EVALUATION OF SUSTAINABILITY INDICATORS IN SMART CITY

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Abstract : This study has been undertaken to investigate the determinants of stock returns in Karachi Stock Exchange (KSE) using two assets pricing models the classical Capital Asset Pricing Model and Arbitrage Pricing Theory model. To test the CAPM market return is used and macroeconomic variables are used to test the APT. The macroeconomic variables include inflation, oil prices, interest rate and exchange rate. For the very purpose monthly time series data has been arranged from Jan 2010 to Dec 2014. The analytical framework contains. For sustainable urban mobility planning the social and economic changes that are taking place with the emergence of environment protection become much more necessary. Sustainability can be evaluated through a system of indicators which reflect its dimensions as it is difficult to be measured directly. This paper determined the importance of various criteria for sustainability in a smart city Nashik by using fuzzy and fuzzy-AHP method. Different sustainability indicators have been identified for designing a smart city Nashik in a developing country India. Efficiency of each sustainability indicators is determined for a smart city according to its input and output criteria. According to measured efficiencies we got idea about which sustainability indicator needs to focus depends on the importance of the input criteria to achieve the desired outputs. The research clearly highlights the need for policies that focuses on Road Condition and Water Quality from while designing and developing a smart city as the efficiencies are 0.47 and 0.42.

IndexTerms – Sustainability Indicators, Smart City. AHP.

I. INTRODUCTION

A smart city is nothing but the efficient and sustainable city providing high quality life by using minimum number of resources.(Anand, Dsilva, and Dsilva 2017) In modern day cities the elements like socioeconomic development and quality of life which can be delivered by the smart cities. Smart cities help to make cities more liveable, sustainable and efficient. A smart city can monitor, manage and integrate functionality of the infrastructure like roads, waterways, railways, tunnels, airways, communication power supply, etc., control maintenance activities. It optimizing the natural resources.(Sujata, Saksham, and Tanvi 2016) The debate over the role of small towns as engines in development of rural areas is just beginning to emerge. There is so much written about sustainable development of cities.(Visvaldis, Ainhoa, and Ralfs 2013) When it comes to the implementation of the principles of sustainable development in the construction sector and their translation into practical actions, the focus has started shifting from single buildings to entire neighbourhoods and cities.(Lützkendorf and Balouktsi 2017)

The ability to regulate and assess the sustainability performance of the natural and build environments, based on measurable criteria at a variety of spatial and temporal scales is critical for sustainable urban development.(Pakzad and Osmond 2016) Many of the smart city projects are marketing projects and in most of the cases their impact on the launch of the city or the actual status of implementation is unknown.(Zubizarreta et al. 2016) Sustainable construction has become a challenge for the construction industry future. For sustainable construction different parameters are taken into consideration like minimal consumption of energy and matter, human satisfaction and minimal negative environmental impact. Such different sustainable parameters used for balancing project objectives like cost, time, and quality and among environment, society and economy. These parameters have widely applied to buildings, now we have to apply it to the construction industry.(Tafidis, Sdoukopoulos, and Pitsiava-latinopoulou 2017)

Sustainable management of construction is not yet being considered adequately in civil engineering projects over their life cycle. The project management standards have been adapted to the construction sector.(Anon 2011) In generic term we can define smart city as an urban environment that utilizes information communication technologies and other related technologies to improve performance efficiency of accelerate city operations and service quality provided to urban citizens. Also in formal terms experts have defined smart city with consideration various aspects and perspectives. A popular definition states that a smart city connects physical, social, business, and information communication technologies infrastructure to uplift the intelligence of the city.(Nathali, Khan, and Han 2018)

Smart city and urbanization has become one of the most important criteria which create a bond between the human with the ecosystem. There is a measuring progress towards sustainable or unsustainable urban development which requires quantification with the help of suitable sustainability indicators. The ignorance about understanding of the concept of sustainability and contextual meaning differs from country to country and economic strata of the society. The identification of major issues faced in implementation of sustainability indicators and the development in an urban context and suggesting remedial recommendations has become very challenging. There are two criteria's of challenges as per the implementation and development phase respectively, and three preliminary criteria in the application of urban sustainability indicators.(Verma and Raghubanshi 2018) Sustainability indicators have become a key element in a market where the environmental impacts of the products they consume is the area of interest of the consumers.(Nappi[a] and Rozenfeld[a] 2015)

The objectives of the project work are.

1. To study the concept of smart city.
2. To find out sustainability indicators in smart city.
3. Evaluation of smart city sustainability indicators by using fuzzy and fuzzy AHP method.

