Designing Innovative Smart City:

User-Centric Framework and Inclusive Strategy

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Degree of

Doctor of Philosophy

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DECLARATION

I, Abhishek Singh, declare that the research work comprised in this thesis entitled "**Designing Innovative Smart City: User-Centric Framework and Inclusive Strategy**" is my own work and carried out under the guidance of Prof. Pratul Ch. Kalita, at the Department of Design, Indian Institute of Technology Guwahati, Assam, India. It contains no materials previously published or written by another person or a significant proportion of material for the award of any other degree or diploma, except where otherwise indicated and due acknowledgement is made in the thesis. I also declare that the intellectual content of this thesis is the product of my own work.

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This is to certify that the research work presented in this thesis entitled "**Designing Innovative Smart City: User-Centric Framework and Inclusive Strategy**" has been carried out under my supervision and submitted by Mr. Abhishek Singh. This work submitted for the degree of Doctor of Philosophy is original and has not been submitted elsewhere for the award of any other degree or diploma.

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TABLE OF CONTENT

Page No.

Page No.

List of Figures

Page No.

Page No.

Page No.

List of Flowcharts

List of Tables

Abbreviations Used in the Thesis

3D - Three Dimensional

AI – Artificial Intelligence

CAGR – Cumulative Annual Growth Rate

CCTV - Closed Circuit Television

CDFI - Centre for digital Financial Inclusion

CISCO – Corps Information System Control Officer

E Tail – Electronic tail (Online retails)

FDI – Foreign Direct Investment

FSSDSC - Framework for Sustainable and self developing smart cities

GWh – Giga Watt hour

IBEF - India Brand Equity Foundation

ICRIER - Indian Council for Research on International Economic Relations

ICT – Information and Communication Technology

IICM - Issue Identification and Categorization Matrix

IOT – Internet of Things

IT – Information technology

LEED - Leadership in Energy and Environmental Design

NCR – National Capital Region

QN – Question Number

RIM - Research Introspection Matrix

SC - Smart City

UAE - United Arab Emirates

UK – United Kingdom

UN – United Nations

US / USA – United States / United States of America

USD – United States Dollar

WPP – World Population Prospects

Abstract

The trend of Smart Cities has fascinated the ambitions of citizens and Governments worldwide. This race has led to the development of huge infrastructures embedded with Hi-tech services for the comfort of city dwellers. In many places, it was observed that the technology was adopted blindly without analyzing the prevailing conditions of the area or the requirements of the population. It resulted in the development of hi-tech ghost towns around the globe. After the completion of such hi-tech townships, policy makers face difficulty attracting occupants. It raises the question of whether to consider such hi-tech projects successful, where technology and environmental realms have attained a level of sanctity but failed to include a human scale.

A critical review of the literature on Smart Cities was done to understand their existing scenario. Researchers of Smart Cities have claimed that the smart city concept is specific to geography, demography, and local context. The insights of the literature review were compared with a series of existing smart cities to correlate the research published with the actual facts and fates of the smart city projects globally. The insights of the case studies have reinforced those of literature reviews, and the analysis found that a bottom-to-top approach is more fruitful than a top-to-bottom approach when planning Smart Cities. The preference should always be given to the end user and planned accordingly. It is very important to develop a framework to incorporate the requirements of the end users and systematically incorporate them when planning Smart Cities. With the same view, the research aims to develop a strategic design management model for designing user-centred Smart Cities. The objectives of the

research are: 1. To introspect the requirement of the local demography to understand their expectations from the cities they want to live in. 2. To identify a set of parameters in which the user requirements can be categorized for systematic resolution through design intervention for the holistic development of Smart Cities. 3. To develop a user-centric innovation management tool that will help in designing/redeveloping any smart city.

In this research, a framework was developed to incorporate all facets of Smart Cities during the designing and developing stage. The research has followed a step-by-step method to first identify the issues and requirements of the city dwellers, followed by segregating the issues and requirements into suitable categories. These issues were then dealt with using different design interventions per their categories. A sample intervention was done for all types of categories identified, forming the framework for designing an intelligent smart city.

All the proposed interventions were validated through 3D Modelling, Product development, grant of Utility patents, and grant of Design Patents (Registration), and user study data were also found to give significant improvement from the prevailing conditions when evaluated by the system usability scale. This framework will be very useful in developing a well-planned user-centred smart city while covering all the facets of Smart Cities.

Chapter 1

Introduction to Smart Cities, Issues, and Challenges in Indian Context and Demography

The path of a nation to move from under-developed to developed status requires well-planned infrastructure growth to have sustainable development. Since one of the indicators of development of any nation is the type of infrastructure in their urban setup, these urban setups are further upgraded depending on the needs and innovative interventions adopted to form Smart Cities. Smart Cities signify a framework for urban development with human requirements and technology as the foundation for the development of urban setup (Angelidou, 2014). In the Literature review it was found that the Smart Cities are perceived in different ways by different researchers. But majority of the recent literature focus on the embedment of information and communication technology (ICT) in the cities for better understanding the cities and accordingly projecting the future requirement. Big data is another buzz word in smart cities in recent literature. Developing a smart city is a continuous process, the latest advancements in the technologies, Internet of Things (IOT), ICT, etc are all to be incorporated in the cities to make them smarter. Various definitions of smart cities are coined by researchers and some of them are quoted in the literature review as under.

Whereas as per few researchers A Smart city is a well planned urban space with all basic utilities and services connected to a network for easy access of all the citizens with the help of advanced technology and sensors. These technologies helps in collecting data, monitoring the city activities, analyzing the data for future prospects and accordingly projecting future requirements. All this is done to improve the quality of life and sustainable growth.

Big Challenge - In this race of developing smart cities by the policy makers it was observed that multiple smart cities were developed and huge amount of funds were invested in

these projects but these cities were not able to get good response from the citizens in terms of occupancy in these cities. Multiple state of the Art smart cities were developed around the globe but were converted into ghost towns. After multiple interventions from the policy makers and the local bodies these cities have started to get some response from the citizens after a decade of their commissioning. These state of the art Smart Cities were replicas of already build smart cities and were further improved with embedment of latest technologies. Hence there was a missing link, why these smart cities were not getting the required acceptance by the end users?

To understand the reasons for poor response of the citizens in the smart cities a series of literature and research papers on these smart cities were analyzed. It was found that the requirements and priorities of the citizens were not taken into consideration while planning these smart cities. These cities were planned for a specific target group of people. But it was not thought through that for those people to sustain a whole bunch of service providers are required. Even if all the services are automated, people will not accept it over night and mega transitions like converting all human based services into automation should be done in a phased manner for better accustomed citizens.

Hence instead of developing smart cities for specific segment of the society, the approach should be to understand the demography of the area in which the smart city is being planned. This will lead to incorporate all the segments of the society available in the area and hence will increase the acceptance of the smart cities. After understanding the demography of the city, their requirements are to be taken into consideration for higher satisfaction levels.

As a part of the research, a user study of the aspirations of citizens for an ideal city was conducted. It was found that unorganized retail and local transport systems were preferred by the users since they interact with these entities on day to day basis. They preferred these services to be within walking distance from the residence for their day-to-day life. On the other hand when the status of these local small scale service providers were studied through the economic reports issued by the Government, it was found that unorganized retails are majority population in any society and the livelihood of this majority population chunk is under threat by the entry of organized and online stores. The lower middle class and the middle class are shifting towards the mall culture, and the share of unorganized retail is dropping very fast.

With the entry of COVID-19, online stores have seen a massive boom. During COVID-19, all the cities have faced lockdowns and work-from-home for multiple months. Even shopping for day-to-day activities was being done online and all the services and products were delivered at the doorstep of residents. People have started enjoying new levels of comfort being delivered at their doorsteps. This has severely affected the share of the unorganized working population and retail in the Indian market scenario. On one hand the cities are moving to a more digital world, but countries like India where more than 70 % of the working population are from the unorganized sector are facing difficulty in sustaining their share in the market.

Whereas the smart city policies of India were also not very clear about the inclusion of unorganized retail in the smart city format for Indian cities. The policies of the Government are more inclined towards organized retail formats. It is clear from the liberal economic reforms adopted by the Government for Foreign Direct Investment (FDI) in the sector of retail. The

employment linked with unorganized retail is very large and hence including them in the transforming nation will be a very important social perspective. Otherwise it may affect the social fabric of the country and increase the economic disparity.

In this thesis we have covered how the Smart cities are perceived by the different researchers, followed by studying some of the success and some less successful smart cities. From these literature reviews it was found that the demography and the geography of any locality plays very vital role in planning an efficient smart city. It was observed that user requirement also play a vital role in designing a successful smart city.

After going through the literature review and the user study the following research questions were formed-

- How can we introspect the requirement of the local demography to understand their expectations from the cities they want to dwell in?
- How can the requirement of the end users of Smart Cities be categorized into well-defined parameters for systematic resolution through design intervention for the holistic development of Smart Cities?
- How can a user-centric innovation management tool be developed that will help in designing/redeveloping any smart city?

One such nationwide project is taken up by the Government of India it is known as “Smart City Mission of India”. It is one of the major steps by the policy makers for establishing smart cities in India. “Smart Cities Mission was launched by the Hon’ble Prime Minister of India on 25 June, 2015. The main objective of the Mission is to promote cities that provide core

infrastructure, clean and sustainable environment and give a decent quality of life to their citizens through the application of 'smart solutions'. The Mission aims to drive economic growth and improve quality of life through comprehensive work on social, economic, physical and institutional pillars of the city. The focus is on sustainable and inclusive development by creation of replicable models which act as lighthouses to other aspiring cities."

We planned to analyze the projects in Smart City Mission as a part of our research. Hence a city was selected from the Smart city mission for our research i.e Guwahati city. Studying a complete city itself is a very massive work, so due to time and resource constraints few locations of the cities were selected based on the level of human interaction by the city dwellers.

Problem addressed in the thesis –In our research we have first analyzed the demography of a given city to identify the end users. Then we have collected data from the end users to understand their requirement with respect to the city planning. After collecting all the data from the users, data was analyzed and segregated in to strategic parameters for developing technical solution. It was observed that there are multiple issues where town planning literature was not having significant solution and hence for addressing all the issues the literature from design studies were also analyzed. In literature review of Design studies subdivisions like product design, space design, system design and service design, was quoted in many literatures.

It was also found that majority of Architecture and Town Planning concerns are covered in space design component of the design field. Hence we need to widen the level of interventions

to have a holistic approach for all kinds of solutions to be proposed for all kind issues/concerns of the end users.

Hence we have considered four different parameters of design interventions:

1. Product design
2. Space Design
3. Service Design
4. System Design

Earlier the scope of Town planning was limited to space design and upto some limit system design in which basic facilities like electricity, water, sewerage network and waste management was covered. But there were large number of issues of the end users which were left unattended. If we are designing a smart city then it should have all sorts of solutions starting from basic need of the people to state of the art technology based requirements of the people. Hence we need new products for the smart cities to make them smarter and ICT based services so that we can be connected with the big data and also predict future needs of the city and be prepared in advance. We also need integrated systems in order have easy accessible control and monitoring of all the facilities. All these four parameters identified are well established and are in use from decades but in different fields of design studies. If we are planning a smart city embedded with latest technologies, IOT, ICT and big data then we need to design for these four parameters in advance, during the planning of the city itself so that it can be made integral part of the smart cities. Hence design intervention of all these four parameters was made integral

part of the smart city design. This helped in addressing many issues which the users were facing.

We have proposed some sample interventions in all the four parameters and tried to address as many issues and concerns identified by the end users in the city during data collection.

We have used system usability scale to analyze the efficacy of the interventions and the results were found to be satisfactory. We have developed prototype, 3D models and also got patents for all the interventions. This way we have tried to establish that we can reduce the issues and concerns of the end users if we change the approach to solve the issue during the planning stage of a town itself. Hence design intervention only in space design in town planning and limited part of system design won't be sufficient for the holistic development of smart cities.

1.1 Literature Review of Smart Cities

The purpose of literature review is to understand what is a Smart City? What is its definition? How it is perceived by different researchers? What are the parameters of Smart Cities? Why some smart Cities are so successful? And why some Smart cities are struggling to attract occupants and are converting into ghost towns?

