"Exploring the concepts of Smart Cities: An empirical study of Smart City Indore"

A Thesis

submitted in partial fulfilment of the requirements for the award of the degree

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Under the supervision of

Mr Santu Kar
(Assistant Professor)

by

Alok Ranjan Mishra

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CERTIFICATE

This is to certify that the work which is being presented in the thesis title **"Exploring the concepts of Smart Cities: An empirical study of Smart City Indore"** in partial fulfilment of the requirements for the awards of the degree of Master of Technology and submitted in Civil Engineering Department, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by **Alok Ranjan Mishra** during a period from July 2016 to April 2017 under the supervision of **Mr Santu Kar**, Assistant Professor, Civil Engineering Department, Jaypee University of Information Technology, Waknaghat.

Date: -   -May-2017

Dr Ashok Kumar Gupta   **Mr Santu Kar**   **External Examiner**

Professor & H.O.D   **Assistant Professor**

Civil Engineering Department   **Civil Engineering Department**

JUIT Waknaghat   **JUIT Waknaghat**

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Date:-   -May-2017   Alok Ranjan Mishra

CONTENTS

Abstract

The century has seen a lot of large scale changes; both constructive and destructive. On one side where people moved from slums to concrete dwellings as a result of urbanization and industrial growth, the other side experienced the thwart of population hike and the problems associated with it. And specifically if our country India is to be taken in consideration, the changes had an even more pronounced effect. With each coming day population increased in leaps and bounds while the resources kept getting scarcer at the same time. And this was the major concern when the society failed to address the demands of this increased human toll. Their very basic needs of food, clothes and housing were not even getting fulfilled. And what added on to it was the rapid migration from the rural background to the towns and cities in the search of employment and development. Cities kept getting congested with a sharp struggle for available resources. The problem now has got even more acute and this is the time when a solution needs to be worked out. One such concept that can come to the society's rescue is that of 'Smart Cities'. These are cities that are very different from the normal ones and are much more efficient too. They are integrated with the cutting edge technology that makes them more intelligent in their ways of resource handling and providing its users a quality lifestyle. This work is an exploratory attempt to have a keen insight into the concept of Smart Cities, its components, the features and challenges that it has to imbibe and fight through in context of India and a case study of the Smart City Proposal for Indore City.

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ABBREVIATIONS

APTS   Advanced Public Transportation Systems

ATIS   Advanced Traveller Information Systems

ATMS   Advanced Traffic Management Systems

AVCS   Advanced Vehicle Control Systems

BRTS   Bus Rapid Transit System

CNG   Compressed Natural Gas

ICT   Information and Communication Technologies

IIM   Indian Institute of Management

IIT   Indian Institute of Technology

IT   Information Technology

RII   Relative Importance Index

SPSS   Statistical Package for Social Sciences

Chapter-1

Introduction

1.1 General

The term 'Smart City' was fairly new to India when our respected Prime Minister Shri Narendra Modi took it to the public for the first time. He inaugurated the 'Smart City Mission' which was an historical event in the chronology of Indian sub-continent. The basic idea was to combat the growing problems that the cities faced as a result of rapid migration from the rural areas and the cities were failing to look after their requirements and demands. These cities are not something that has landed from some other world; rather they are our own cities but teamed up with a number of modifications and additions. The only thing that makes themstand apart from the normal ones is their linking to Information & Communication Technologies (ICT) which makes them more efficient in their ways of working and allows them to make the resources available to people rationally. A substantial part of our country's population is now heading towards to the urban areas. We being a developing country are witnessing a surge in the number of industries that are getting established and the cities are the places where this evolution is taking owing to the availability of resources they offer as compared to a rural area. These industries are offering employment opportunities to many and thus the cities are under the acute pressure of migration of human resource from their villages to the cities and towns. Congested living spaces, inefficient waste management, polluted ambience and unhealthy ways of survival, inadequate resources and what not. The life in cities was getting more cumbersome and miserable. What was once an employment gallery is soon turning into an arena of struggle and misery. And this is exactly the time when the concept of Smart Cities was badly needed for India to come into existence.

Now, after knowing the fact that what triggered the start of 'Smart City Mission', it is important to know in detail as to what a Smart City is. Actually, there is neither any particular definition of a Smart City, nor there can ever be. Every city has its own conditions, its own requirements, its own cultural and demographic impacts and its own economical constraints. So, there can never be a single tailor made plan that fits well to every city under consideration. It's just a simple concept to make any city well equipped with the basic amenities with efficient utilization of resources, implying those methods in the functioning of

various activities that are sustainable and render least harm to the environment, where the infrastructure, be it urban transportation, energy supply, waste management, policing methods are technology driven and offer the best convenience and performance with the least possibility of glitches. And when these above mentioned features combine together then what comes up as the output is nothing but what we call a 'Smart City'.

Fig 1.1: The 'Smart City Mission' logo

1.2 Need of the project

It is an obvious fact that behind any initiative, there are certain reasons triggering it. These factors define the severity of the project and the level on which it needs to be worked out. The same is true for this project too. The Smart City concept has not been talked about in good detail in India and thus its features, components, strategies remain unheard to many. And thus, people find working in this direction. Thus, it is the right time to get into the depth of this concept and imbibe its core details to combat the growing problem of congested cities, inadequate resource distribution and degrading lifestyle.

1.3 Objective of the project:-

The work aims at accomplishing the following objectives:-

1) To explore the components and features of the Smart City concept.
2) To find out the required key features by conducting a Questionnaire Survey for Smart City Indore.

3) To prepare a framework of suggestions and recommendations based on the critical features deduced from the responses of the questionnaire survey.

1.4 Scope of the Project:-

The scope of the project is limited to performing a questionnaire survey for Smart City Indore. Although a Smart City consists of several factors like technical, economical, governmental, social, environmental etc., while designing the suggestive framework only the critical ones are considered.

1.5 Project Methodology:-

While preparing this work, the following sequence of work was adopted:-

- Exploring the various components and features of Smart City Concept with the help of pre published works by various scholars of India and abroad.
- Studying the Proposal of Smart City Indore as submitted to the Government of India and taking key points out of it.
- Preparing a questionnaire survey on the basis of the findings from the proposal and personal experiences of the city.
- Ranking out the features on the basis of received responses and classifying the critical ones out of them with the RII Evaluation and correlation with the help of SPSS software.
- Creating a suggestive framework based on the features identified as critical for Smart City Indore.

Chapter-2
Literature Review

2.1 General

The concept of Smart City is indeed a new step for the Indian context but the western countries have been practising it for a fairly good duration. Their researches have gone up to a large extent dealing with various additions in a Smart City and its interaction with different components of the society viz. technical, economical, administrative, psychological etc. Though they can not be incorporated as it is in our country due to obvious differences in the economic level and resource availability scenario, cues can certainly be taken from them as to how to initiate the work in various spheres. In this pursuit, the following research works have been studied in order to identify the key features required for a Smart City and the factors that contribute significantly in its successful execution.

2.2 Summary

[1] Refer to a paper by Paul Varghese, on "Exploring other concepts of Smart Cities within the urbanising Indian context" an is published in International Conference on Emerging Trends in Engineering, Science and Technology (ICETEST), Procedia Technology 24 in the year 2016. This paper examines the idea of Smart City with respect to the motives behind it, current urbanisation models, development needs and the city planning in India. It states that the process of urbanisation is mostly because of lesser option in the rural background to make a better living than because of the dream of a better life in the city.

