for Academic Experts

Characteristics	**IE-1**	**IE-2**	**IE-3**	**IE-4**	**IE-5**	**IE-6**	**IE-7**	∑	**Final Weight**
Economy	0.65	0.65	0.25	0.45	0.65	0.65	0.65	3.95	0.1468
Living	0.85	0.65	0.65	0.85	0.85	0.85	0.85	5.55	0.2063
Environment	0.85	0.85	0.85	0.85	0.85	0.65	0.85	5.75	0.2138
Governance	0.65	0.65	0.65	0.65	0.65	0.85	0.65	4.75	0.1766
Mobility	0.65	0.65	0.65	0.65	0.85	0.85	0.65	4.95	0.1840
People	0.25	0.25	0.45	0.25	0.25	0.25	0.25	1.95	0.0725
$\sum C_{wk}$								26.9	

Table 7: Average Fuzzy Numbers & Final Weights for Industrial Experts

Characteristics	**UE-1**	**UE-2**	**UE-3**	**UE-4**	**UE-5**	**UE-6**	**UE-7**	∑	**Final Weight**
Economy	0.65	0.65	0.25	0.65	0.65	0.65	0.65	4.15	0.1554
Living	0.85	0.85	0.85	0.85	0.85	0.85	0.85	5.95	0.2228
Environment	0.85	0.85	0.65	0.85	0.65	0.65	0.85	5.35	0.2004
Governance	0.65	0.25	0.65	0.65	0.65	0.85	0.85	4.55	0.1704
Mobility	0.65	0.85	0.65	0.65	0.65	0.65	0.85	4.95	0.1854
People	0.25	0.25	0.25	0.25	0.25	0.25	0.25	1.75	0.0655
$\sum C_{wk}$								26.7	

Table 8: Average Fuzzy numbers & Final Weights given by Urban Experts

The weights are derived from the fuzzy numbers for all three groups of experts individually. The average of weights of all the experts are calculated and presented in the Table 9.

Characteristics	Academic Experts	Industrial Experts	Urban Experts	Average Subjective Weights (W^k)
Economy	0.1350	0.1468	0.1458	0.1425
Environment	0.2110	0.2138	0.2084	0.2111
Governance	0.1654	0.1766	0.1708	0.1709

Mobility	0.1958	0.1840	0.1884	0.1894
People	0.0665	0.0725	0.0682	0.0691
Living	0.2262	0.2063	0.2184	0.2170

Table 9: Defuzzifed subjective weights assigned by experts

Similarly, expert opinion was collected for all the indicators under each characteristics and the subjective fuzzy weights (w_j^k) are derived where j denotes the factor and k denotes the character. The normalized crisp scores (r_{ij}^k) in the normalized decision matrix X_{ij}^k of each factor were multiplied by respective weights w_j^k and aggregated for total score (where j denotes the factor under the characteristic k)was computed.

$$X_{ij}^k = \sum_{j=1}^{m} w_j^k x_{ij}^k \ where\ i = 1,2,3\ldots,n, j = i,2,3,\ldots.,m, k = 1,2,3\ldots,p \quad (5)$$

The weighted scores for each city under each domain k is calculated and presented in Table 10.

Cities	Economy	Environment	Governance	Mobility	People	Living
Ahmadabad	0.616	*0.406*	*0.280*	0.798	0.566	0.716
Surat	0.665	*0.400*	*0.425*	0.802	*0.301*	0.682
Vadodara	0.530	*0.486*	*0.310*	0.658	0.667	0.722
Rajkot	0.376	0.630	*0.386*	0.774	0.530	0.659