Critical review of literature as stated by (Garrod, B., 2023 and De Klerk, W., & Pretorius, J.,2019). was conducted for proper understanding of the subject. Initially the articles were searched in Scopus, Science Direct and Google Scholar databases with the help of key words

followed by detailed study of all the relevant papers and identifying its relevance in our field of interest. Key words selected for search were smart cities and smart city. While doing the key word search in Scopus, Science Direct and Google scholar the results shown were 54329, 90449 and 28900 respectively. On going through the literature it was found that majority of the paper was not on the smart cities research but were published on some other subjects and those research were also having prospects in the upcoming smart cities. Hence to identify relevant research we had limited the key word search to the title of the article only and the results found were, 16429 papers in Scopus, 5108 papers in Science direct and 15600 in Google scholar.

Further we have limited the keyword search to articles format only and the results found for Scopus was 6338 articles , for science direct it was 1314 research articles and in google scholar there was option only for review articles and hence the review articles in google scholar was 632 only.

Further we have filtered the Smart city literature on the basis of subject in which it was affiliated to. In Scopus database 50% of the articles on smart cities were from computer science field i.e 3235 articles out of 6338 articles. Remaining distribution of subject in descending order are Engineering 2771 articles, Social Science – 2159 articles , Energy – 884 articles, Environment – 863 articles , Business management – 764 articles, etc.

Where as in Science Direct the subject distribution out of 1314 articles with Smart city/cities word in their title is 561 articles were from Social Science, 548 articles from Computer Science , 365 articles from Engineering, 273 articles from Business Management, 209

articles from Energy, and 136 articles from Environment subject. In the literature review we have tried to compile the diverse point of view of all the researchers. Then it was narrowed down to conclude the findings from the literature review.

The literature review of smart cities can be broadly categorized into two types of literature one projecting the future requirements and the second category stating the current state of the art of smart cities. The future prospects of smart cities have discussed about the advancements in IOT, ICT, AI, new technologies, etc.

Javed, A. R.et al.(2022). noticed that state-of-the-art smart cities lacks in several areas of research which majorly include 6G networks, WiFi-7, industry 5.0, robotic systems, human well-being, HVAC, pantry backup, calamity backup that are inevitable for future smart cities.

Whereas many other literature states that technology is not the only perspective to be considered for smart cities, it is very vital component but not the only component. Different researchers have interpreted different facets of Smart Cities as the main factors and published data accordingly. As per Angelidou (2015), the main four forces which govern smart city projects are forces of smart city are urban future, knowledge and innovation economy, technology push, and application pull. Urban future means how urban setups are designed to be future-ready. Knowledge and innovation economy related to education and knowledge sharing can open new gates for creative minds to come up with new inventions and technology which will support economic sustainability and lead to an innovative culture. Technology push means enforcing the latest technology in everyday use so that the maximum benefit of the new

technology can be utilized. Application pull means from any new technology multiple and maximum applications to be interpreted and brought to everyday use.

Many cities in the developed world are already moving to smart cities technology implementation. These cities include (but are not limited to) London, Stockholm, Dubai, New York, Barcelona, Hong Kong, Amsterdam, Singapore, Tokyo, Paris, and Copenhagen (Lai et al., 2021).

On another aspect of smart city, Yamagata and Seya (2013) have analyzed that different land use patterns have a huge impact on the transport and energy demands in Smart Cities. As per their study compact cities can reduce the electricity demand as compared to huge dispersion-type cities. So, factors other than the main frame of smart cities concepts can also contribute to making the project more economical in long run. Lazaroiu and Roscia (2012) concluded that Smart Cities are particularly more influenced by innovative, sustainable and safe public transportation, household, fuel, and management of municipal solid waste. The sensitivity associated with the availability of ICT infrastructure and transparent governance seems low.

On contrary Allam, Z., & Allam, Z. (2021) has stated that "as urban fabrics are increasingly connected, there is today the possibility of automating certain urban processes in response to urban challenges; but this should be carefully led so as not to allow the creation of fully automated cities that render mechanical decisions made to impact negatively on urban liveability." This is a transition from the literature of a decade ago to the current scenarios of Smart cities. Where ICT is playing a major role.

Lee et al. (2014) suggested that to make an effective Smart city, the following factors play a major role:

- Initiating more engaging citizens in interactive services.
- Open innovation and open data facilities.
- Exploit or Explore new realms of service development?
- How to accelerate adoption: bottom-up market-driven partnerships Vs top-down public-driven.
- New value-added smart city services embedded with advanced intelligent technology supports.
- Network accessibility and multiple devices can create network grids for services in Smart Cities. Comprehensive strategy boosts of smart initiatives can be implemented through centralized leadership.

Neirotti et al. (2014) revealed that there is no exclusive definition of a smart city; the trends of all the evolving Smart Cities are largely local context-specific. It may be completely different in the technology or any other aspect of implementation. In his article published in 2008, Richard Holland explains that very often cities claim to be smart but fails to explain the context or justify any evidence for such claims. Even in the recent literatures irrespective of the buzz word of ICT and IOT in the smart cities among the research community, Government and private organisations, there is no universal definition of "smart city" (Prasad & Alizadeh, 2020).

Similar cases have been observed in various nations around the globe like Bangalore, the Silicon Valley of India (Graham, 2002), Brisbane, a smart and sustainable urban set up of Australia, to culturally based inclusions in urban setup with more emphasis on arts are other

prospects being explored by several cities in which culturally creative industries and digital media are favoured more. Furthermore, the framing of strategic plans for the development of Smart Cities is unexplored in multiple facets (Hollands, 2008). The researchers have tried to develop a standardized framework for the smart city model. However, the perspective of Smart Cities changes from city to city depending on multiple factors and the mindset of the Designers and policymakers. So, it was very difficult for the designers to come up with a common smart city strategic framework.

Ravetz (2000) claimed that the environmental function is supposed to "reduce environmental impact and resource use to "sustainable" levels, and enhance environmental quality and safety"; the economic part of the function is to "enhance long-term resilience, competitiveness, employment, and equitable distribution of resources" and the social part of the function is to "enhance health, education, security, cohesion, diversity, and quality of life."

Based on Sustainable Development Goals SDGs of United Nations UN, smart cities have diversified their objectives and these objectives are taken into consideration by different countries for the future prospects. In this scenario, it is important to adopt a systematic decision support system at the countries strategic level (Pichler, 2017) to incorporate smart and sustainable city objectives as per the 2030 UN SDGs.

In an another dimension of smart cities, Brenner and Theodore (2002) emphasized the world acceptance and demand for neo-liberal urban spaces while a shift of urban governance in the majority of western cities was identified by Quilley (2000) and Harvey (1989), starting from managerial to entrepreneurial forms. The cities were more into business or corporate-oriented

structure and form (Gottdiener, 2001; Monbiot, 2000). Similar claims were observed from self-designated Smart Cities like Edmonton, Canada. Their webpage (City of Edmonton, 2006) stated, “a smart city is characterized by a vibrant economy where businesses want to locate and expand”.

Multiple researchers have concentrated on the development of smart city framework as per (Heaton & Parlikad, 2019; Kumar et al., 2020; Yigitcanlar et al., 2018). Whereas majority of researchers have focused extensively on the technological aspect (Bhushan et al., 2020; Ismagilova et al., 2019) and research focused on community to develop smart city were also found in literature (Deakin & Reid, 2017; Macke et al., 2018). The policy point of view for developing smart cities was also discussed in some papers (Lu et al., 2019; Prasad & Alizadeh, 2020).

All the facets of smart city concepts are spread over a very diverse spectrum. Some projects are focusing on basic amenities and services while the majority are focusing on information and communications technology (ICT) and the Internet of things concepts. While competing with the global market all the countries are more focused on automation, Information technology, Data/statistics sciences of urban setup, Innovation in technology, smart governance, Education, Transport, etc. (Van der Meer & Van Wilden,2003) have talked about e-governance as a part of Smart Cities. On the other hand, social learning and communities were considered points of focus of Smart Cities by (Coe et al., 2001). Literature issues related to urban growth, social aspect, and environmental sustainability are major factors of concern (Polèse & Stren, 2000; Satterthwaite, 1999). When the discussion of the

knowledge economy is taken up ingress of confusion is unavoidable between knowledge, IT, and the creative culture industries (arts, media, culture) (Carrillo, 2006; Holbrook & Wolfe, 2002), and the significance of creative cities (Hall, 2000; Florida, 2002; Landry, 2008).

While considering poor and affluent segments of society the concern of environmentalism and ecology (Arrow, et al, 2004; Martinez-Alier, 2002) is a complex problem in terms of urban governance. New forms of divides are observed between poor and affluent city dwellers in the uses of natural resources and environmental quality .Hence inclusion of all segments of the society is very critical to maintain a balanced society. While planning a smart city it is very difficult to prioritize whether to provide for the basic need of the bottom level of society is more critical or making the city embedded with technology is more important. On the other hand the pace of development is hand in hand with the entrepreneurial and industrial growth of the cities which is adversely impacting the environmental and sustainable growth of the city. In the race of development, technology and environment the other important parameters like social impact, cultural affluence and creative components are getting silenced. Hence these parameters along with other parameters are also to be included in making a smart city more vibrant.

From the literature review, it was found that there are multiple parameters as shown in the Figure 1.1, such as social, technological, cultural, entrepreneurial, environmental, and creative are having a tug of war for inclusion as a major component in the Smart city concepts.

Smart City literature was further explored to understand the existing/upcoming Smart Cities and study their acceptance rate by the occupants of the cities. This exploded another dimension in smart city design which is user-centric design or the requirement of the occupants. While going through the city specific literature it was found that catering end user needs was playing an important role in the early acceptance of the newly designed Smart Cities by the end users. Cities like Singapore are more successful since they have evolved with time and the dwellers have grown along with the development of the city. Whereas, in the new cities developed as green field projects, the occupants are subjected to major transformation causing discomfort to adapt easily. The most advanced and well-designed cities are under-occupied and facing difficulty in attracting more dwellers.

smart city literature. The resident perspective to evaluate the smart city performance should be considered in smart city design but limited literature is there to support it. There are literatures which have evaluated resident preferences in smart city design but are generally limited to a single city. (Macke et al., 2018; Vidiasova & Cronemberger, 2020; Yeh, 2017) or the end user preference are limited to services available through smart city design (Han & Kim, 2021; Wu, 2020).