II. MATERIAL AND METHODS

2.1 Introduction

The evaluation of sustainability indicators in smart cities has been applied differently from project to project, using various methods to evaluate the sustainability in certain activities of the projects.(Wulf et al. 2018) This study is aimed at highlighting the main sustainability indicators that Indian smart cities are facing and involving in construction projects and the evaluation methods are used to manage the sustainability. It also describes the significance of the indicators used for their management. The research methodology used was the expert judgment questionnaire. The research used a questionnaire to evaluate the sustainability indicators in the smart city. The questionnaire-based survey was used as the main source of data collection. The questionnaire was prepared following a thorough literature review and in-depth interviews with experienced professionals in this industry for questionnaire finalisation as per local conditions. (Anand et al. 2017)

2.2 Sustainability indicators Identification

In this study five input criteria and three output criteria are selected. The input criteria considered in this study are mobility (MO), economy (EC), environment (EV), society (SO), energy (EN). The output criteria considered are quality of life (QL), self-sustenance (SS) and economic prosperity (EP). Sustainable indicators have been identified from the review. DEA (Data Envelopment Analysis) helps to find the relative efficiency of various sustainable indicators.(Anand et al. 2017)

2.3 Determining the importance of criteria

The methodology proposed has been adopted for determining the importance of criteria using fuzzy AHP. Different experts were identified in the relevant area and they were asked to rank the input and output criteria. Then pair wise comparison of each expert was carried out using the triangular fuzzy logic (TFN) scale. Fuzzy AHP (Analytical Hierarchy Process) helps to get the relative weights for input and output criteria.(Jayawickrama, Kulatunga, and Mathavan 2017)

2.4 Estimating the relative efficiency of sustainability indicators

DEA (Data Envelopment Analysis) method was adopted in this paper to estimate the relative efficiency. AR (assurance region)-CCR model was adopted to avoid the zero effect. The decomposition efficiency measures clearly highlight which sustainability indicator the country needs to focus based on the importance of the input criteria to achieve the desired outputs.(Anand et al. 2017)

III. RESULTS AND ANALYSIS

The relative importance of the input output criteria was obtained from experts. The consistency (CI) and the consistency ratio (CR) for each of the experts were found to be within the acceptable range ($CR \leq 0.1$). The average importance of the criteria using fuzzy and fuzzy AHP is given in.
Table 3.1

Table 3.1 Importance of criteria using AHP and fuzzy AHP: a comparison

	Criteria	**AHP**	**Fuzzy AHP**
Input Criteria	Mobility (MO)	0.19930	0.19564
	Economy (EC)	0.11153	0.12156
	Environment (EV)	0.26541	0.26654
	Society (SO)	0.18697	0.15219
	Energy (EN)	0.22698	0.22358
Output Criteria	Quality of Life (QL)	0.36958	0.37526
	Self Sustenance (SS)	0.29635	0.25694
	Economy Prosperity (EP)	0.31496	0.34255

It is found from the table that energy is a very important criterion as indicated by both AHP and fuzzy AHP method. This is followed by society. With reference to the output criteria it is found that economic prosperity is found to be very important with regard to AHP while self-sustenance is found to be an important criterion from fuzzy AHP method. The experts were requested to rate each of the 20 sustainability indicators, the relationship it has on the input criteria for obtaining the desired output. The DEA model was run considering the assurance region using criteria multipliers. The decomposition efficiency of the indicators is given in Table. 3.2