Indian population touched the mark of 1.291 Billion (2015) which is projected to reach 1.657 Billion by 2050 and by the present day conditions, India is set to overtake China by 2028 in terms of population. The key factors behind this surge in population over the last century are better biological immunisation, improved nutrition, better living conditions, modernised medical care and such. Thus, it will not be wrong to say that urbanisation is a strong force to combat with, not just for India but for the world fraternity.

This work also goes through the various tentative attempts of assigning a definition to Smart Cities and states the current definition used by the government as-

"A Smart City offers sustainability in terms of economic activities and employment opportunities to a wide section of its residents, regardless of their level of education, skills or income level.

[2] Refer to the paper by Navarro,C. ,Roca-Riu,M. et.al., on "Designing new models for energy efficiency in urban freight transport for Smart Cities and its application to the Spanish case" and is published in the The 9th International Conference on City Logistics, Tenerife, Canary Islands (Spain), Transportation Research Procedia 12 in the year 2016. This work considers the fact that the transport sector is responsible for 30% of the CO_2 emission in the European Union reaching up to 40% in the urban areas making it important to look out for technological innovation and improvements in the field of Smart Transportation. It is evident from the above statement that the urban freight system needs reforms that will promote the use of renewable energy sources leading to reduced dependency on fossil fuels and the consequent reduction in the emission of Green House Gases while at the same time keeping in mind that the economy stays unaffected. In this context, six Mediterranean cities (Barcelona, Bologna, Piraeus, Rijeka and Valencia) collaborated with the purpose of improving energy efficiency on the urban freight transport as a part of the SMILE Project (2015). The SMILE project aims to improve the energy efficiency of Mediterranean cities by promoting innovative 'green' and cost effective alternatives for urban freight solutions contributing to the target of Green and Smart urban development.

[3] Refer to a paper by Joshi,Sujata. , Saxena,Saksham. , Godbole,Tanvi. , Shreya., on "Developing Smart Cities: An integrative framework" and is published in 6th International Conference on Advances on Computing & Communications, ICACC, Procedia 93 in the year 2016. This paper involves the analysis of various aspects and dimensions of a Smart City, along with the preparation of a framework to get a deeper insight in to the functioning of a Smart City. It identifies six significant pillars of a Smart City viz. Social, Management, Economy, Legal, Technology, and Sustainability (SMELTS) and narrates the role of these factors in making the Smart City Project a successful attempt.

[4] Refer to a paper by Laura Aeleneia, Ana Ferreiraa, Claudia Sousa Monteiro, Ricardo Gomes, Helder Gonçalves, Susana Camelo, Carlos Silva, on "Smart City: A systematic approach towards a sustainable urban transformation" and is published in International Conference on Solar Heating and Cooling for Buildings and Industry in the year 2015. The paper states the fact that around 50% of the world population dwells in the cities which is

forecasted to reach 80% in the upcoming years. The growing population and rapid mobilization from rural backgrounds to the urban ones are the reason why resource efficiency is a crucial factor to promote global sustainability. The paper identifies Smart Cities as a feasible solution to the problems cities face these days and finds them capable of improving human living standards, resource efficiency etc. There have been various initiatives of the Smart City Concept and none of them could be denoted as the benchmark. It actually works on the best suit basis. Rather, a Smart City is nothing but simply a sustainable city. It is the one which defies the harmful effects of the surroundings to the maximum possible limit.

[5] Refer to a paper by Aditya Gaur, Bryan Scotney, Gerard Parr, Sally McClean, on "Smart City Architecture and its Applications based on IoT" and is published in The 5th International Symposium on Internet of Ubiquitous and Pervasive Things (IUPT) in the year 2015. This paper talks about the significance of Wireless sensor networks and their dominance these days. The infrastructure that is linked with Information & Communication Technologies generates a large amount of data everyday like environment monitoring, health monitoring, traffic monitoring etc. However, this large amount of data needs to be managed and thus there is a need of an effective management and analysis system that can generate information that can help in managing the resource utilization in a smart way. It represents the step of Smart City architecture as:-
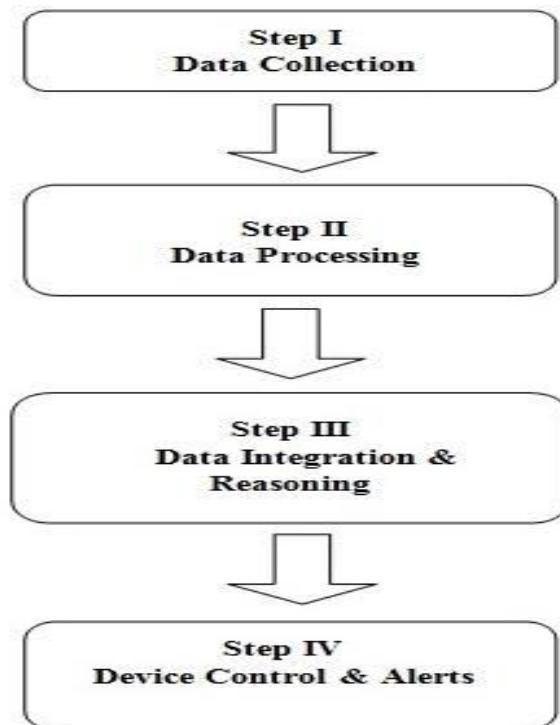

Fig 2.1: Steps of Smart City Data Architecture

[6] Refer to a paper by Nasrin Khansari, Ali Mostashari, Mo Mansouri, on "Conceptual Modeling of the Impact of Smart Cities on Household Energy Consumption" and is published in Conference on Systems Engineering Research (CSER) in the year 2014. The paper takes in account the behavioural patterns of users in terms of energy consumption. It signifies the importance of visible energy consumption to the users which makes him conscious about the amount he uses. The objective is to reduce the energy consumption which is a huge problem these days and lead towards sustainable urban development. The paper uses a CLIOS (Complex, Large-scale, Interconnected, Open and Socio-Technical) model to determine the behavioural effect of the user on the household energy consumption. Smart cities perform the best when their infrastructure is linked with the cutting edge technology and they are monitored in such a way that no misuse takes place. And once the user gets a good access to his resource consumption, he uses them even more wisely which subsequently leads to the conservation of resources.

[7] Refer to paper by Hafedh Chourabi, Taewoo Nam et.al., on "Understanding Smart Cities: An integrative framework" and is published in 45th Hawaii International Conference on System Sciences in the year 2012. The work defines Smart Cities as the strategy that is best suited for the sustainable development for the future. It gives due consideration to the fact that even today there is a broad gap between the academic researches and their on site implication that would have otherwise benefited the cause considerably. It outlines eight critical factors for a Smart City initiative viz. management & organization, technology, governance, policy context, people & society, economy, infrastructure and environment and discusses each of them in detail. It also states certain working definitions of the Smart City concept based on various factors and their interaction with the surroundings.

[8] Refer to a paper by Vanajakshi Lelitha. , Ramadurai, Gitakrishnan. , Anand ,Asha., on "Intelligent Transportation Systems: Synthesis Report on ITS Including Issues and Challenges in India" and is published by the Centre of Excellence in Urban Transport, IIT Madras in the year 2010. The paper describes Intelligent Transport System (ITS) as a measure of solving the traffic problems and if not then at least minimizing their severity. It identifies the components and classifications of the Intelligent Transport Systems and at the same time lists out the challenges that it has to overcome when it comes to Indian context. It

takes the examples and case studies of the leading countries in the world, from where suggestions and ideas can be taken and incorporated into the Indian scenario.