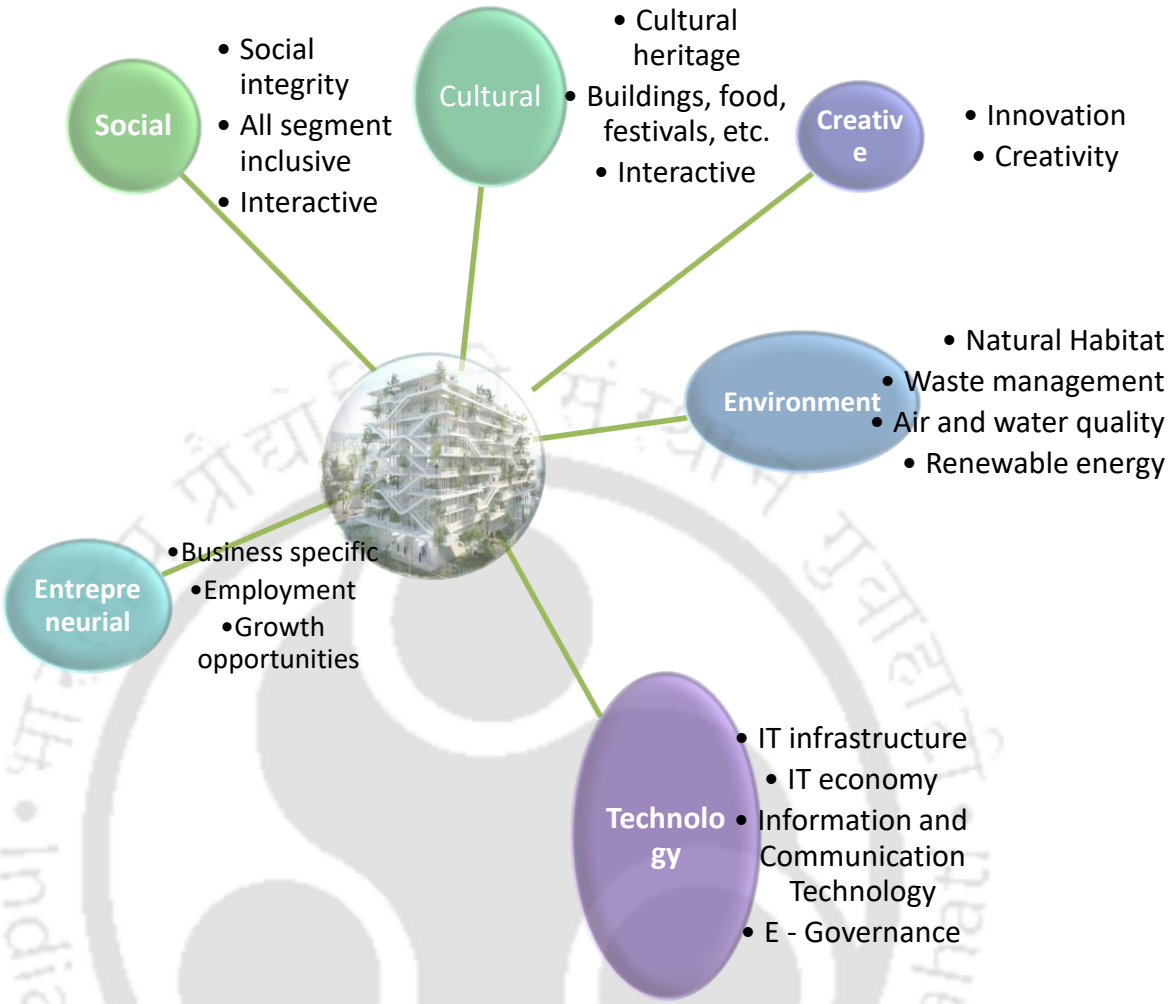


Figure 1.1 – Tug of war of various parameters of smart cities identified in the literature review
Source: Photo at the centre by: Nicolas-Laisné-Associés-Lyon-Offices

(Ji et al., 2021; Lytras et al., 2019; Xu & Zhu, 2021) identifies that there is a gap in the Majority of literature assessing public engagement efforts in implementation of smart city projects has been critical of limited attempts of the municipalities and private firms to incorporate or at least hear the suggestions of the public (see Goodman et al., 2020; Shelton & Lodato, 2019). For instance, Cardullo and Kitchin (2019) have discussed that the citizens role and presence is generally sought for solution of design elements, such as apps creation or user design, rather than on institutional design considerations or central planning, hence the author

has concluded that very limited opportunities are there for higher level engagement opportunities, this further result in efforts that annoy rather than truly incorporate the public. Similar conclusions were also observed in Canada in some literature, where public engagement was very superficial and policy makers were struggling to find the right forum for active public engagement (Levenda et al., 2020; Johnson et al., 2020). In a similar vein, Lember et al. (2019) contend that incorporation of new technologies in the smart city design are formulated to systematically reduce the public interaction and are more in favour of centralized management and design. In fact, Engelbert et al. (2019) suggest that prevailing market, governance and investments are fundamentally incongruent with a resident-centred approach to smart city design.

In an intriguing case of Chinese cities, it was found that China's policies have seen a massive transition from a planned economy to a more market-specific economy, introduced in 1979 by Deng Xiaoping. This made China one of the least eco-efficient economies. The environmental governance policies of China might seem significant in the current scenario but they are lagging behind the impact of the ecological implications already done due to their enormous growth in the production and consumption process. Also, the policies are merely a selective implementation of reactive regulations.

1.1.1 Insights from a literature review of Smart Cities

- A general notion from the majority of the researchers identifies that connecting the service with ICT, IOT, Big data, Deep learning and AI is making cities smarter.

- On the other hand, researchers have denied that ICT or big data is not the answer for Smart Cities, it should be more creative and innovative for the dwellers.

- Other factors that were identified by the researchers were smart transport/ mobility, E-Governance, smart economy, smart environment and Smart living.

- The literature has also pointed out that cultural and social aspects of society are also influential factors which are missing in technology-based Smart Cities.

- As per the literature the need for smart features was varying as per the demography and geographic conditions of the city. Singapore is one of the classic examples and the same is discussed in the upcoming chapter.

- Few researchers and policy makers have focused on the need and advantages of an "entrepreneurial city."

- The critiques have even claimed that many business-oriented Smart Cities are self-designated Smart Cities.

- As per literature review it was observed that there are various parameters to be incorporated in smart city but the distribution of these parameters required is neither uniform nor generic for all smart cities.

- The distribution of these parameters in any smart city is very context specific and it is based not only on the geography of the city but majorly on the demography of the city and what the demography of the city wants. Hence a citizen centric city is more likely to

be successful as compared to state of the art smart cities in terms of technology and IT/ICT/IOT infrastructure.

1.2 Indian Scenario of Smart Cities

Indian policymakers are also working on an ambitious smart city projects all across the nation. Their main objective is to drive economic growth and improve the quality of life. Ministry of Urban Development, Government of India, launched a Smart City mission as Transform–Nation initiative in June 2015. The scheme was initiated with a vision of 100 Smart Cities in India. It was later increased to 110 cities. It was designed in such a way that each city of the nation willing to adopt this ambition will submit their reports as designed and asked by the smart city mission. The city was selected on the basis of its calculated scores.

The short-listed cities were supposed to submit their own local-specific proposal for smart initiatives.

The smart city mission has indicated some core infrastructure requirements:

- Water supply infrastructure
- Ensuring Electricity supply
- Solid waste management and sanitation
- Efficient Public Transport and Urban Mobility
- Housing schemes for the poor
- Digitalization and IT connectivity
- E-Governance, citizen participation and good governance
- Environment sustainability

- Citizen's security and safety (particularly elderly, women and children)
- Education and Health care

Apart from the above basic infrastructure for Smart Cities of India, some more smart solutions are highlighted in Figure 1.2 as indicated by the Government of India in their guidelines of Smart city mission.

Figure 1.2 – Illustrative list of solutions for the smart city mission of India
Source: http://smartcities.gov.in/upload/uploadfiles/files/What%20is%20Smart%20City.pdf (cited on09/12/2018)

We have discussed the main objective of the Smart Cities Mission, which is to drive economic growth and improve the quality of life. These are few steps how it can be achieved as per the Smart City Mission:

- It promotes mixed land use as per the area. With the mission, the states will have more flexibility to use the land for various purposes and make bye-laws as per the change. However, the fulfilment of environmental safeguards will be taken care of.

- It aims to expand housing opportunities for everyone. Housing is one of the essential requirements for the growth of the Smart Cities Mission. Smart Cities require more housing projects to cater to large and lower-income demographics.

- Smart City Mission aim to reduce congestion ensures security, reduce air pollution, and promote interaction and the local economy. New way pedestrians are built for walkers and cyclists to reduce accidents.

- Development of playgrounds, parks, open gyms and other recreational spaces is another objective. This is done to enhance the quality of life for Indian citizens.

- More transport options are promoted, like transit-oriented development (TOD) and public transport.

- To bring transparency and accountability in governance, more online services are launched. For example, a citizen can use an online website instead of going to the municipal offices.

- Identity is provided to the city based on the education sector, health sector, local cuisine, sports, culture, art, furniture etc.

- Smart Solutions are applied to infrastructure and services for area development.

The guidelines have also specified that smart city initiatives and features are not limited to the list of core infrastructure mentioned earlier or the illustrative list as in Figure 1.2. Any individual city can propose their context-specific service or features.

1.2.1 Insights from Indian scenario of Smart Cities

- The smart city mission has not considered the demography of the city for implementing its plan.
- The smart city mission does not have a bottom-up approach, but rather a top-to-bottom approach. Here, the policy planning is done with limited consideration of the user perspectives.
- The provision for user-centric smart city planning in the smart city mission is very limited.
- There is no clear policy for the largest share of the working population in the smart city mission i.e., unorganized sectors.
- All the policies and technologies in smart cities are in favour of organized and e-tail.
- Recent liberalization by the Government in FDI related to retail has opened a big opportunity basket for global retailers. It will further increase the competition level of the unorganized retail and workforce.

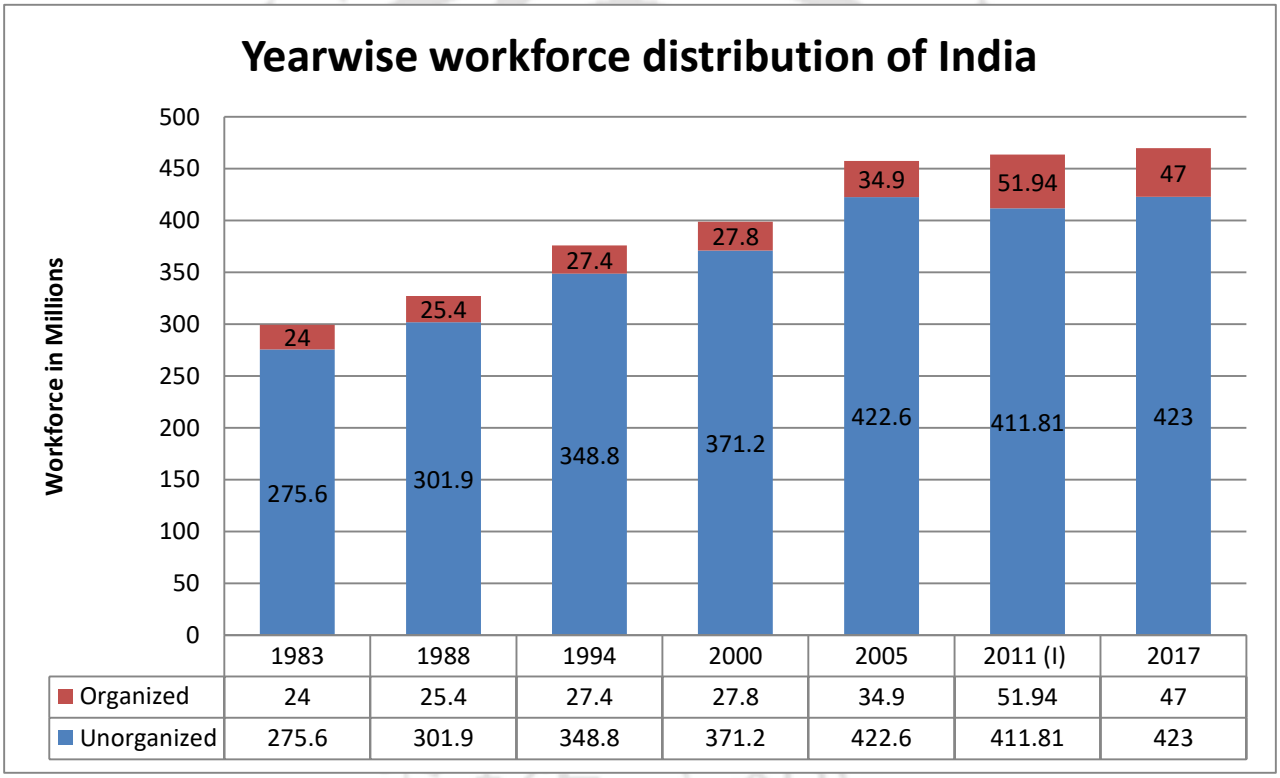
1.3 Indian Demographics

After understanding the Goals of Smart City Mission of India we have also analyzed the demography of India. This helped in understanding the requirement of the people who will live in Indian Smart Cities. As inferred from the literature on Smart Cities, to develop a successful smart city it should be demographic, geographic and local context-specific. In India the geographical conditions are very diverse hence it cannot have a generalized framework for all geographies and miscellaneous local contexts due to its intrinsic characteristics. However, we can generalize the framework on the basis of the demography of the country. According to the UN estimates, India has overtaken China in having the largest population in the world with population of 1,425,775,850 at the end of April 2023. In India, the population increases by 1 person every 2 seconds. India is expected to reach its peak population by 2064, accounting for 1.7 billion people as per the population Data via United Nations estimates 2023. After 2064, the population of India is expected to decrease, as per the UN WPP report.