Table 10: Weighted aggregate score for each domain

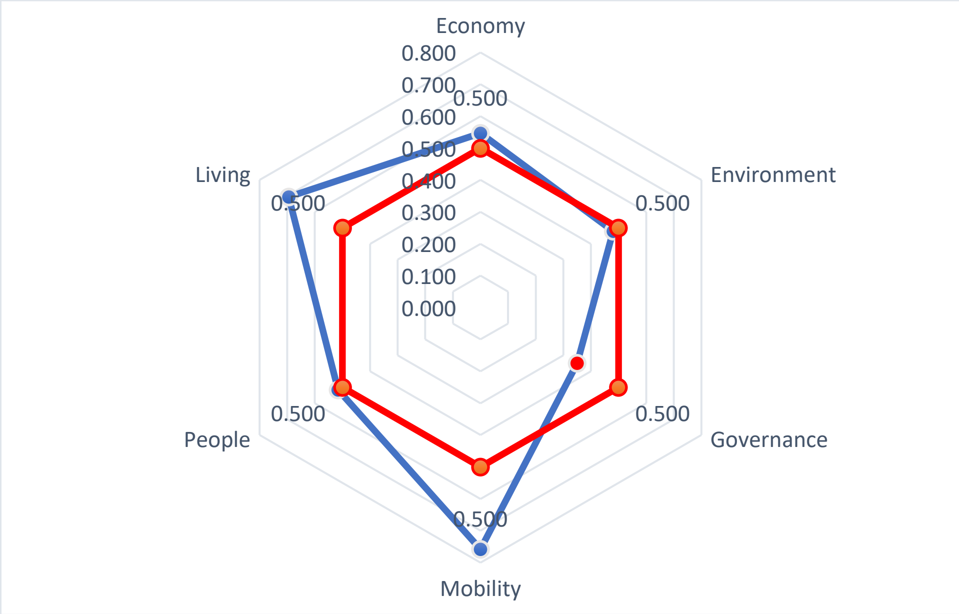

Figure 2: Average performance of Gujarat Smart cities

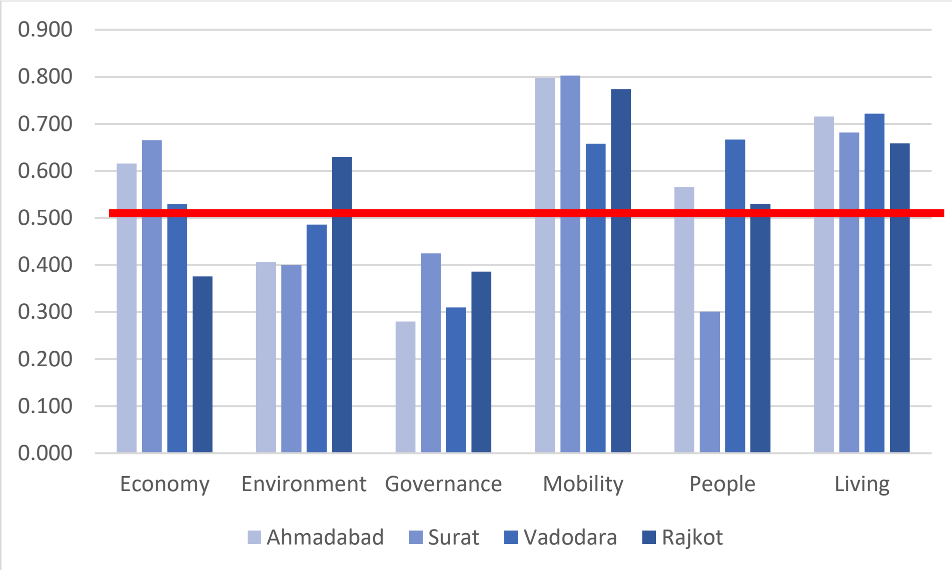

Figure 3: Performance of Cities across indicators

2.5. Stage-III : Smartness Score and ranking of Cities

The de-fuzzified weights W^k computed in the Table 9 are applied to the scores of each city scored under respective factors in Table 10 namely Economy, Living, Environment, Governance, Mobility and People and aggregated scores is computed. All the cities have scored close to Rajkot is ranked best on smartness index.

Cities	Economy	Environment	Governance	Mobility	People	Living	Overall Score θ^{Ov}	Rank
Ahmadabad	0.088	0.086	0.048	0.151	0.039	0.155	0.567	3
Surat	*0.095*	0.084	*0.073*	*0.152*	0.021	0.148	0.572	2
Vadodara	0.076	0.103	0.053	0.125	*0.046*	*0.157*	0.558	4
Rajkot	0.054	*0.133*	0.066	0.147	0.037	0.143	0.579	1

Table 11: Smartness scores and ranking of cities

3. Discussion:

Table 10 gives smartness performance for the four sample cities of Gujarat. Considering that the value of the overall smart performance is within the range from 0 to 1, four grades of overall performance can be classified, namely, best, good, average, and poor, which is defined in Table 12. The smartness performance of the all the four sample cities is in good category

Smartness Grade	Poor	$0.00 < \theta^{Ov} < 0.250$
	Average	$0.251 < \theta^{Ov} < 0.500$
	Good	$0.501 < \theta^{Ov} < 0.750$
	Best	$0.751 < \theta^{Ov} < 1.000$