[9] Refer to a paper by Mahmoud Al-Hader, Ahmad Rodzi, Abdul Rashid Sharif, Noordin Ahmad, on "Smart City Components Architecture" and is published in the International Conference on Computational Intelligence, Modelling and Simulation in the year 2009. The paper aims at linking the Information and Communication Technologies (ICT) to the basic infrastructure in order to ensure an efficient monitoring of the resources and avoid their wastage as already the resources are too scarce. The key objective behind the objective is to set up a collective management database for a system of processing methods influence by a number of sub systems.

Chapter-3

Smart Cities- Features and Questionnaire Data Collection

3.1 Characteristics of a Smart City Project:-

Preparing a Smart City Proposal is a task that is totally dependent on the conditions of the area and its residents. There can never practically be a benchmark that will suit to every city, as every city has got its own unique demographic, geographic, economic constraints etc. However, the basic features that are needed can be identified and outlined which are parts of every person's daily life are listed below:-

- Housing opportunities for all; assuring a basic dwelling unit for every person.
- Managing road conditions in a way to create walkable localities with reduced congestion, better air quality, efficient resource usage and ensured security.
- Development of open spaces like parks, open spaces, recreational zones in order to create a healthy ambience for the residents and to minimize the effect of urban heat.
- Encouraging variety of transport options that are both sustainable in nature as well as efficient in their operational roles.
- Making an internet based framework for government services so as to reduce the proximity of corruption, enhanced transparency, to lower fatigue due to rush in offices and easier access to the common man.
- Defining an identity to the city that makes it stand apart amongst other cities of the nation in any sphere, be it economic, educational, culinary, technological etc.
- The application of Smart services to the core infrastructure and services is a good way to ensure their better performance. It will help in making them less prone to troubles, resource and cost efficient.

3.2 Six components of a Smart City Project:-

For any Smart City, even with different backgrounds, features and requirements, the key components remain the same. These are the main headers under which various facilities and amenities are to be provided. These determinants are:-

1) Smart Mobility
2) Smart Environment
3) Smart Living
4) Smart Government
5) Smart People
6) Smart Economy
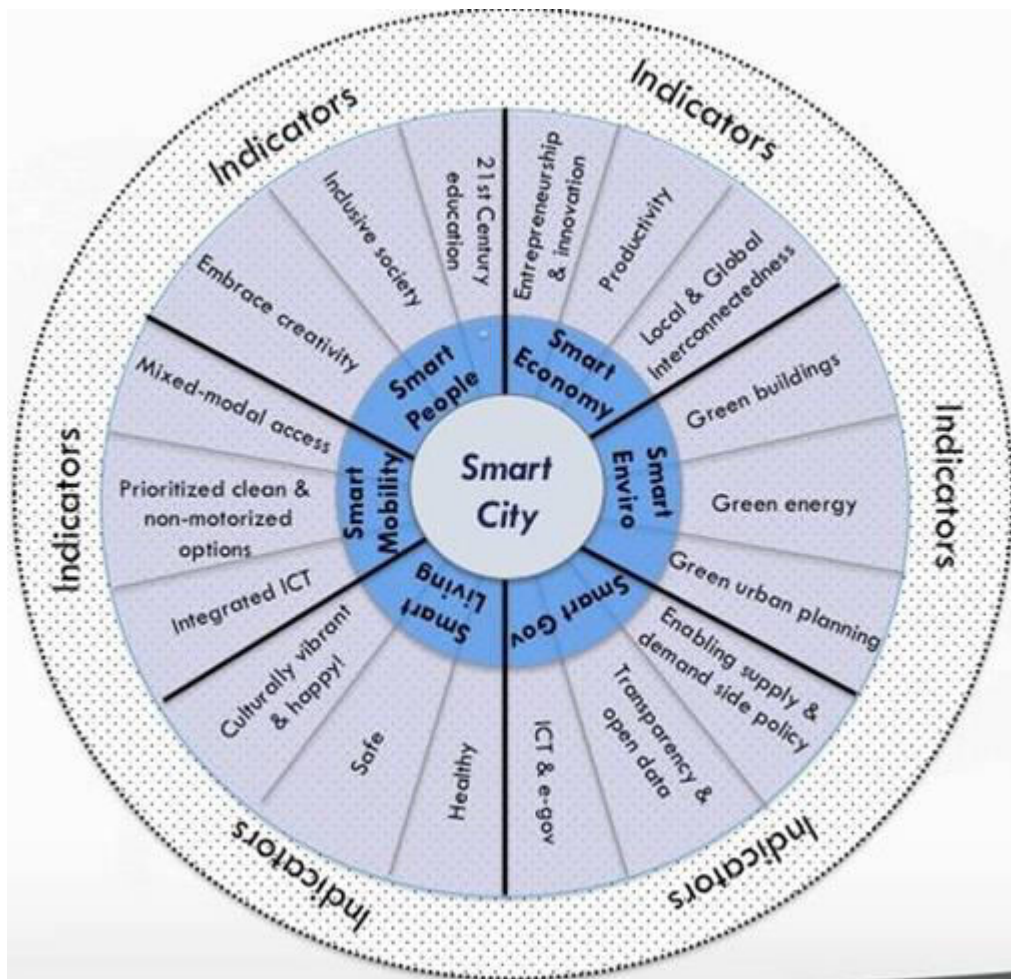
Fig 3.1: Six components of a Smart City

3.3 Brief Introduction of Indore

Indore is a city located on the southern edge of the Malwa Plateau. Known for the legacy of the Holkar Dynasty, it has emerged out as one of the most promising cities in the Central Zone. Housing equal opportunities for commerce, education and technological advances, the city was chosen in the first round of the Smart City initiative by the Government of India along with 19 other cities round the nation.

Some of the key features of the City Indore is:-

- Indore comes under the Tier-2 cities of India and is a home to nearly 2.5 Million inhabitants.
- Being the economic capital of Madhya Pradesh, it is often termed as "Mini Mumbai".
- It is the only city in the country having both IIT and IIM.
- The average literacy rate is fairly good counting up to a total of 85%.
- Offers quite a wide variety of cuisines and thus attracts a lot of tourist and food enthusiasts.

3.4 Questionnaire Survey

3.4.1 General

One of the best ways to design things that will be of help to the citizens is to know it from the citizens itself. And that is the time, when feedback/questionnaire surveys come to the rescue. The report involves conducting the following questionnaire survey with people from all walks of life and knowing their idea about what Smart City Indore should be like. The details of the questionnaire are as below:

3.4.2 Questionnaire Format

(Fill the boxes with appropriate information)

Email Address

Name

Contact Number

[   ]

Occupation

[   ]

(Tick the answer that you find the most suitable)

What is your idea of Smart City Indore?

Sustainable   [   ]
Economically Stable   [   ]
Well Educated   [   ]
Culturally Rich   [   ]

(Rate the options according to their importance in establishing Indore's identity)

What according to you is the key factor of Indore's Identity on the Map of India?

Very Low Priority (VLP)-1
Low Priority (LP) - 2
Moderate Priority (MP) -3
High Priority (HP) – 4
Very High Priority (VHP) – 5

Factors	Ratings				
	VLP	LP	MP	HP	VHP
Education Sector	1	2	3	4	5
Connectivity with major cities	1	2	3	4	5
Citizen Co-operation	1	2	3	4	5
Geographical & weather conditions	1	2	3	4	5
Employment opportunities	1	2	3	4	5
Culture	1	2	3	4	5
Heritage	1	2	3	4	5

Along with the above mentioned options, if there is any other factor(s) that you think that can be added to the list?