In 2018, gender distribution in India was 51.18% male and 48.19% female. India is considered a young country since almost 50% of the Indian population is below 25 years of age. It is a positive indicator in terms of workforce availability in the future and the economy of the country. On the other hand, developed countries around the globe are facing a workforce shortage and are forced to import workforce from under-developed and developing nations. China, being on the top of the population scale, adopted a one-child policy to control population growth in 1979. This proved helpful in controlling population growth but also negatively impacted workforce availability in the future. In the present scenario, the workforce of China has started to shrink and, on the other hand, the population of people over 65 years of

age is increasing. This will increase the number of dependents and negatively impact the economy of China.

The growing working population of India is categorized under two broad categories - organized and unorganized. Any organization or sector with less than 10 employees is considered unorganized and the remaining are under the organized sector category, as per the guidelines of the National Commission for Enterprises, Government of India.



	1983	1988	1994	2000	2005	2011 (I)	2017
Organized	24	25.4	27.4	27.8	34.9	51.94	47
Unorganized	275.6	301.9	348.8	371.2	422.6	411.81	423

Figure 1.3 – Year wise workforce distribution of India

(Source: NSS 61st Round 2004 - 2005 and NSS 55th Round, 1999-2000, Employment-Unemployment Survey. Computed.)
(I)* Interpolated the value of the total working population. The sector-wise percentage was known.

Figure 1.3 shows the chronological variation of the working population distribution of India. In the Y axis the workforce population is shown in millions and the X axis represents the

year of evaluating the population distribution. The blue bar represents the population of the unorganized sector and the red bar represents the population of organized sector. As per the data shown in Figure 1.3 , the total working population of India, in 2005, was 457.7 million; out of which, 422.6 million belonged to the unorganized sector and 34.9 million to the organized sector. Whereas it is clearly visible from the data that in 2017 the unorganized sector population was almost same as of 2005 in spite of steep rise in the population of India in the same duration, but the organized sector population has increased drastically. This signifies that when we see the overall market share of unorganized sector in the Indian working population context, it can be observed to be dropping very fast.

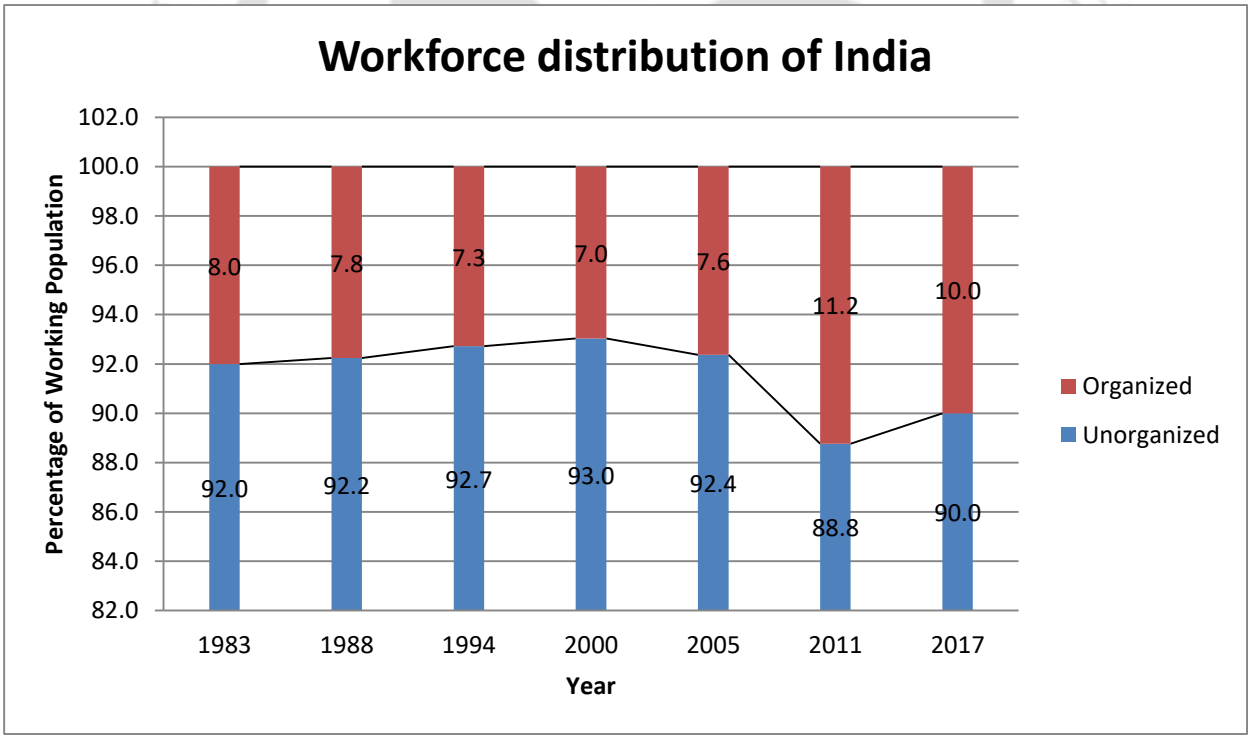


Figure 1.4 – Year wise Distribution of Workforce in percentage
Source: 68th Round, National Sample Survey at Observer Research Foundation's India Data Labs

Figure 1.4 shows the chronological variation of the percentage of the working population distribution of India. In the Y axis the percentage of workforce population is shown and the X axis represents the year of evaluating the population distribution. The blue bar represents the percentage of the population in unorganized sector and the red bar represents the percentage of the population in organized sector. As per Figure 1.4, the contribution of the unorganized and organized sectors to the total workforce of India in 2005 was 92.4% and 7.6%, respectively. The percentage of unorganized sector has reduced to 90 % share of total working population in 2017. There is a drop of 2.4% in the working population share of unorganized sector in last 12 years. Whereas the percentage of population working in organized sector has increased from 7.6% to 10% in 2017.

1.3.1 Insights from the demographic condition of India

- As per the literature review and the data collected from the census and reports from the Government of India. It is prominent that the unorganized sector is the main contributor to the employment of the workforce in India, constituting more than 92% of the total working population.
- The historical data has confirmed that in the last couple of decades the contribution of unorganized retail was always close to 90% of the total working population.
- The growth in the organized sector was observed in the last decade.
- In the smart city scenario to generalize the demographic prospects, we can state that the policies should be in the favour of supporting the unorganized sectors also. Since this sector is the largest component of the Indian working population.

- In the current scenarios, several online service providers have entered the Indian market for creating an environment of personalized mobility like OLA, Uber, My taxi, Zoom car, etc. They are converting an unorganized transport system to a self-reliant mobility alternative for the user and the drivers as well. There is a huge transformation of the transport system from an unorganized to an organized sector.
- In Unorganized sector majority of population is working in the retail business. Either they are selling their home produce or reselling the products which were purchased in discounted rates. Hence it is very important to study and understand the scenario of retails also to have actual perspective of majority of working population of India. The Indian retail is discussed in the upcoming section of the thesis.

1.4 Retail

Retail can be defined as the sale of goods in relatively small-scale quantities in public for use or consumption and not for resale. This type of earning does not require any prior qualification or first-hand experience to start up with. Depending on the liquidity available to the person, they can start their own retail. They purchase the products in bulk with discounted rates and sell them in the localities at the maximum retail price. The discounts are their margin of earnings. Or purchasing a product which is available in bulk at some location and selling it in localities where it is scarce at a higher price is another way to see this transaction.

Currently, there are three types of retail - organized retail, unorganized retail, and e-tails. Any retail with less than 10 employees is called unorganized retail and the remaining are called organized retail. In organized retail, there is one more criterion of e-tail. E-tail is selling products online with the help of the internet. India Brand Equity Foundation (IBEF) is a

Government organization which analyzes the market trends in the retail segment and publishes report quarterly. As per the report of IBEF in 2017, 93% of retail contribution was from unorganized retail and only 7% was from organized retail. As per the estimate of the IBEF report by 2020 the unorganized retail will crunch by 3% giving room for organized retail to expand. Since Government policies are in the favour of organized retail. Relaxation in Foreign Direct Investment and increasing the ownership percentage in any foreign-owned retail in India by policy makers have opened doors for organized retail from all around the globe.

The study by (Kalhan, 2007) indicated a 20% drop in the sale of unorganized retail due to the entry of organized retail. In a similar study, the drop in the sale of unorganized retail due to the entry of organized retail was 7.51%; ICRIER Report (2008) found a drop of 16% in the sale of unorganized retail.

Improving the position of India in ease of doing business ranking was one big success for the Indian policymakers. The report is analyzed and released by the World Bank Group. In the last 5 years, India jumped from rank 132 to 77. This index is one of the parameters investors consider while looking for a new nation to invest in.

The changing foreign trade policies and liberalization have also placed India in the ranks of the FDI Confidence Index. India, at 11th rank, is ready to compete with the top economies in the global business environment. The more the Indian market is open to global trends, the more will be the entry of organized retail and business opportunities in the nation. It is a good indicator for the economy of the nation but bad news for the unorganized retail. Since the global players are now in the open market with unorganized retail. Organized retail

will increase employment opportunities, but at the same time, engulf the existing markets. The global players have large amounts of funds to establish huge infrastructures with hi-tech facilities. On the other hand, the massive unorganized sectors are a group of miniature investors who do not have sufficient credibility or investment to take any major steps to compete with.

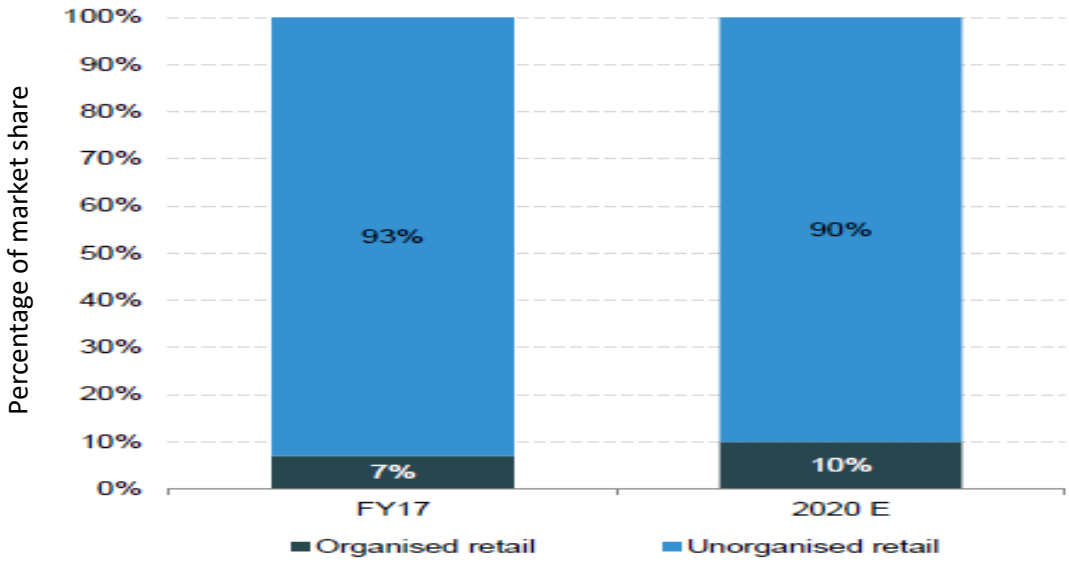


Figure 1.5 – Market share of unorganized and organized retail

Source: BCG, KPMG-indiaretailing.com, Deloitte Report, Winning in India's Retail Sector, Centre for Digital Financial Inclusion (CDFI) report, Crisil. (Note: E -estimate)