Table 3.2 Identification of Sustainability Indicators and its Consistency

Sr. No.	Indicators	Consistency	MO	EC	EV	SO	EN	QL	SS	EP	Rank
1	Smart Housing	0.95	0.26	0.95	0.69	0.14	0.75	0.05	0.28	0.92	1
2	Safety & Security	0.73	0.69	0.33	0.75	0.63	0.11	0.92	0.71	0.65	12
3	Infrastructure	0.89	0.95	0.87	0.08	0.88	0.37	0.03	0.42	0.73	4
4	Harmonious Living	0.76	0.69	0.02	0.95	0.17	0.87	0.32	0.22	0.34	11
5	Economy	0.85	0.64	0.18	0.63	0.11	0.92	0.38	0.28	0.74	7
6	Material Quality	0.91	0.15	0.08	0.39	0.19	0.39	0.35	0.66	0.57	3
7	Waste Treatment	0.84	0.05	0.80	0.55	0.07	0.95	0.69	0.47	0.36	8
8	Saving Potential	0.80	0.69	0.01	0.17	0.27	0.26	0.79	0.58	0.27	10
9	Pollution	0.83	0.02	0.31	0.88	0.55	0.60	0.09	0.74	0.61	9
10	Drainage	0.61	0.08	0.18	0.25	0.11	0.08	0.48	0.58	0.52	15
11	Water Quality	0.42	0.39	0.08	0.66	0.37	0.95	0.68	0.12	0.52	19
12	Population	0.57	0.67	0.14	0.17	0.49	0.18	0.39	0.44	0.04	16
13	Mass Transport	0.70	0.25	0.13	0.09	0.03	0.58	0.85	0.27	0.19	13
14	Non motorized transport	0.63	0.68	0.64	0.37	0.15	0.31	0.95	0.69	0.07	14
15	Road Conditions	0.47	0.15	0.11	0.08	0.19	0.39	0.48	0.66	0.15	17
16	Distance of travel	0.49	0.25	0.11	0.08	0.21	0.58	0.63	0.31	0.48	18
17	Renewable Energy Use	0.88	0.25	0.11	0.08	0.28	0.18	0.95	0.68	0.27	5
18	Land use	0.92	0.62	0.25	0.11	0.08	0.29	0.58	0.31	0.17	2
19	Automation	0.87	0.15	0.31	0.5	0.19	0.39	0.15	0.66	0.84	6
20	Life Style of People	0.79	0.08	0.15	0.58	0.95	0.69	0.27	0.55	0.11	20

3.1 Sample Calculations:

Table 3.3 Criteria Comparison Matrix

	MO	EC	EV	SO	EN	QL	SS	EP
MO	1	0.33	0.2	0.11	0.14	0.33	0.11	0.33
EC	3	1	0.14	0.33	0.11	0.14	0.2	0.2
EV	5	7	1	0.2	0.33	0.2	0.33	0.11
SO	9	3	5	1	0.14	0.11	0.33	0.33
EN	7	9	3	7	1	0.2	0.14	0.33
QL	3	7	5	9	5	1	0.11	0.33
SS	9	5	3	3	7	9	1	0.14
EP	3	5	9	3	3	3	7	1
SUM	40	37.33	26.34	23.64	16.72	13.98	9.22	2.77

Table 3.4 Normalize matrix

Column Sum	40	37.33	26.34	23.64	16.72	13.98	9.22	2.77	**Criteia Weights (W)**
	MO	**EC**	**EV**	**SO**	**EN**	**QL**	**SS**	**EP**	
MO	0.025	0.009	0.007	0.005	0.008	0.024	0.012	0.119	0.0261
EC	0.075	0.027	0.005	0.014	0.006	0.01	0.022	0.072	0.0289
EV	0.125	0.187	0.038	0.008	0.02	0.014	0.036	0.04	0.0585
SO	0.225	0.081	0.19	0.042	0.008	0.008	0.036	0.119	0.0886
EN	0.175	0.241	0.114	0.296	0.06	0.014	0.015	0.119	0.1293
QL	0.075	0.187	0.19	0.381	0.3	0.072	0.012	0.119	0.167
SS	0.225	0.134	0.114	0.127	0.419	0.644	0.108	0.051	0.2278
EP	0.075	0.134	0.342	0.127	0.179	0.214	0.759	0.361	0.2739
	1	1	1	1	1	1	1	1	1

Note: Criteria Weights (W) = Average of each row
(Divide each element in every column by column sum)

Table 3.5 Calculating Consistency

Criteria	**MO**	**EC**	**EV**	**SO**	**EN**	**QL**	**SS**	**EP**	**Weighted sum Value (Ws)**
MO	0.026	0.0086	0.0052	0.0029	0.0036	0.0086	0.0029	0.0086	0.0663
EC	0.087	0.029	0.0041	0.0096	0.0032	0.0041	0.0058	0.0058	0.1485
EV	0.29	0.406	0.0058	0.0116	0.0191	0.0116	0.0191	0.0064	0.7697
SO	0.792	0.264	0.44	0.088	0.0123	0.0097	0.029	0.029	1.6641
EN	0.903	1.161	0.387	0.903	0.129	0.0258	0.0181	0.0426	3.5694
QL	0.501	1.169	0.835	1.503	0.835	0.167	0.0184	0.0551	5.0835
SS	2.052	1.14	0.684	0.684	1.596	2.052	0.228	0.0319	8.4679
EP	0.825	1.375	2.475	0.825	0.825	0.825	1.925	0.275	9.35

Note: Weighted Sum value (Ws) = Sum of Each row
Take first matrix which is not normalized; multiply each row by its rows criteria