Rate the following features in the order of their importance for the city.

Features	Ratings				
	VLP	LP	MP	HP	VHP
Economy and Employment	1	2	3	4	5
Public Health and Sanitation	1	2	3	4	5
Smart Public Transportation	1	2	3	4	5
Efficient Waste Disposal and Recycling	1	2	3	4	5
Citizen Safety (Specially for the Aged ones, Women and the children)	1	2	3	4	5
Clean and Green Energy Sources	1	2	3	4	5
Internet based Government Departmental Services	1	2	3	4	5
Changes in the Educational Systems	1	2	3	4	5
Pan City IT Connectivity	1	2	3	4	5
Encouraging the use of green fuels	1	2	3	4	5
Public-Private Partnership Model in Government tasks	1	2	3	4	5
Industrial Suitability	1	2	3	4	5
Encouragement to Solar Energy Devices and subsidization by the Government	1	2	3	4	5
Metered LPG pipelines and Connections	1	2	3	4	5
Dedicated Pedestrian Areas	1	2	3	4	5
Updating the Policing Equipments	1	2	3	4	5
Conservation of Biodiversity	1	2	3	4	5
Heritage and Culture	1	2	3	4	5

Along with the above mentioned options, if there is any other feature(s) that you think that can be added to the list?

Choose the area that needs to be developed first under the Area Based Proposal of the Smart City.

(Tick the answer that you find the most suitable)

Rajwada   ☐

Chawni   ☐

M.G. Road   ☐

Palasia-Geeta Bhawan Zone   ☐

Juni Indore   ☐

Any Other area   ☐

In case of any other area apart from the listed ones, name the area.

☐

Which problem of Indore city annoys you the most?

(Tick the answer that you find the most suitable)

Increasing Traffic Congestion   ☐

Increasing slum problem due to migrants ☐

Water Crisis   ☐

Problem of scattered garbage and inefficient   ☐

Garbage collection mechanism.

Inefficient public transport   ☐

Increased Pollution and reduced air quality   ☐

Any other problem that seems troublesome to you and should be taken care of?

☐

What according to you will be the most suitable mode of public transport for the city?

(Tick the answer that you find the most suitable)

Metro Rail Network   ☐

BRTS Network   ☐

Tata Ace & Mini Vans ☐

CNG Driven Auto Rickshaws ☐

E-Rickshaws ☐

Bicycles at Rent ☐

What according to you is the best way to generate revenue which can be used for the Smart City Project?

(Tick the answer that you find the most suitable)

Encouraging Tourism through rejuvenating tourist spots ☐
and generating revenue out of them.

Attracting Investors in order to raise the industrial growth ☐

Encouraging Start-ups and entrepreneurship ☐

Introducing Public-Private Partnership Model in Project works ☐

Any other Ideas of revenue generation that you want to suggest?

Your Suggestions that can make Indore Smart?

Chapter-4

Results and analysis of the questionnaire survey

4.1 General

A total of 60 responses were expected and the questionnaire was sent for the same number. Out of which 42 responses have been received and analysed. Analysis of the responses has been done by Relative Importance Index (RII) and with the help of MS-Excel and SPSS (Statistical Package for the Social Sciences) software. While, RII has been used to assign rankings to the features according to the received responses, SPSS derived the correlation between those features signifying their dependency/independency and the statistical information for the single answer type questions. The pie charts have been deduced out of the statistical information provided with the help of MS-Excel.

The formula of RII is:-

$$\mathbf{RII} = \frac{\Sigma W}{(N * A)}$$

Where,

W= Priority given by each respondent ranging from 1 to 5.

A= Highest number of priority (5 in this case)

N= Total number of respondents.

The results of the questionnaire surveys are as follows.

In SPSS, Spearman Correlation coefficient has been used for the ranking based questions, in which a higher value of correlation coefficient of a factor with respect to the considered factor highlights a strong interdependency with each other and vice versa.

4.2 Responses of the Questionnaire Survey

1) What is your idea of Smart City Indore?
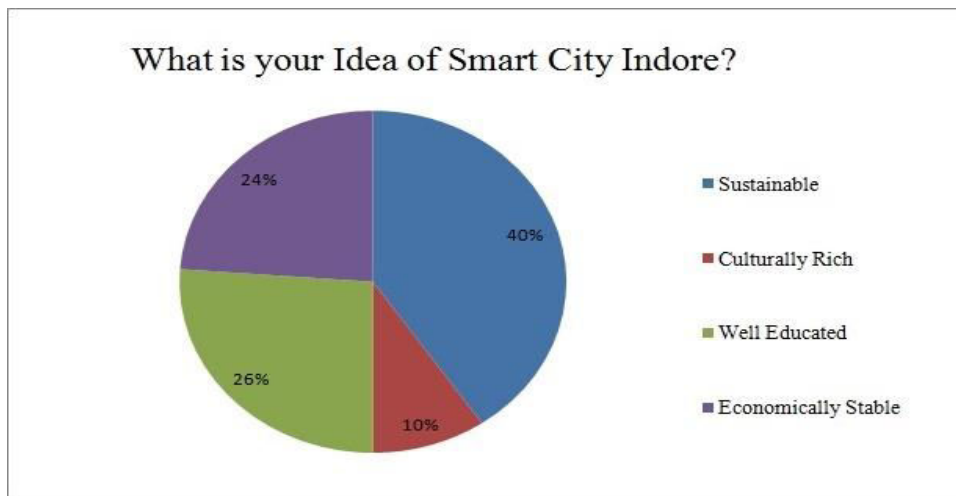
Fig 4.1 Public Response of Idea of Smart City Indore

2) What according to you is the key factor of Indore's Identity on the Map of India?

Table 4.1: Ranking allocation of Indore's Identity based on the responses

Factors	Relative Importance Index = ($\sum$W/ A×N)	Ranking
Education Sector	**0.728**	**1**
Connectivity with major cities	0.719	2
Citizen Co-operation	0.685	3
Geographical & weather conditions	0.676	4
Employment opportunities	0.671	5
Culture	0.652	6
Heritage	0.628	7

3) Along with the above mentioned options, if there is any other factor(s) that you think that can be added to the list?

a) Clean Indore

b) Cuisines

c) Local transport, Security etc.

d) Infrastructure Development

e) Special Economic & Political Significance for the State of Madhya Pradesh.

f) City Planning Practice

4) Rate the following features in the order of their importance for the city.

Table 4.2: Ranking allocation of features according to their importance.

Features required for the Smart City Indore	Relative Importance Index= ($\sum$W/ A×N)	Ranking
Economy and Employment	**0.814**	**1**
Public Health and Sanitation	**0.804**	**2**
Smart Public Transportation	**0.8**	
Efficient Waste Disposal and Recycling	**0.8**	
Citizen Safety (Specially for the Aged ones, Women and the children)	**0.8**	**3**
Clean and Green Energy Sources	**0.780**	**4**
Internet based Government Departmental Services	**0.761**	
Changes in the Educational Systems	**0.761**	**5**
Pan City IT Connectivity	**0.761**	
Encouraging the use of green fuels	**0.757**	**6**
Public-Private Partnership Model in Government tasks	0.733	7
Industrial Suitability	0.733	
Encouragement to Solar Energy Devices and subsidization by the Government	0.723	8
Metered LPG pipelines and Connections	0.719	9
Dedicated Pedestrian Areas	0.714	10
Updating the Policing Equipments	0.709	11
Conservation of Biodiversity	0.704	12
Heritage and Culture	0.695	13

🟥 **Factors identified as critical (RII>0.75)**

5) Along with the above mentioned options, if there is any other feature(s) that you think that can be added to the list?
   a) Sustainable Road Network
   b) Housing, Vehicles Parking, Hotels & Hospitality.