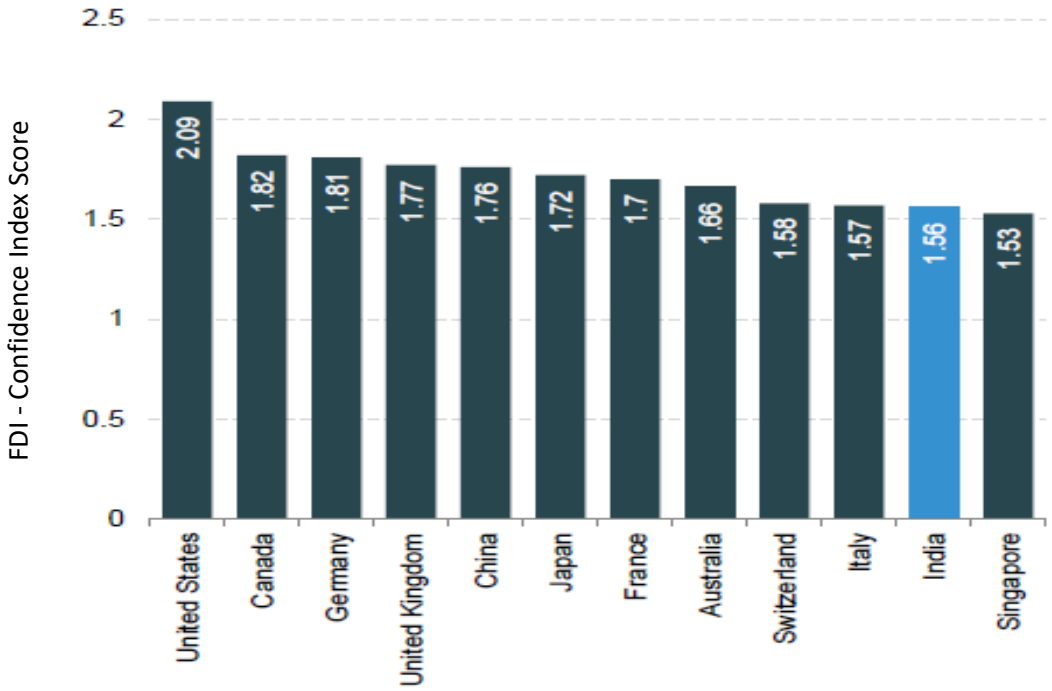


Figure 1.6 – Foreign Direct Investment Confidence Index 2018

Source: AT Kearney 2017 FDI Confidence Index

Till now, the advantages in favour of unorganized retail were having interpersonal relations with the customers, a credit system between customers & vendors, and close vicinity with the customers. It was a self-organized system for all the unorganized retail owners they were having their area and fixed customers. This notion was also challenged by the entry of e-tail and home delivery systems adopted by organized retail. In the last decade, e-tail entered the Indian market and started expanding its root exponentially. As per the 2015 report of IBEF, online retail has done a business of 13 billion USD, in 2016 it grew by 11.5% and in 2017 it grew by 22.75%. It is forecasted that by end of 2018, the yearly growth of online retail will be 84%.

The ease of shopping and rising confidence of the customers in online stores are a great threat to unorganized retail since their market share is being distributed in the emerging

market formats. The Figure 1.5 can give a clear picture of the scenario. In this figure Y axis represents the percentage share of the market. In which sky blue bars represents the percentage of unorganized retails and dark blue bars represents the percentage of organized retails. The x Axis represents the year of evaluation of the data. As per Figure 1.5 their market share has reduced by 3% in 2020 from 2017.

Figure 1.6 shows the Foreign Direct Investment Confidence Index (FDICI) of various countries. In the Y axis the value of FDICI is mentioned and in X axis the list of various countries are mentioned. Higher FDICI score represents higher level of confidence of the global market in investing in that particular country. It can be seen from the Figure 1.6 that the FDICI of India is higher than that of Singapore. That is a very good sign for the market of any country. Hence a lot of Foreign Direct Investment is entering in the Indian market format but instead of rise of all the market formats the influx of funds is diverted more towards the organized retails only and hence the unorganized retails even after having the majority of the workforce is not getting their share of development/growth.

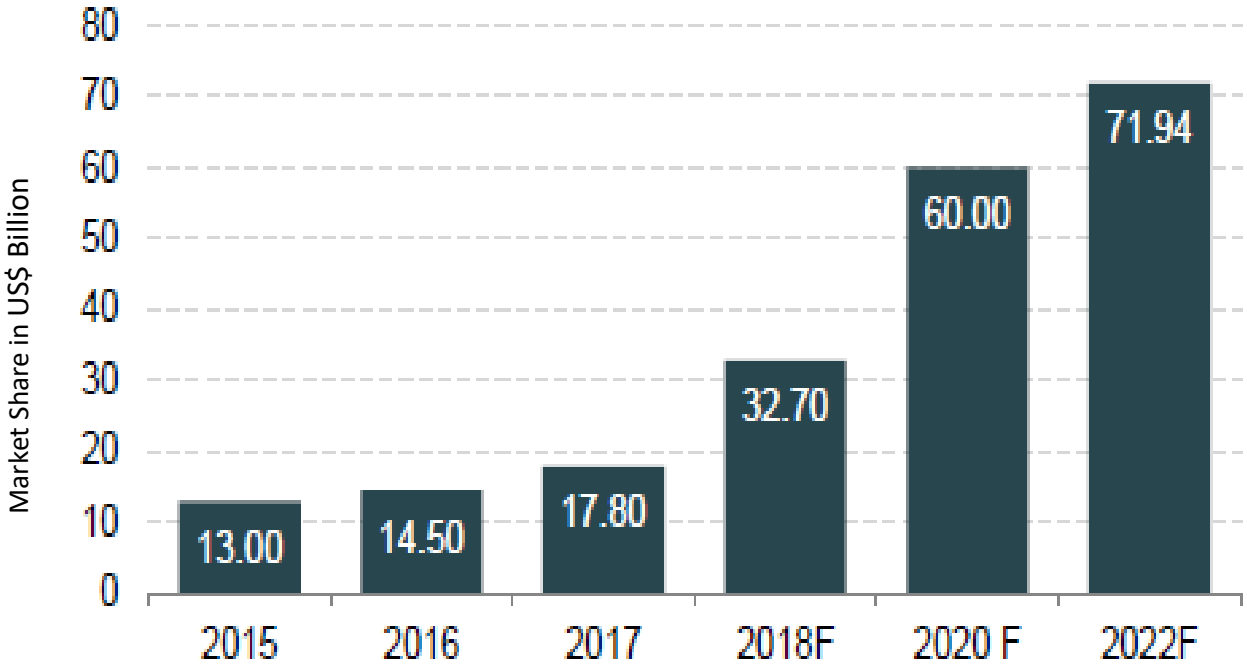


Figure 1.7 – Online retail share in the Indian market (US$ billion)

Source: MasterCard Worldwide insights 4Q 2010, PWC ecommerce in India report, ASSOCHAM, UN Report 'The power of 1.8 billion', NAsscom annual guidance 2018, Redseer consulting, eMarketer

Another segment of the organized retails which has grown very fast is the e-tail business or online stores. The figure 1.7 shows the growth of online retail shops. The Y axis is the overall value of online retail business of India in billion US $ and the X axis is the year of the evaluation of the market share. It is clear from the figure that the whole network of e-commerce is replacing the existing logistics system of unorganized retail. There are a lot of people who have recognized the potential of e-tail and e-commerce and are switching their mode to these latest technologies. However, this business model does not have enough space to accommodate the entire unorganized retail sector.

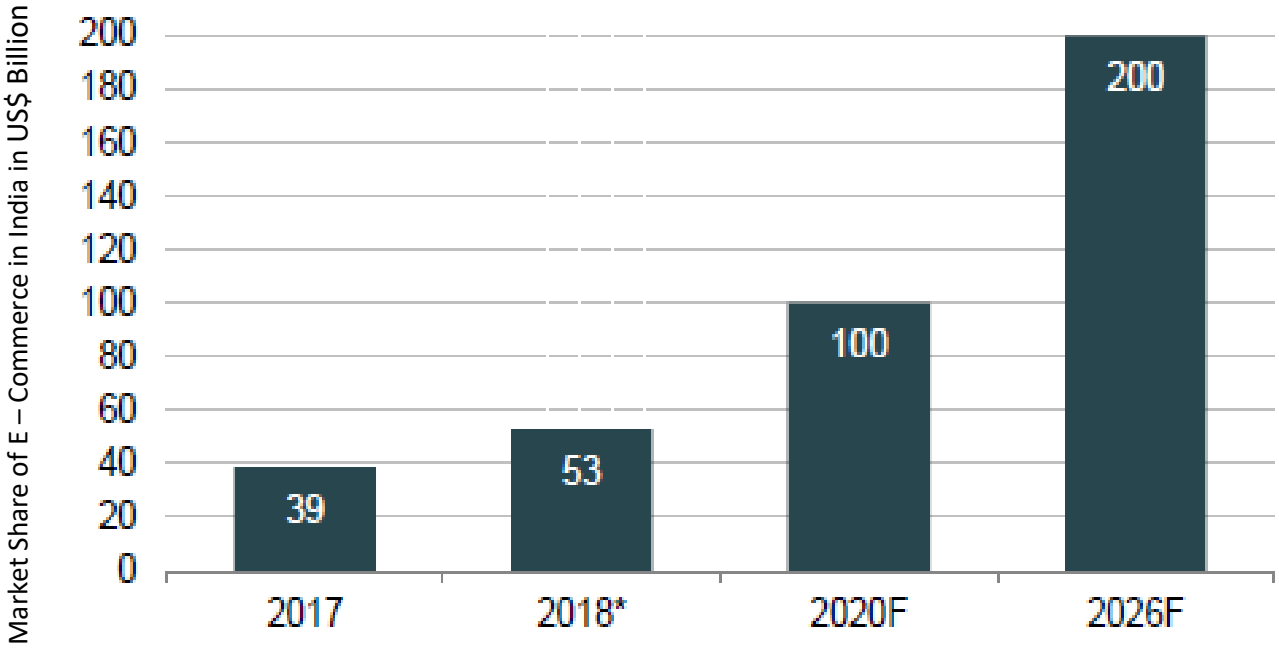


Figure 1.8 – Indian E-Commerce Market (US$ billion)

Notes: APMEA-Asia/Pacific, Middle East and Africa, F-Forecast,*-May 2018

Source: MasterCard Worldwide insights 4Q 2010, PWC ecommerce in India report, ASSOCHAM, UN Report 'The power of 1.8 billion', NAsscom annual guidance 2018, Redseer consulting, eMarketer

As per Figure 1.8, which shows the value of Ecommerce share of India market in billion US $ in Y axis and the year of evaluation in X axis. The growth of the e-commerce market is also exponential. As per the forecast IBEF report, the e-commerce market will show a growth of 256% in just three years and 512% in just 9 years. This rapid expansion of the market is going to have sharp cuts on the unorganized retail market due to its slow adaption to technology. The unorganized retail market has another good prospect - the rate of growth of the Indian market is very good. The historical data of the Indian market shows a cumulative average growth rate of 7.82%. This can be attributed to the rapidly growing middle class. The average income of the middle class is increasing and the purchasing power of the people is also increasing. Now,

people are moving from the purchase of basic necessities to luxury items. The easy loan and financial support from the banking and financing institution also play a major role in increasing the purchasing power of Indian citizens. The overall living standard of the people is changing with aspirations of global standards.