Table 12: Smartness Grade

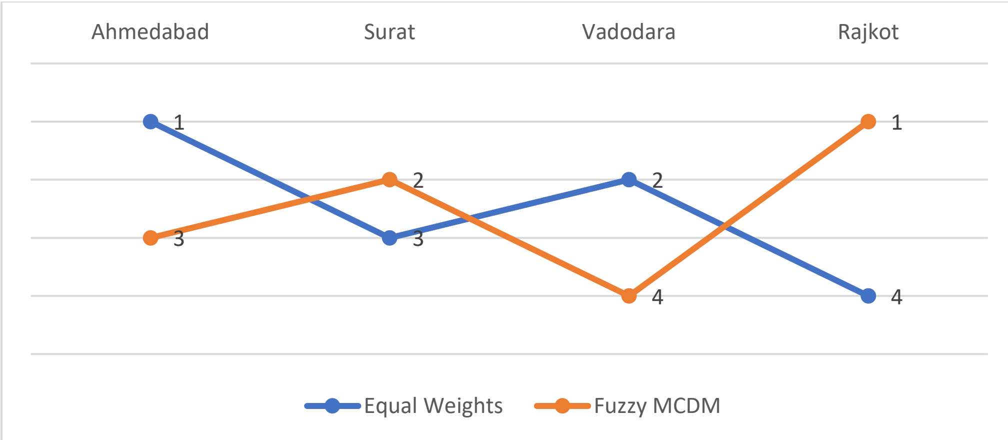

Figure 4: Ranking of cities

Figure 2 presents the average performance of cities of Gujarat in each of the characteristics, its pertinent to state that, despite having a strong industrial profile across the four sample cities which have a long lasting legacy being employment friendly and front runners on contributing to the nation GDP, the economy score has been just above average depicting that to address issues pertaining to equity - income distribution and gender equality. Overall the cities have underperformed in smart governance, smart people, and environment. Further analysis of the detail performance in these sectors show that on governance the weakness is in adequate town planners employed in the city planning and water tax collection. With respect to human capital (people), Vadodara ranks the best due to its cosmopolitan character, approach of citizens towards migrants, gender parity, inclusiveness, and education levels. Surat & Rajkot have underperformed in these factors and need to improve upon education facilities, access to internet & communication infrastructure to its citizens. In the context of environment, Rajkot has relatively performed well amongst the four sample cities. However, the sustainability factor has not been so encouraging in these cities and they need to ramp up capacities for recycling of waste water & municipal wastes and the cities needs to promote use of renewable energy through roof top solar at domestic levels. For comparison on the use of weighting, as shown in Figure 4 it is seen that city rankings changes while using equal weights and Ahmedabad is ranked number one and Rajkot is ranked fourth.

4. <u>Conclusion</u>

Smart city is the flavour of the season in urban development models globally, which is widely considered as an effective solution to mitigate urban issues. The taxonomy, framework and performance evaluation methodology are not uniform and depends on the challenges of the geography and suitable customized solutions the cities have adopted. A comprehensive evaluation on the performance of smart city is essential to help identify the existing problems properly, thus adequate measures can be taken for improving the performance. However, choosing the right indicator and weighting framework is of importance for the city to identify the areas of improvement. Ranking helps in motivating city authorities and citizens to improve on the weakness and work collectively towards perfection.

This study presents a holistic picture of Indian Smart city model and attempts to build a smart city performance measurement framework analysing 31 factors under six broad characteristics of smartness for Indian cities with million plus population. Smart city is a fuzzy concept and is used in ways that are not always consistent and uniform. There is neither a single template of framing smart city nor a one-size-fits-all definition of smart city. This study presents a new methodology for assessing smartness performance of city using Fuzzy MCDM. Introducing subjective weights to smartness characteristics, through Fuzzy MCDM gives a more realistic results while choosing the best city on smartness performance in the Indian context.

The framework is applied on 4 sample cities of Gujarat namely Ahmedabad, Surat, Vadodara & Rajkot. The results of the study show that the overall performance of smart cities in Gujarat is at a just above average level with Rajkot to be the best. However, using scoring using z transformation and equal weights would have nearly reversed the ranking with Ahmedabad ranked the best. This model can be applied to smart cities under development in India and measure the performances suitably and could be future scope for ranking of cities across the nation. Additionally, under future scope for research, other MCDM techniques could be used for ranking of smart cities which could give different insights of modelling Smartness index problems.

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