6) Choose the area that needs to be developed first under the Area Based Proposal of the Smart City.
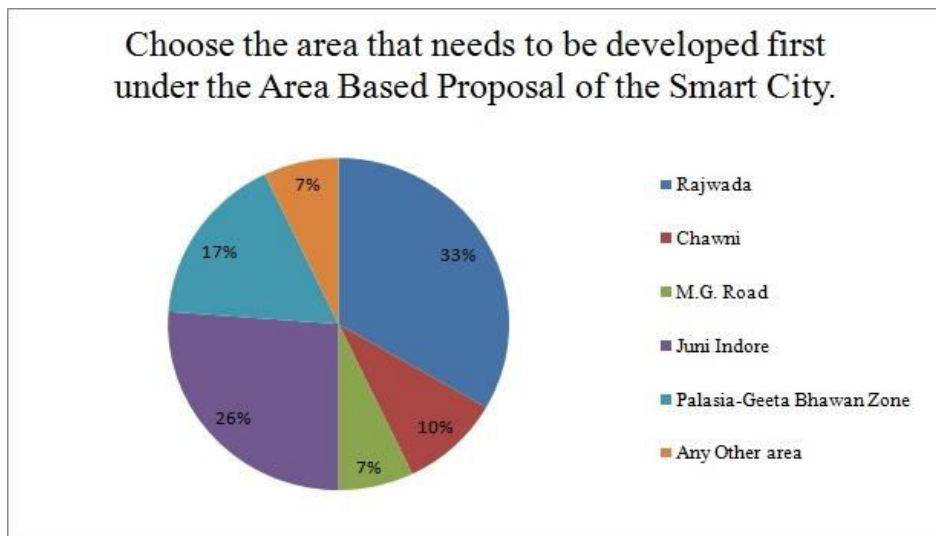
Fig 4.2 Public Response of Area based proposal

7) In case of any other area apart from the listed ones, name the area.
   a) Bhanwarkua
   b) Palda
   c) Bypass and Ring Road
   d) Annapurna Road
   e) Aerodrome Road
   f) Pardeshipura Area
   g) Khajrana Temple
   h) Malhargunj

8) Which problem of Indore city annoys you the most?
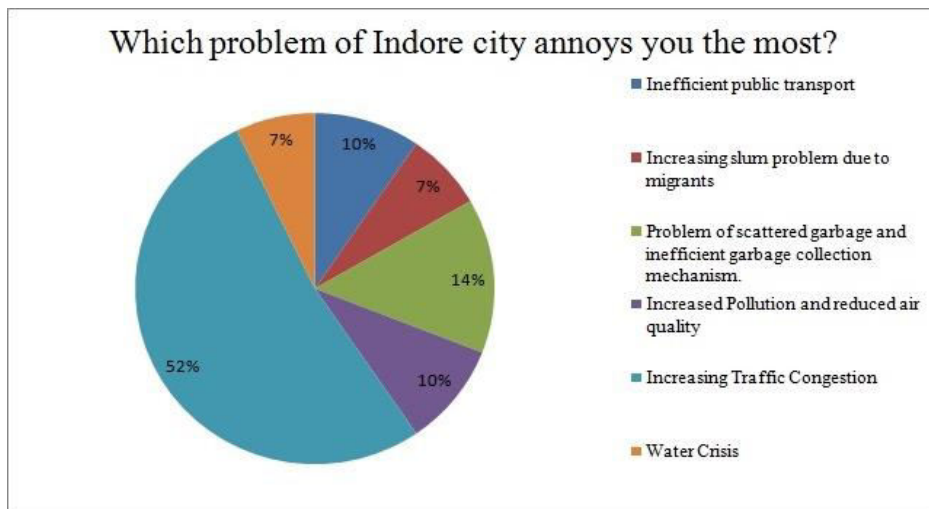
Fig 4.3 Public Response of the most annoying problem of Indore

9) Any other problem that seems troublesome to you and should be taken care of?

   a) Stray Animals

   b) Drainage Problem

   c) Improper Traffic sense in public

10) What according to you will be the most suitable mode of public transport for the city?
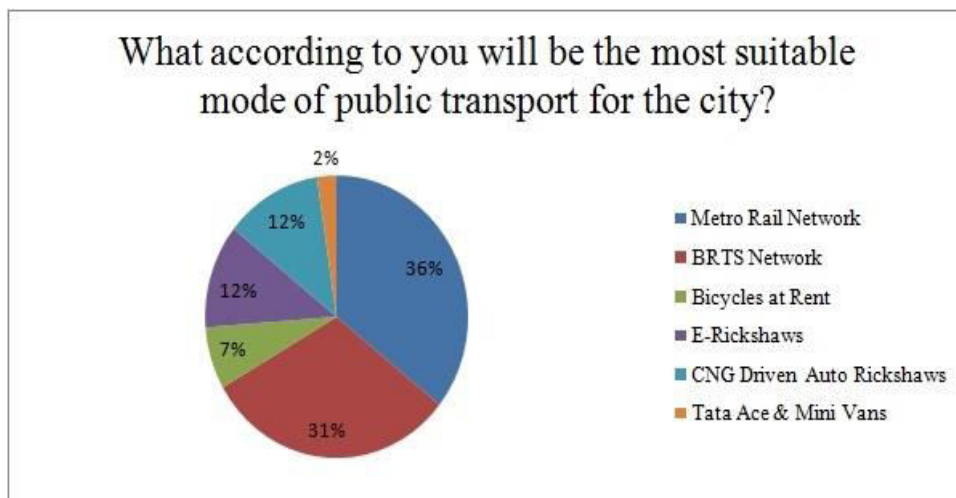
Fig 4.4 Public Response of the most feasible public transport mode

11) What according to you is the best way to generate revenue which can be used for the Smart City Project?
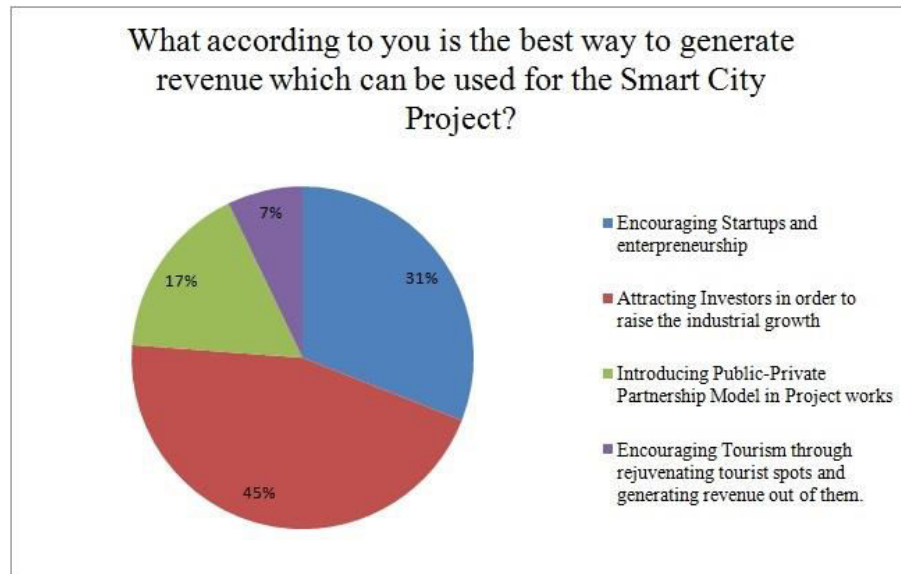
Fig 4.5 Public Response of the suggestions for revenue generation

12) Any other Ideas of revenue generation that you want to suggest?

   a) Transfer of development rights & FAR premium will generate revenue for the smart city development.

   b) Seeking Sponsor ship for organisation ready to help in development of City.

   c) Online Advertisement on City Website and Public Transports.