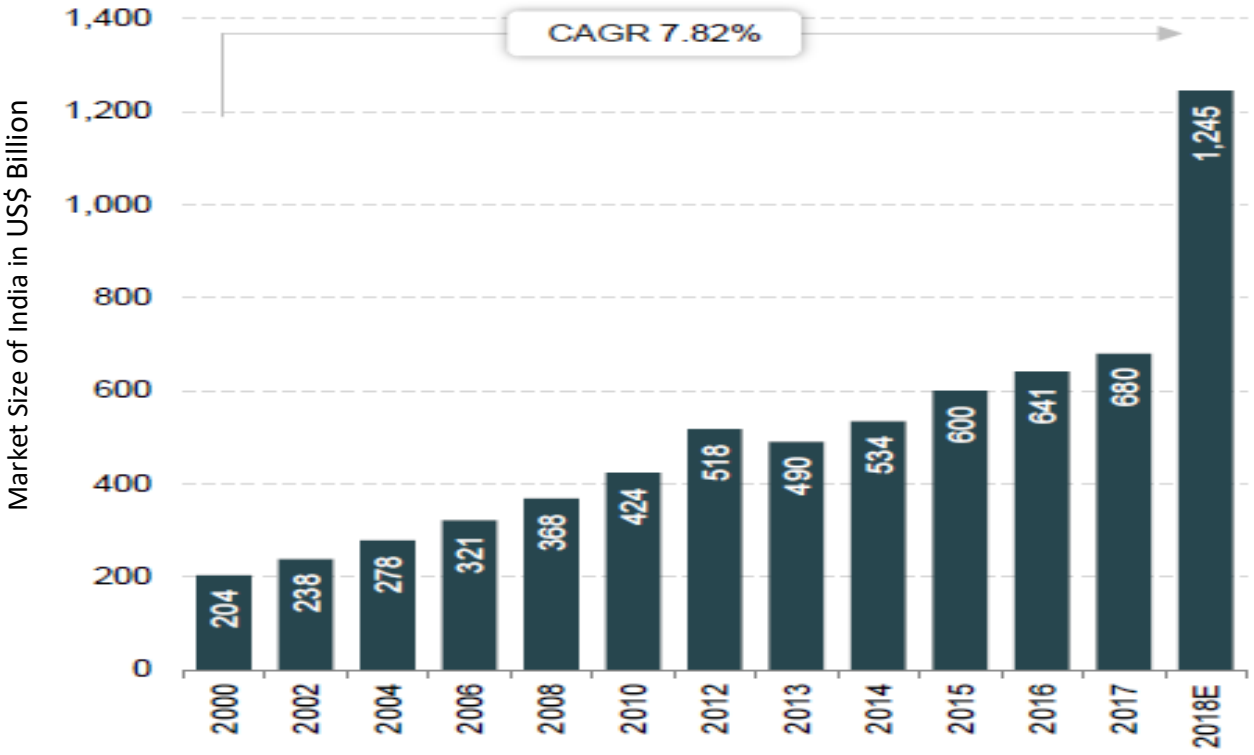


Figure 1.9 – Market Size over the past few years (US billion dollars)

In figure 1.9 we can see that the market size of India was growing rapidly. In the Y axis the market value in Billion US $ is indicated and in X axis the year of evaluation is listed. The cumulative annual growth rate of market of India is 7.82%, but as per Figure 1.5 the advantages are being exploited by the organized retail as compared to unorganized retail. Whereas the unorganized retails are facing the difficulty in taking the advantage of growing market.

Latest trends and factors influencing the sales in the retail business – (Virchez and Cachon, 2004) found that the following parameters (Courteous Sales Person, Respect for Customers, Product Quality, Service Quality, Store cleanliness, and Reasonable Price) have a great impact on the customer response and have tested it on the organized and unorganized retail in the USA. He found that the small retailers are aware of the competition from organized retail and were paying more attention to the cleanliness factor after the survey was over. The same study was conducted in Ahmadabad and similar results were observed by (Srivastava, 2015) at the University of Mumbai. (Inman & Nikolova, 2017) indicated that the use of technologies can improve the customer experience and can prove to be beneficial for the business too. Scan-and-go technologies, self-check-out, Que-vision, and smart shelf technologies are some of the mobile-based apps which change the customer's perception of shopping.

Technological advancements are the new strengths of organized retail and sooner or later will replace the need for employees or salespersons. On the other hand, the expense of adopting technologies is not feasible for unorganized retailers. The addition of channels of retail is being adopted by some of the players in unorganized retail but is in limited segments only. The unorganized are collaborating with the online stores to have better exposure to the customer base. Through this channel, the retailers are not only supplying to their own locality but are selling their products all around the nation. The early adopters of multichannel retail have exploited the opportunity. Initially, the sale was less but as the online business increased, their scope also increased. The main advantage of the online partnership is that they are getting reviews from the customers; it is being accessed by everyone and hence the retailers

are becoming more aware of the quality of the products being sold. The customer is more comfortable with the reviews and the feedback of previous customers.

There are different types of store formats if many retail stores in one place or a building with a common roof they are called a mall. Large self-service retail outlet selling household goods and food items are called supermarkets. If the store is very large with a self-service format and with a large range of goods along with a large car parking space it is called hypermarket. The stores which offer discounts on their huge range of products but might have limited variety and even inferior quality as compared to department stores these types of stores are called discount stores. They sell almost everything, e.g., Walmart, Vishal Mega mart, etc.The stores whichgive stock in bulk at discounted rates. They are not much concerned about the display of the products and the aesthetics of the store these types of stores are called warehouse stores. Local stores that sell everyday use products are called Mom and Pop store or kirana store in India. The store which sells products of their expertise only like watches, jewellery, Reebok, Adidas, etc are called speciality store. The stores which interact with customers through their online websites are called E- tails.A Dollar store is a type of discount store with fixed prices for all the products but the quality of the product may be questionable. There are multiple formats of stores available in the market and have their respective significance. The organized formats of stores are gaining popularity and the unorganized retails which were the major contributor and shareholder of the market are losing their share to these organized retails.

1.4.1 Insights from literature review of retails

- The growth of the Indian market is being exploited more by organized retail and e-tails as compared to unorganized retail. As per Figure 1.5. Unorganized retail is on the verge of a decline in market share. E-tails on the other hand are growing exponentially.
- Several unorganized retailers have joined hands with e-tails to make their presence in Omni market formats. However, the overall percentage of unorganized markets adapting to this format is very limited.
- There are counter statements by some researchers stating that organized retail and e-tails will increase employment opportunities also.
- "Also, Indian consumer is the most confident consumer in the world" (The Nielsen Company, 2011). The growth of India's purchasing power is increasing as per the historical data from IBEF.
- Despite the global economic depression, the economy of India remained insulated to a great extent; it was a good sign for the domestic retail sector for positive growth.
- These organized markets are continuously working on technology to reduce the human interfaces in their outlets so that they sustain with the least employees and more profit. Amazon Go is a breakthrough store where the customer does not need to interact with any salesperson. They can simply scan their mobile, enter the store, and leave with their desired product. With the entry of technology for replacing humans more social concerns will emerge in a country like India.
- Unorganized retail, on the other hand, struggles to compete with the low prices and huge discounts of organized retail and online stores. It is important to study the

changing scenarios of the retail business and have better clarity on how it is affecting the population of India as a whole. In order to keep the unorganized sector vibrant major intervention is required in design as well as at the policy level.

From the literature review it can be interpreted that instead of running behind the same global trends, these smart city projects should be more individualistic and socio-geographic-specific. Their intent should be the same, to be intelligent infrastructure but their approach should be more practical and sustainable. These projects should be more focused on demography, geographic location, and resource availability at specific locations, along with existing culture and their local attributes, rather than following their global counterparts. If we consider the smart city model for an industry-based country then it will be completely different from the smart city model of a tourism-based country. In either of the cases, the respective smart city model will require different services, have different priorities, need different infrastructure setups, etc. So, it is difficult to formulate a standard smart city model which applies to all.

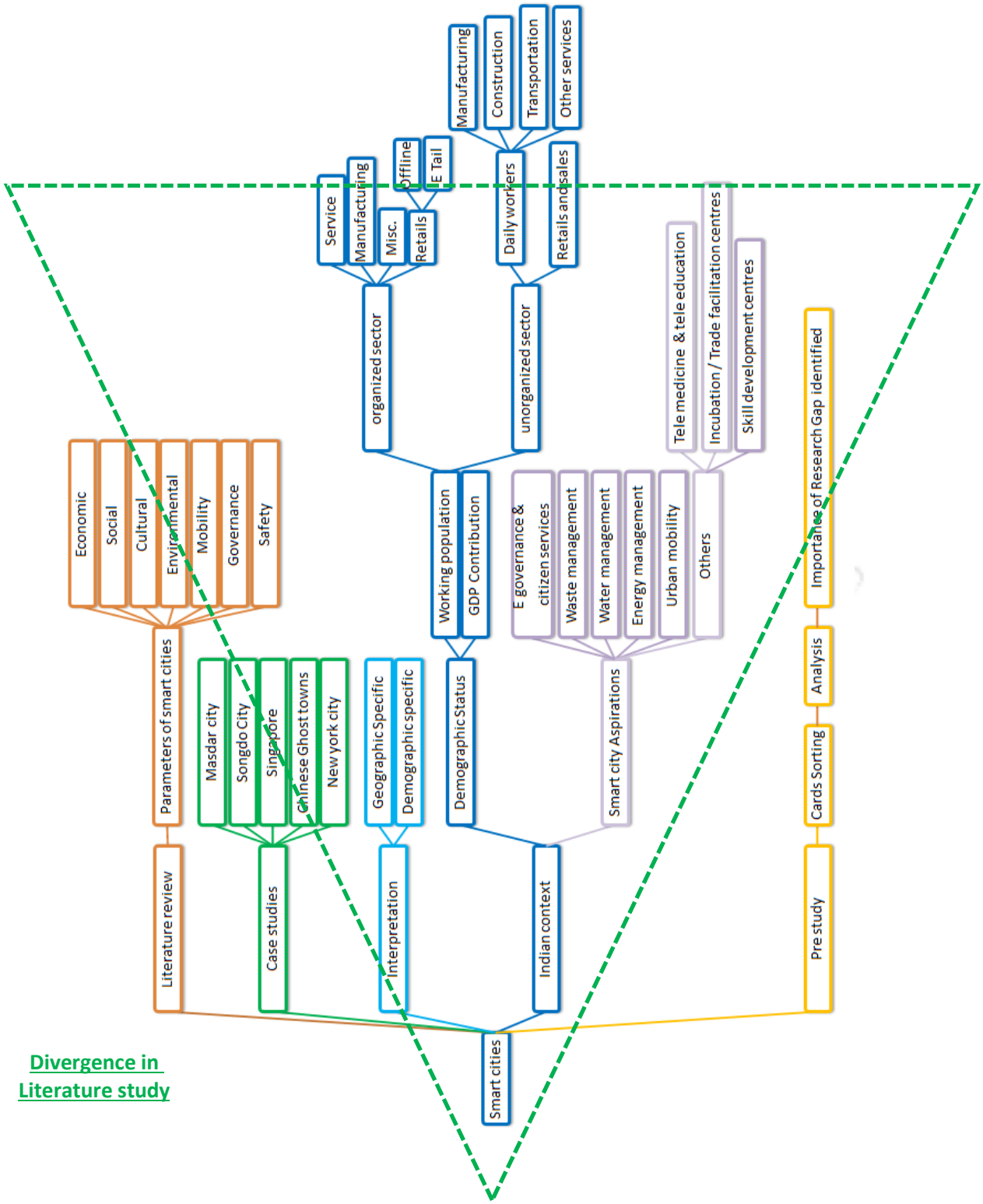


Figure 1.10 - Literature Review Flowchart

The Figure 1.10 shows the divergence of the literature of smart cities, there were multiple facets to be explored to understand the smart city scenario. The literature was having multiple parameters of smart cities as per the preferences given by various researchers. Hence we have identified the generalized parameters from the literature reviews for consideration in our smart city research. We have also analyzed the case specific literature of existing smart cities to understand the individual smart cities and their requirements. From the above two literature it was clear that context specific smart city is more relevant and successful. There are two contexts for planning any smart city, one is the geographical conditions and the second one is the demographic conditions. For geographic conditions we have considered India as a site for research, since mega scale project of Government of India is already going on, with the name Smart City Mission of India. In this scenario also we have two components to be analyzed, one is the demographic distribution of India and the second one is the objectives of Smart City Mission of India. The demography can be better understood with the help of working population distribution. Since the overall population is dependent on the working population. Hence growth of the working population is directly linked with the growth of the overall population. As per the census data 90 % of the working population in India is from unorganized sector and only 10 % is from the organized sector. In Unorganized sector also we have multiple division but unorganized retails were found to be a major segment in the unorganized sector of working population. And the level of their interaction in any city is also very high on day to day basis. But the Smart City Mission was not having very specific goals for the unorganized retails in their policy framework. Even after unorganized retails being the largest working population in any city.