Table 3.6 Criteria Ratio (Ws/W)

Criteria Weights (W)	Weighted sum Value (Ws)	Ratio (Ws/W)
0.02613	0.0663	2.5378
0.02888	0.14848	5.14216
0.58500	0.76966	1.31566
0.08863	1.66408	18.7766
0.12925	3.56943	27.6165
0.16700	5.08348	30.4400
0.22775	8.46792	37.1808
		157.149

ƛmax = Sum of Ratio Values/Number of compared elements

$$ƛmax = \frac{157.149}{8} = 19.64$$

ƛmax = 19.64

$$\textbf{Consistency Ratio} = \frac{\textbf{Consistency Index}}{\textbf{Random Index}} = \frac{\textbf{CI}}{\textbf{RI}}$$

$$\textbf{Consistency Index (CI)} = \frac{(ƛmax-n)}{(n-1)}$$

Where n is number of compared matrix

$$\text{Consistency Index (CI)} = \frac{19.64-8}{8-1} = 1.66$$

Random Index (RI)

For n=8, RI = 1.41

For Random Index (RI)										
n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

$$\textbf{Consistency Ratio} = \text{(CI/RI)} = \frac{1.66}{1.41} = 1.17$$

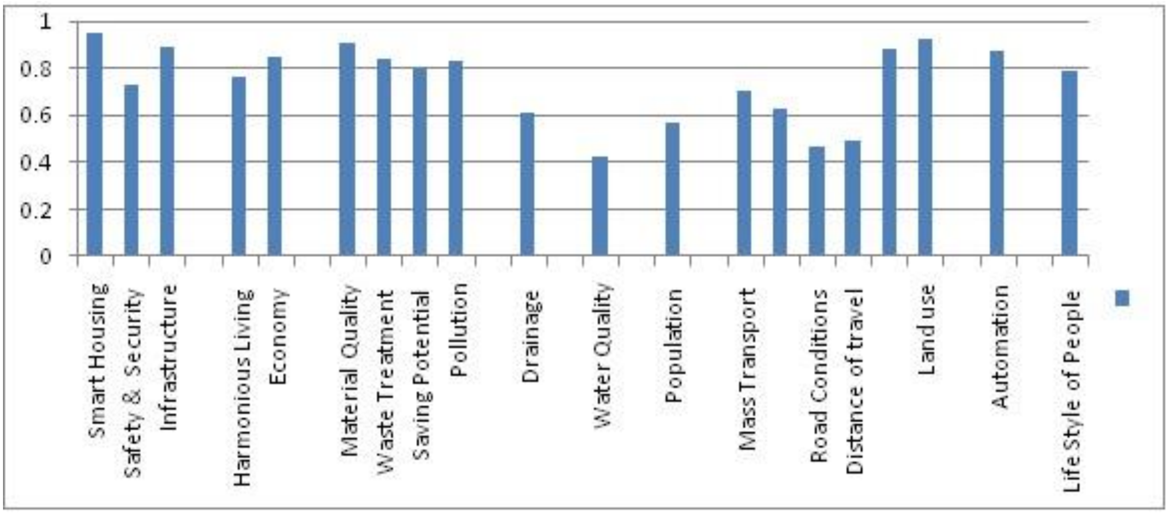

Figure 1 Graphical Representation of Consistency for Sustainability Indicators

It is found from the table that environment is a very important criterion as indicated by both AHP and fuzzy AHP method. This is followed by society. With reference to the output criteria it is found that Quality of life is found to be very important with regard to AHP while self-sustenance is found to be an important criterion from fuzzy AHP method. Hence we have to focus on these two criteria environment and Quality of life. The experts were requested to rate each of the 20 sustainability indicators, the relationship it has on the input criteria for obtaining the desired output. Road Condition and Water Quality are very important criteria to be concentrated upon while developing the infra structure for a smart city in a developing country as the consistency are 0.47 and 0.42. The research clearly highlights the need for policies that focuses on Road Condition and Water Quality while designing and developing a smart city.

IV. CONCLUSIONS

The requirements for a sustainable smart city considering diverse criteria have been studied. Though it may be difficult to integrate all elements of the criteria yet it is crucial to identify the most influencing ones so that concentration on the vital few will result in a ripple effect. This paper considers multiple criteria simultaneously for prioritizing the sustainability indicators for the creation of a smart city. The fuzzy AHP DEA analysis reveals that policy makers need to focus on the energy and economy. This will facilitate in securing the environment, ease out mobility issues and provide a higher quality of life to its citizens.

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