Chapter-5

Framework of Suggestions and Recommendations

On the basis of the responses received and the rankings allotted to the various factors accordingly, a framework of suggestions and recommendations has been drafted. Starting from the first question, the majority of respondents found that their Idea of Smart City Indore is a sustainable city. Now, the term sustainable has a broad range. Sustainability is the tendency of things and methods to serve for a long time with the maximum efficiency and minimum harm to the surroundings. Or in other words it can be said that a Sustainable system meets the human development goals without affecting the ecological equilibrium. It can be adopted in the context of Smart Cities in the following ways:-

1) **Sustainability:-**

a) The maximum consumption of energy takes place in transportation and industries and while most of them depend on the fossil fuels, these areas are the ones that need to be taken care of first. While in transportation, it can be done by encouraging people to reduce the usage of personally owned vehicles and try to utilize the public means of commutation more. Moreover, encouraging the use of bio fuels, electricity driven automobiles can also prove to be helpful.

b) One such feature that is quite in vogue in the western countries is "Bicycles at Rent". At the stoppages of public transport means, these kiosks operate. From there, a commuter can take a bicycle up to near distances and leave it at the nearest kiosk after paying the due rent. Thus, while a person can take public transport means like buses, metro railways for long distances, shorter ones can be traversed by this way. And since these bicycles are GPS enabled, the kiosks are always aware about the location of the device.

c) Similar is the case of industries, where from the very first step of sorting raw materials to manufacturing and then packaging finally, everything requires energy. These machines are either fossil fuels driven or work on electricity. Now, since in our country the major portion of electricity is still devised from Thermal power plants which offer a considerable loss to the environment owing to their hazardous smoke output. Instead, the industries should opt for their own power feeders with the help of solar energy devices. Though, it will increase the initial cost of setup, the long term benefits are totally worth the investment.

d) Not only in terms of energy, should sustainability be exercised in various other operations like construction, agriculture, food processing etc. As a Smart City is nothing but a combination of smart components. As in construction, the design of the structure and the materials used should be the one that requires the least energy consumption and minimum waste generation. The same goes for agriculture which is largely affected by the increased usage of chemical fertilizers and pesticides leaving both the crop as well as the land unhealthy. Instead of them, natural manures and pest repellent should therefore be used to keep the environment and the edible products healthy.

2) **Well Educated:-**

a) Education is undoubtedly an inevitable part of our lives now and this was evident from the responses. A city is made of its people and it will obviously be as smart as its people. Thus, it is one component that is to be included in the list.

b) Since a long time, Indore has kept its position in the Central and Western Indian Zone in terms of education. Owing to the standard level of infrastructure, quality of education and affordable fees, Indore emerged out as the education hub in the region.

c) However, the situation has changed in the recent years. The quality which was once the key point started degrading and fees structure surged. Increasing number of institutions without the required infrastructure, experienced faculty produced inefficient professionals. And, since a smart city can not exist without smart brains working for its improvement, the changes in education sector are required with immediate effect.

d) The range of education at most of the places now is confined to mere allotment of certification. The innovative component of education has somewhere been forgotten and that shows in the figures that state the unemployability of youth these days due to their non-suitability for the job.

e) What needs to be done is to balance the curriculum with the theoretical as well as the application part of the same. Granting allowance to only those institutions that fulfil the eligibility criteria and infrastructural requirements is one of the steps that needs to be exercised strictly in order to offer quality education.

f) It is also necessary to follow a strict guideline before granting sanctions to educational institutions. Only those who fulfil the required criteria should be allowed to establish schools and colleges and no external pressure should be tolerated for granting acceptance to the ineligible ones.

g) Moreover, there needs to be an impartial body setup that reviews the fees charged by the institutions time by time. Irrelevant hikes make it difficult for students from humble backgrounds to access the corridors of education and thus failing the objective of an educated society that forms a Smart City.

3) Economically Stable:-

a) The whole world is in a state of economic turbulence at this time and thus economic suitability is one parameter that needs to be had a strong grip on. There are various ways through which the economy can be strengthened, out of which some of them are discussed here.

b) Encouraging the use of country made goods will help in increasing the Gross Domestic Product and reduce our dependence on imported goods which cost a tremendous sum to the country. And since the country's money will circulate within the country only, the economic health will by default improve.

4) Economy and Employment:-

a) Economy of any city or country is the backbone of its development model because no work can be done without a strong base of monetary support. And for a Smart City, where things are supposed to and edge sharper than the normal ones, no ordinary implications can be adopted.

b) If sustainable development is the aim, then the initial investment is going to be higher certainly but it's worth the long term benefits that come with it.

c) To strengthen the economy, a city should have an equal level of feasibility for the entrepreneurs and service sector. Because both of them are a complementary part of each other and cannot function separately.

d) Employment opportunities will rise when more new ventures will come into existence and will need employees to function it. By far, Indore has shown a promising performance towards encouragement to entrepreneurship. However, it could have been better if certain changes can be introduced.

e) Clearance and issuing of licences to business holders should be done through a single window system with the least possible time consumption in irrelevant paper work and formality issues.

f) For innovative ventures with a well defined plan but limited resources, government subsidies should be granted in order to make them possible.

g) Vocational training centres should be encouraged in order to make the students capable of fitting in the industry, because in the past few years the education specifically in professional courses has been limited to mere allotment to certificate and degrees and hence caused a considerable increase in the unemployment index.

5) Smart Public Transportation:-

a) It was clearly evident from the survey that a major portion of the respondents found traffic congestion and transport related issues a major problem. And it is an obvious thing, owing to the fact that the population has increased many folds and commuting to places has become quite cumbersome and difficult. Since the largest portion of general and economical transportation takes place through the roadways only, roads have became a crowded place where wastage of time and fuel takes place.

b) Another thing is the environmental effect of the exhaust from the vehicles. The main fuel used these days is derived out of the fossil components that leave Green House Gases after combustion which are the key culprits behind the pronounced Global Warming phenomenon.

c) So, the thing sums up to finding an Intelligent transportation system, which is described now in detail:-

Intelligent Transportation Systems (ITS):- ITS is a recently emerged term that has been widely adopted across the globe as a trouble-shooter for traffic and inefficient transport related issues. It involves combing the Information & Communication Technologies (ICT) to the pertaining transport infrastructure in order to improve their efficiency, provide real time monitoring and policing for enhanced safety, give users the access to the information of public transport means and many other things. ITS in broad terms are classified as below:-

i. **Advanced Traffic Management System (ATMS):-** ATMS is an integral framework of various sub systems like CCTV devices, vehicle detection, alert messaging systems etc that makes a single interface which is responsible for providing real time data about the traffic status and predicts traffic conditions so that in case of any hindrance ahead, the user may have ample time to plan his change of route.