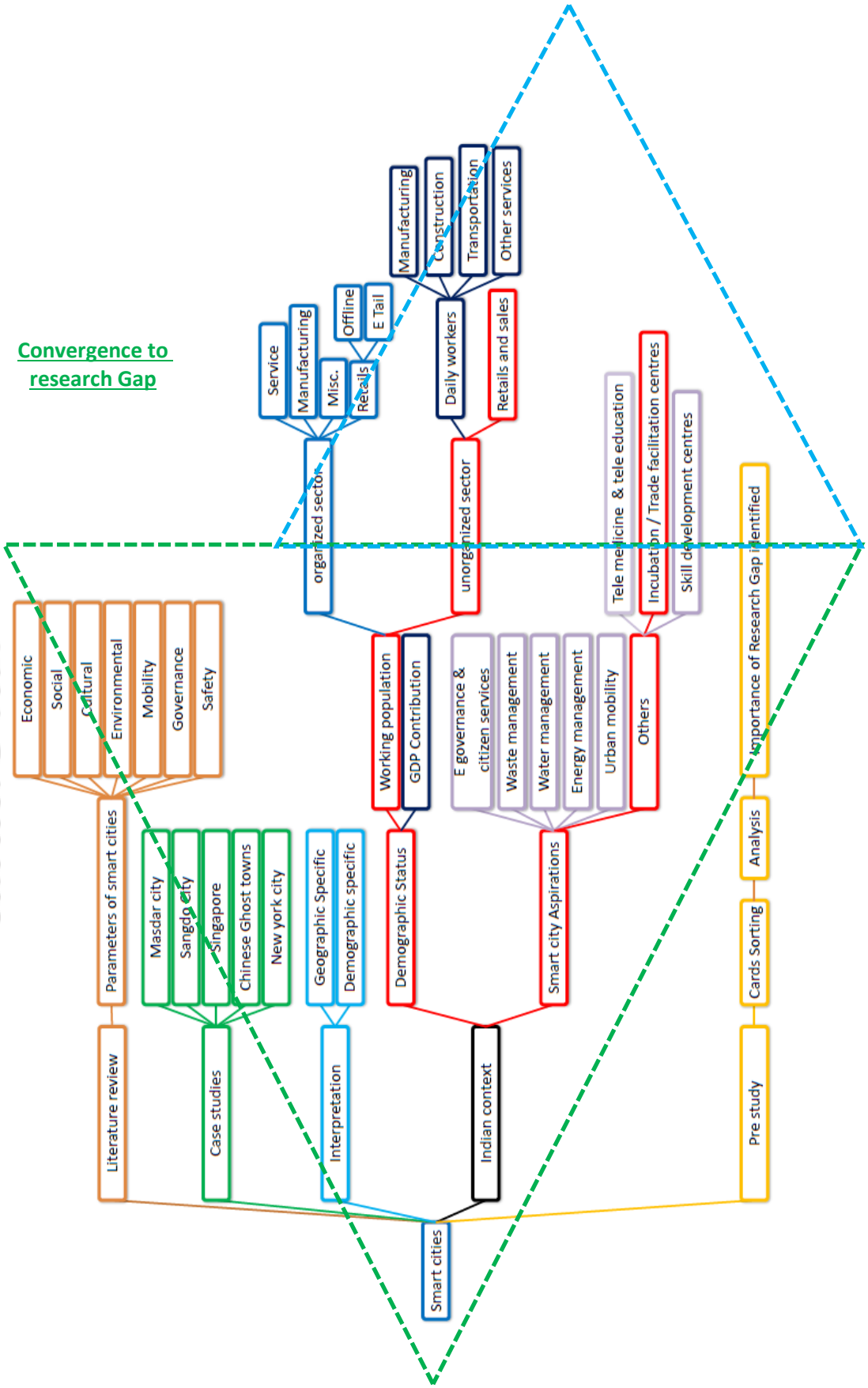


Figure 1.11 - Literature Review to Research Gap

1.5 Research Purpose and Question

A critical review of the literature on Smart Cities was done to understand their existing scenario. The main purpose of this section was to identify the research gap. As shown in Figure 1.11 the study started with the smart city concept as the field of interest. Different formats of Smart Cities were studied. The literature converged to the notion that all Smart Cities are unique and have their own issues and smart solutions. Hence, for designing any smart city, it is important to identify the local context of the city and its issue. Any city constitutes two parts, physical conditions and habitat; in other words, the geographic conditions, natural ecosystem, and the demography of people living there. Our research focused on the Indian context of Smart Cities. Here, the geographic conditions and the natural ecosystem are very diverse; hence, a common solution cannot be framed for all the cities. It is to be designed strictly location-specific. Whereas, demography of any city can be analyzed and a common framework for demography specific requirement can be worked out for making it user centered planning. From studying the demography of India, it was found that 90% of the working population is part of unorganized sectors and only 10% of the working population belongs to organized sectors. After agriculture, retailers were found to have the second largest workforce involved in the unorganized sector.

After analyzing the demography, a study was conducted with the help of a card sorting technique for understanding the requirements of the individual and their demands from their town. The results have shown the majority of people are willing to stay near the small-scale vendors or the unorganized sector of the city. Some of the participants wished to have malls

and other organized units of the town at a significant distance. In individual interviews, some people have intentionally kept the places with organized sectors away to avoid traffic near their residential areas. In the sequence of the research, it was found that unorganized retail was more in demand by individuals and people were willing to keep these units near their residential areas.

After having data about the requirements of the citizens and the demography analysis it was clear the unorganized retails are very important in any Indian City. The unorganized sector needs to be strengthened and their living standards need to be elevated and incorporated into smart city missions. The unorganized sector comprises of daily wage labourers, farmers, maids, vendors, stores, shops, rickshaw pullers, auto drivers, taxi drivers, etc. Among all the different segments of the unorganized workforce, if the physical presence in the city-scape is to be considered then street vendors/shops are having the maximum presence as compared to the other segments of the unorganized workforce. It can be inferred that street vendors or shopkeepers are critical and important parts of the city in terms of their presence as well as the share of the population dependent on them. Since they are part of the city infrastructure and they need approachable space to sell their services and sustain in rapid city-life. Hence, the population of focus for our research was selected as unorganized sector retailers and vendors.

Whereas, while studying the retail specific design interventions in various smart cities around the globe it was found that numerous design and technology interventions are adopted around the globe in the retail sector and most of them are in organized retail. This also makes them a part of a smart city. However, no such interventions are adopted in unorganized retail

and are mostly neglected part in major Smart Cities design. The smart city vision of India is also unclear regarding the policies related to unorganized retail. Few municipalities have worked for unorganized retail by providing them with space and maintaining the area for them, the most that unorganized retail is offered. In the first list of 13 fast-track city proposals, none had proposed any development for the retail sector. Only tele-medicine was initiated by New Town, Kolkota. None of the smart city policies is made to strengthen the largest employment sector of all the cities of India i.e., "unorganized retail."

The organized stores are exploring all the possibilities starting from space design, service design, product design, system design as well as policy design to conquer the vast potential of the Indian market. At the same time, unorganized retailers are helpless and are trying omni-marketing formats to compete but are not able to exploit them properly. Interpersonal skills are the only tool for unorganized retail to sustain their customers' since e-tail has removed the concept of long-distance trade. On the other hand, e-tail entered with meagre quantity and is growing by leaps and bounds. A group of retailers in Gujarat have formed cooperatives to compete with organized retail and they were working on improving the customer experience, services and product quality. It shows that the retailers are aware of their conditions and are willing to compete with the emerging market trends. They need guidance and tools to survive in this fast-growing market and their depleting share of the market. After detailed deliberations the following research questions were formed for our research.

1.5.1 Research question

- How can we introspect the requirement of the local demography to understand their expectations from the cities they want to dwell in?
- How can the requirement of the end users of Smart Cities be categorized into well-defined parameters for systematic resolution through design intervention for the holistic development of Smart Cities?
- How can a user-centric innovation management tool be developed that will help in designing/redeveloping any smart city?

1.6 Aim: The aim of the research is to develop a strategic design management model for designing user-centered Smart Cities.

1.7 Objectives:

Objective 1. To understand the demography of the city for which it is being planned for and to understand the requirement/expectations of the demography from the city.

Objective 2. To establish strategic categories of parameters in which all types of solutions can be bifurcated for systematic resolution of requirement of end users in smart city planning.

Objective 3. To develop an innovation management tool or methodology to incorporate user perspectives in Smart city design.

In this research, a framework was developed to incorporate all facets of Smart Cities during the designing and developing stage. The research has followed a step-by-step method to first identify the issues and requirements of the city dwellers, followed by segregating the

issues and requirements into suitable categories. Then, these issues were dealt with using different design interventions per their category. A sample intervention is done for all types of categories identified forming the framework for designing an intelligent smart city. All the proposed interventions were validated through 3D Modelling, Product development, grant of Utility patents, and grant of Design Patents (Registration), and user study data were also found to be above the significance mark in the system usability scale. This framework will be very useful in developing a well-planned user-centred smart city while covering all the facets of Smart Cities.

Chapter 2

Research Methodology

2.1 Selection of Site

For conducting the research, we need to identify the site where the data collection and design interventions are to be proposed. Our requirement was to identify a city which was part of the smart city mission of the policymakers. The location of our research should have a significant amount of unorganized workforce population density. At the same time, it should have a modern outlook as a city, and a good prospect of becoming a smart city.

In all the North Eastern states, Guwahati is the fastest-growing and the most advanced city in terms of connectivity, infrastructure development, business prospects, population density and rate of expansion of the city. Guwahati is also selected as part of the smart city mission by policymakers. Hence, this city was identified as the site for research. Next, areas with a high density of unorganized workforce/vendors/stores were identified. In Guwahati, 2 areas with a high percentage of unorganized stores and vendors were identified. Initially, Beltola market, Lokhra, PaltanBazaar, Fancy Bazaar, and Ganeshguri were identified. Lokhra is located near the highway and outer periphery of the city, with low population density. Hence, it was discarded from the list. Fancy Bazaar and Paltan Bazaar are in close vicinity, hence, can be considered the same locality. Three options were left - Ganeshguri, Beltola market, and Paltan Bazaar. In the Ganeshguri market, infrastructures to handle the traffic, parking, etc., are in progress. However, the weekly markets in Beltola are creating multiple issues by occupying the roads and footpaths, leading to long traffic jams. A complex is under construction in Beltola for street vendors but the parking and other basic facilities are missing in the Beltola market. Hence, the Beltola market was selected for the study. In Paltan Bazaar, the traffic for the railway station, bus stop, and regular traffic as well as that for shopping is creating major issues

for all the citizens. The road is already converted to a one-way road but still is subjected to huge traffic jams during office hours. Hence, Paltan Bazaar and Beltola market were selected as the sites for data collection and design intervention.