Fig 5.1: Example of ATMS

ii. Advanced Traveller Information Systems (ATIS):- ATIS directly assists the users in making route decisions, calculating travel times and evading congestions. It is generally done by providing technologies like GPS enabled in-vehicle navigation systems, dynamic road signs that give real time information about the road and traffic conditions, internet based support in terms of maps showing density and volume levels on highways.

Fig 5.2: Example of ATIS

iii. Advanced Vehicle Control Systems (AVCS):- AVCS is an efficient technology driven tool that improves the driver's control over the vehicle in order to make travelling safer. In Vehicle collision alert systems, the driver is warned about a probable collision with an

approaching vehicle so that he may avoid it. In some even higher versions, the vehicles can themselves steer away or break automatically in a collision like situation when the warnings were left unattended by the driver.

Fig 5.3: Example of AVCS

iv. Commercial Vehicles Operation (CVO):- CVO works with the help of navigational systems and communication devices for commercially operating devices. The system helps in constant monitoring and tracking, thus ensuring the safety of the persons and goods carried in those vehicles.

v. Advanced Public Transportation Systems (APTS):- APTS is used for the ease of access to public transportation networks. It involves real time passenger information systems, vehicle location systems, arrival and departure notification systems and transit signal priority.

Fig 5.4: Example of APTS

vi. Bus Rapid Transport System (BRTS):- BRTS has been implemented in India and has been fairly successful. It is a way in which a particular lane on the road is assigned solely to the public transportation vehicles in order to avoid congestion and their swift moving. The following cities have either functioning or planned BRTS corridors in India:-

Table 5.1: List of Indian Cities with BRTS Networks

City	BRTS Network
Pune	Pune BRTS: One corridor (Katraj-Swargate-Hadsapar)
Delhi	Delhi BRTS: One functioning and one planned.
Ahmedabad	Ahmedabad BRTS: One functioning and 17 under construction
Indore	Indore BRTS: One corridor (Niranjanpur to Rajiv Gandhi Square)
Mumbai	Mumbai BRTS: 7 corridors
Hyderabad	Hyderabad BRTS: 2 corridors
Bangalore	Bangalore BRTS: 17 corridors planned
Chennai	Chennai BRTS: 1 planned
Coimbatore	Coimbatore BRTS: 1 corridor planned
Jaipur	Jaipur BRTS: 4 corridors
Madurai	Madurai BRTS: 2 corridors
Nagpur	Nagpur BRTS: 1 corridor
Vijaywada	Vijaywada BRTS: 2 corridor
Vishakhapatnam	Vishakhapatnam BRTS: 2 corridors.

d) Though a step has certainly been taken towards ITS in India, but then too there are certain things that need to be tackled. There are still challenges that need to be addressed. Some steps are mentioned herewith that can be taken to make an efficient ITS exist:-

e) A standard code for ITS applications in the country needs to be devised

f) A dedicated bureaucratic body for clearing the ITS projects in time and without long formalities.

g) Setting up of Traffic Management centres for real time traffic data collection and analysis to draft out patterns that can be used further.

h) Encouraging more interaction between academia and industry to implement the best possible research that can leave fruitful results.

6) Pan city IT connectivity:-

a) Internet has made the world a small town well connected within. It has indeed made things easier and more accessible. Its application in Smart Cities is pivotal and without its proper involvement, the project can never be a success

b) Pan City IT connectivity deals with providing ICT access throughout the city in order to make the infrastructure linked with it and help in making things easy through it. It will help making data collection and analysis more transparent and accurate. Generating patterns out of it and using it to find solutions for the troubles that might be occurring in the operation.

c) Along with it, linking the government services with ICT will make them more transparent, easily accessible and corruption free. It has been a problem since long that the government departments faced a lot of rush of users which caused a decreased efficiency in their work. It can be combated with networking techniques where every single person can access government services at their location without the need of visiting the offices facing the long queues and wastage of time.

d) And since, creating a network based framework for government services will need the help of professionals of the relevant fields creating employment opportunities for the same.

7) Public Health and Sanitation:-

a) Health is a major concern for the government as once it moves out of the hands it takes a lot of time and resources to restore it.

b) For a Smart City, the health services need to be of the top quality along with the fact that they should be easily accessible and affordable for every strata of the society.

c) There can be a centralised database recording details of the citizens and issuing smart cards for the same so that in the case of an emergency, the treatment can begin quickly instead of being stuck in formalities.

d) Though a lot of places in the country have become open defecation free, some are still left. The idea should be to maintain a good level of hygiene in the area so as to avoid the contaminative diseases later. In every locality community toilets and urinals should be installed, encouraging the people to quit on foul practices of open defecation and urination.

e) Potable water is a critical issue these days and at the same time unhygienic water is a host to several water borne diseases. Since the water resource is getting scarce day by day, metered connections can be installed. It can help in ensuring a quality supply of water as well as reduced wastage by the people as they will have to pay according to the metered quantity.

Chapter-6
Conclusion and Future Scope

7.1 General

1) Smart city initiative is quite new for the Indian context and that too with no standard benchmark. So, it was a mandatory thing to know the people's views and expectations regarding their version of Smart City.

2) The questionnaire was done with the motive to know the expectations of the residents as to what they want from their Smart City? Out of the expected number of responses that was 60; the reception of 42 responses was appreciable and helped a lot in framing the structure of this project.

3) Suggestions and recommendations have been deduced on the basis of those responses only, so that those particular areas can be focussed well. Areas like sustainable approaches, pan city IT connectivity, employment opportunities, changes in education system, smart transportation systems and public health and sanitation have been identified as the features that are crucial for the transformation of an ordinary city into a Smart City.

4) With the help of SPSS software, the correlations between features have been identified so as to find out the dependency/independency of the features over each other. For instance, employment opportunities are strongly dependent on the quality of the education imparted by the city institutions. These correlations will be beneficial to make sure that the amenities are improved simultaneously so as to achieve more resource efficiency.

7.2 Future Scope

1) Smart City concept is new for India and somewhat difficult too, owing to the economic and diversity constraints of the country but is totally achievable. The only thing that is needed is to have the will power and adequate planning for the same.

2) The project has got a tremendous scope to be extended in future as there is a lot to be done and individual factors can be taken in consideration and developed accordingly. Smart cities have a combination of various spheres of operation like economical, technical, environmental, governmental etc. They have a lot of horizons to be explored in their individual fields.

3) As far as the role of civil engineering is considered in the development of a Smart City, the modules of Smart Transportation and Smart Environment are commanded by the field and dealing them in sustainable ways will require new researches and offer the scholars ample opportunities to look for new approaches and strengthening the link between industry and academia through it.

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Appendix

Factors	R 1	R 2	R 3	R 4	R 5	R 6	R 7	R 8	R 9	R 10	R 11	R 12	R 13	R 14	R 15	R 16	R 17	R 18	R 19	R 20	R 21
What according to you is the key factor of Indore's Identity on the Map of India? (Very Low Priority=1, Low Priority=2, Moderate Priority=3, High Priority=4, Very High Priority=5) R_n= No. of the respondent																				
Education Sector	4	3	4	3	4	5	2	3	5	4	4	5	3	2	4	4	4	4	5	4	3
Culture	4	3	2	3	3	4	1	2	4	4	3	4	4	4	4	3	4	3	3	3	2
Heritage	3	3	3	2	3	3	2	3	3	4	3	4	5	4	3	4	3	3	3	3	2
Employment Opportunities	5	3	4	3	3	4	2	2	5	4	4	4	2	2	3	4	3	4	4	3	3
Geographical and Weather Conditions	4	3	2	4	3	3	2	3	3	4	3	5	4	4	3	3	3	4	2	5	3
Citizen Co-operation	3	3	4	4	4	3	2	2	4	3	3	4	4	3	4	4	4	4	3	4	3
Connectivity with major cities	4	4	4	4	3	4	2	3	4	4	3	3	3	2	3	5	3	5	5	5	4

Factors	R 22	R 23	R 24	R 25	R 26	R 27	R 28	R 29	R 30	R 31	R 32	R 33	R 34	R 35	R 36	R 37	R 38	R 39	R 40	R 41	R 42
Education Sector	3	5	5	3	4	3	4	4	4	3	3	3	4	3	2	3	4	3	3	3	5
Culture	4	5	3	4	3	3	4	2	4	3	3	3	3	3	2	3	5	2	2	4	5
Heritage	4	5	3	4	3	3	3	2	5	3	3	3	2	3	1	3	4	3	2	3	4
Employment Opportunities	4	5	4	4	4	3	4	3	4	2	2	2	3	2	2	3	5	3	3	3	5
Geographical and Weather Conditions	3	5	5	2	4	4	3	3	4	3	3	3	4	3	3	4	3	2	2	5	4
Citizen Co-operation	4	5	5	3	4	3	2	3	5	3	3	2	4	4	1	2	5	3	2	5	4
Connectivity with major cities	4	5	4	4	4	4	4	4	5	1	1	1	4	4	2	4	4	3	3	5	4

What according to you is the key factor of Indore's Identity on the Map of India?

Factors	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21
Pan City IT Connectivity	4	4	4	3	4	5	2	3	5	4	3	3	5	4	3	5	4	4	5	4	4
Smart Public Transportation	4	4	2	4	4	5	2	3	5	4	5	4	4	5	5	5	4	5	4	4	4
Metered LPG Pipelines and Connections	4	3	1	4	3	5	2	3	4	3	4	4	5	5	3	5	4	4	4	4	2
Encouragement to Solar Energy	4	3	4	4	4	4	2	3	4	3	3	4	4	4	5	4	4	5	4	5	2
Economy & Employment	5	3	4	3	4	5	2	4	5	3	4	5	5	5	5	4	4	4	4	5	4
Public Health & Sanitation	5	3	5	5	4	5	1	5	5	3	4	5	5	4	5	3	4	4	3	4	3
Updating the Policing Equipments	4	3	4	3	4	3	1	3	4	3	3	5	4	3	5	3	4	5	3	4	3
Heritage and Culture	4	4	2	3	3	3	2	4	3	4	3	3	4	3	5	3	4	3	3	4	3
Dedicated Pedestrian Area	4	3	4	4	4	3	1	4	4	3	3	4	5	3	4	4	4	4	2	5	4
Changes in Education System	5	4	4	3	4	5	1	4	3	4	3	3	5	5	5	4	4	5	4	5	3
Encouraging the use of green fuels	5	3	3	3	5	5	2	4	4	3	3	5	4	4	5	3	4	3	4	5	2
PPP Model in Government tasks	5	4	3	3	5	4	2	3	4	3	5	5	5	5	4	3	4	3	3	5	3

Rate the following features in the order of their importance for the city.

Factors	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21
Internet based Government services	5	4	4	4	5	5	2	4	4	3	5	3	5	4	4	2	4	4	1	4	4
Efficient Waste Disposal and Recycling	5	3	5	4	5	5	1	4	4	3	5	5	5	4	5	3	5	3	4	5	3
Citizen Safety	5	4	5	4	5	4	1	4	5	4	5	4	4	4	4	5	5	2	4	5	3
Conservation of Biodiversity	4	3	4	3	4	3	1	4	4	3	3	4	4	3	4	3	5	2	4	5	3
Industrial Suitability	5	4	3	3	3	4	2	4	4	4	3	4	3	5	3	4	4	2	5	5	4
Clean and green energy sources	4	4	5	3	5	4	2	4	4	3	3	5	4	5	5	4	5	4	5	5	4

Rate the following features in the order of their importance for the city.

Factors	R 22	R 23	R 24	R 25	R 26	R 27	R 28	R 29	R 30	R 31	R 32	R 33	R 34	R 35	R 36	R 37	R 38	R 39	R 40	R 41	R 42
Rate the following features in the order of their importance for the city.																					
Pan City IT Connectivity	4	4	4	3	4	5	2	3	5	4	3	3	5	4	3	5	4	4	5	4	4
Smart Public Transportation	4	4	2	4	4	5	2	3	5	4	5	4	4	5	5	5	4	5	4	4	4
Metered LPG Pipelines and Connections	4	3	1	4	3	5	2	3	4	3	4	4	5	5	3	5	4	4	4	4	2
Encouragement to Solar Energy	4	3	4	4	4	4	2	3	4	3	3	4	4	4	5	4	4	5	4	5	2
Economy & Employment	5	3	4	3	4	5	2	4	5	3	4	5	5	5	5	4	4	4	4	5	4
Public Health & Sanitation	5	3	5	5	4	5	1	5	5	3	4	5	5	4	5	3	4	4	3	4	3
Updating the Policing Equipments	4	3	4	3	4	3	1	3	4	3	3	5	4	3	5	3	4	5	3	4	3
Heritage and Culture	4	4	2	3	3	3	2	4	3	4	3	3	4	3	5	3	4	3	3	4	3
Dedicated Pedestrian Area	4	3	4	4	4	3	1	4	4	3	3	4	5	3	4	4	4	4	2	5	4
Changes in Education System	5	4	4	3	4	5	1	4	3	4	3	3	5	5	5	4	4	5	4	5	3
Encouraging the use of green fuels	5	3	3	3	5	5	2	4	4	3	3	5	4	4	5	3	4	3	4	5	2
PPP Model in Government tasks	5	4	3	3	5	4	2	3	4	3	5	5	5	5	4	3	4	3	3	5	3

Rate the following features in the order of their importance for the city.																					
Factors	R 22	R 23	R 24	R 25	R 26	R 27	R 28	R 29	R 30	R 31	R 32	R 33	R 34	R 35	R 36	R 37	R 38	R 39	R 40	R 41	R 42
Internet based Government services	5	4	4	4	5	5	2	4	4	3	5	3	5	4	4	2	4	4	1	4	4
Efficient Waste Disposal and Recycling	5	3	5	4	5	5	1	4	4	3	5	5	5	4	5	3	5	3	4	5	3
Citizen Safety	5	4	5	4	5	4	1	4	5	4	5	4	4	4	4	5	5	2	4	5	3
Conservation of Biodiversity	4	3	4	3	4	3	1	4	4	3	3	4	4	3	4	3	5	2	4	5	3
Industrial Suitability	5	4	3	3	3	4	2	4	4	4	3	4	3	5	3	4	4	2	5	5	4
Clean and green energy sources	4	4	5	3	5	4	2	4	4	3	3	5	4	5	5	4	5	4	5	5	4