2.2 Research Flow

After selecting the site, a research flow was formulated in which all the steps of research were incorporated, it is shown in Figure 2.1. It was divided into 4 steps mentioned as under:

2.2.1 Data Collection

2.2.2 Data Analysis before design Intervention

2.2.3 Design Intervention

2.2.4 Post Data Analysis and Validation

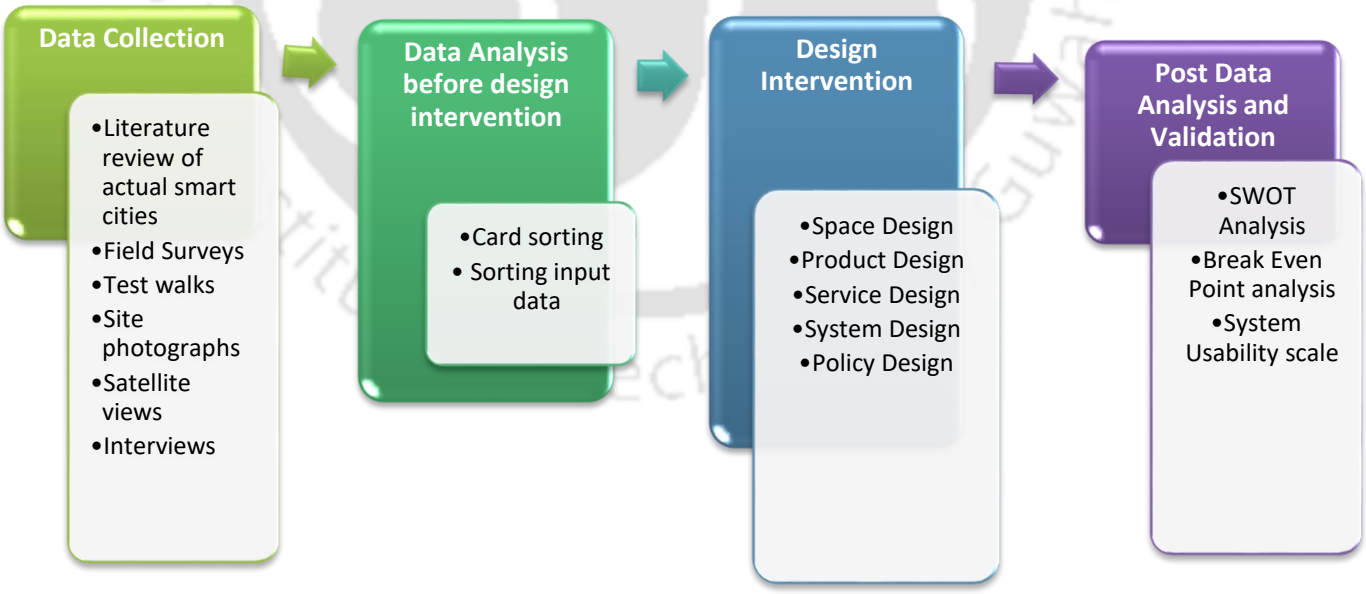


Figure 2.1 – Research Flow Diagram

2.2.1 Data collection

The process of collecting information in any form is called data collection. The data directly collected by the researcher from the field is called primary data and the information which is collected by someone else is called secondary data. The various data collection done in this research is listed below:

2.2.1.1 Literature review

Literature review is a form of Secondary data collection. The insights discussed in Literature review of Chapter 1 helped in identifying the research gap, research questions, aim and objective. Critical review of literature was conducted with the help of keyword search on multiple databases. The literature collected was studied in detail as per the procedures discussed by (Garrod, B., 2023 and De Klerk, W., & Pretorius, J., 2019) and only the relevant data was extracted to further interpretation. Apart from the literature review of smart city research, the literature of the existing smart cities was studied to understand their current scenario. The reasons for their success and failure were analyzed and the learning from the actual existing smart cities was summarized for proper understanding.

2.2.1.2 Field survey

(Ahrens, T., & Chapman, C. S., 2006). Concluded that "By showing the relationship between qualitative field study observations, area of research, theory, the observation and analysis of organizational process can be structured in ways that can produce theoretically significant contributions".

Qualitative field surveys/studies is considered as a disciplined process. The ongoing questioning of own ideas, the field researcher works in a zone of contact with the field

(Hastrup, 1997) in which members of the field challenge and confront them with their own theorizing of their practices. Hence the qualitative field survey can be very beneficial for getting accurate and significant data for research. Hence field surveys were conducted to collect the data from the citizens of the city.

The field survey was designed in multiple layers. The roads and traffic were studied through test walks and site photographs which are part of qualitative field survey. The layout of the market and services were studied with the help of Google maps and test walks. The traffic density on different occasions was studied with the help of Google earth. Multiple test walks in both localities were conducted, followed by site photographs, satellite views, Google maps, and interviews.

2.2.1.3 Test walks and site photographs

Test walk is another qualitative method of data collection (Ahrens, T., & Chapman, C. S., 2006) and is very effective in retrieving the useful data for research. During test walks the localities under observations are explored and their various scenarios are recorded in the form of photographs or diary entry. These photographs and observations recorded during test walks are analyzed for variations and movements with respect to different locations and time. To infer the reasons associated for any changes in the area of observation. Hence Test walks and site photographs of selected localities of Guwahati were taken for multiple days to understand the flow of people and traffic.

2.2.1.4 Satellite views and Google map data

The satellite views or remote sensing is another important data collection tool. With the help of Google Earth and Google map screen shots were taken for a couple of months to study the variations in the movement of people and traffic. As of now there is no fixed rate of Google Earth or Google Maps. The Google Earth or Google Map is not having a fixed rate of update. It keeps on updating their portal regularly but since the amount of data to be updated is very huge so it may take years to reflect any changes. Generally it takes 3-5 years for updates. But the refresh rate in urban setup is much faster as compared to rural setup. Since the rate urban infrastructure and traffic movements are developing very fast hence Google is also focusing more on these areas. Google is also having option for user centric update. The end user can specifically get any area of the map updated through a feedback option on Google earth but it may take months to year to get it reflected on Google Earth or Maps depending on the cloudy weather and other available options with Google. It is to specify that we have not opted for the update of Google portal of our designated area during our research. We kept on checking the Google Earth and Google Maps for variations and the same was recorded when the change took place. The change in the satellite imagery has given us valuable inputs for the research.

2.2.1.5 Interviews

Interviews are a Qualitative method for data collection Dunn, K. (2010) and are very effective in understanding the user perspective. There are generally 4 types of interviews. First one is Focused Group discussion in which group of subjects sit together to have detail discussion of the issue and the data is recorded for intervention by the researcher. Second one is structured interviews with closed ended questions in which questions are fixed and replies

are to be given in limited words like yes or no. Third one is unstructured interviews with open ended questions and replies can be in descriptive form and the data is interpreted from it. Fourth one is semi-structure interviews where some questions are close ended and some questions are open ended this method has more flexibility for changes. For our research we have conduced unstructured interviews so that we can get more detailed perspective of the issue. Personal interviews were conducted with open ended questions to understand the problems faced by the end users on the streets, including vendors, commuters, customers, etc passing or residing in the identified localities.

2.2.2 Data analysis before design intervention

In our research we have used two data analysis methods before design intervention i.e strategic categorization of data collected of personal interviews and Card Sorting. In case of strategic categorization of the interview data, the data collected as explained in section 2.2.1.5 of the thesis was segregated on the basis of type of end user who gave the data and the type of design intervention required for resolving the issue. This method forms a matrix in which all the issues identified were placed and accordingly the intervention is proposed. In card sorting method we have collected the space requirements of the end users with the help of card sorting tool.

2.2.2.1 Categorizing the input data into strategic parameters

All the data collected from the personal interview as mentioned in section 2.2.1.5 were strategically segregated. The data was plotted against a matrix as shown in Table 2.1 in which the type of end user from whom the interview was taken was plotted in the X axis and the

desired types of design interventions for resolving the user specific issue were plotted in the Y axis.

The interview was conducted of the following end users during site visits they were plotted in the 'x' axis:

1. Street Vendors - The vendors who come to sell their products on daily basis or biweekly basis.
2. Customers – The people who come to market to purchase vegetables, grocery and various goods.
3. Commuters – The people who were passing by the market area or the area under observations.
4. Policy Makers – The Government organizations/officials or Local bodies handling the area as per Government Norms.

The various Design intervention categories are well established and identified in the Design Studies:

1. Product Design – In this category of design intervention we will develop new products which can be used to cater the needs and requirement of the city dwellers. As per (Vitalii Ivanov, 2024) "Product design refers to creating and developing new products or improving existing ones to meet specific objectives and user needs. Product design

addresses various aspects such as aesthetics, functionality, usability, ergonomics, materials, manufacturing processes, cost-effectiveness, and sustainability."

2. Space design – Space design is positioning of items and services in the cityscapes. In this category we deal with issues which can be addressed by positioning the items and services in proper location in the city after proper brainstorming sessions and analysis. This component of design intervention is main component of town planning being practiced by Architects and Town planners.

3. Service Design – Service design is the section of design interventions which deals with providing services to the city dwellers. That means to add a service provider between the end user and the product to consumed or utilized. In this segment we try to develop logistics support for the end users. In the current market scenario majority of the products are being delivered with the help of service providers. There are numerous service providers for delivery of meals, daily use products, transport, etc. They cover the gap between end user and the manufacturer.

4. System Design – System design is a more holistic and comprehensive version of the service design. This segment of design intervention deals with ensuring the smooth transition of the product/service, from user requirement and demand registering to delivery to the product/service to the end user, to collecting the feedback from end user for improving the product and service to the satisfaction of the end users. It can be done through developing a systematic framework and converting them to mobile app or in

the physical form with the help of standard operating procedures of execution of the service or delivery of the product to the end user.

5. Policy Design – This segment of Design Intervention consists of policy framework to support the weaker segments of the society or city. It covers how Policy can enhance the standard of living of all the city dwellers residing in a particular city.

To validate the process we have asked four different design teams with 3 people (of minimum 5 years of design experience) in each team to categorize the listed issues as per their perception of design intervention required. In case the design intervention proposed by them lies among the 5 identified design intervention groups then they can place the issue in the respective section otherwise they can keep any of the unidentified issue out of the box also, if the respective design intervention is not identified. The same process was repeated in the interval of 4 months for two times with the same group of design teams. Each time all the teams have discussed and brainstormed to find new solutions of all the issues identified. It was found that each time all the issues were categorized in one or the other section but all the issues identified were resolved by distributing them in either one of the design intervention section. This is further to add that 90% of the time the issues identified was resolved by positioning them in the same section of design intervention. In both the cases when multiple teams identified the design intervention categories on a given day and when these teams conducted the same exercise at intervals of 4 months the results of selecting the issues in the same design intervention section was 90% and above. All the data collected from

the field survey were analyzed and categorized into 5 strategic parameters for proposing suitable design intervention depending upon the nature of intervention required.

Table 2.1 - *Issue identification and categorization Matrix.*

		Stake Holders			
		Vendors	**Customers**	**Commuters**	**Policy makers**
Design Intervention categories	**Product**				
	Space				
	Service				
	System				
	Policy				

2.2.2.2 Card sorting

The card sorting technique was used to understand the mind maps of the people residing in the city to understand how they perceive their city in their minds and what are their expectations. In this process, we try to retrieve the user requirements of services layout in the city.

We have used card sorting method, it is very popular method of analyzing user perception in web page designing. In card sorting technique we have 2 Dimensional space in which cards with various items mentioned on it are placed in a particular pattern as per the liking and requirement of the end user and on the basis of end user preference the position of these items are fixed on the 2 D space or we can say on the computer screen. In our case the layout of the city is a 2D space in which we have to position the cards with various items and

services mentioned on them. So space design of town planning is very similar to web page design since in both the cases we have to position items in 2 D space.

2.2.2.1.1 Methodology of card sorting

The study listed all the services of a town. The list was made by interviewing multiple people from different localities and backgrounds. After the list was prepared, all the services were positioned in different localities of the town.

The card sorting technique was used to zone the listed services. A hybrid card sorting technique was used in the research; categories were decided on the basis of distance. A 0-1 km range is considered a comfortable walking distance if the quality of the route is good. This is the appropriate distance considered in most cities by architects. A majority of cities have their city centre in a radius of 1 km to ensure comfortable walking (e.g., Zurich, Brisbane, Pittsburgh, Copenhagen, etc.). This range is considered for utilities and services required on daily basis by most citizens for which no extra transport is required. In larger cities, the comfortable walking distance is the same but they might have multiple city centers (Gehl, 2010). The second range was considered for cyclists, rickshaws, and auto-rickshaws. It was considered on the basis of comfortable cycle able distance. This range was discussed with all the participants and considered 2-5 km in the Indian context. “This distance is considered the average suited to cycling in urban areas” (Blair, 2004; Lindsay et al., 2011). This range was linked with services of daily use but need not be close to a residential area. The third range was 6-10 km. Other than 6 cities in India, all other cities’ average radius is below 10 km. The fourth range was 11- 20 km, this area is the outskirt of cities or the neighbourhood of the cities. The fifth range is the range

beyond 20 km from the starting point. The starting point of every range is not the city centre but the residence of the subject. Since the participants may or may not be able to quantify the importance of distance from the perspective of a city as a whole, they can easily asses the distance based on their own daily requirements.

A chart was prepared with clear demarcations of the ranges and was placed in front of the subject. All the participants were given cards with names of the services and utilities of any town. Blank cards were also provided to the subject to add any additional service of their choice.

The participants were asked to arrange the cards with services and categories mentioned on them in the chart with different ranges of distance as per their requirements. The data was collected from 45 samples and was analyzed. The user data was used to establish relations between the services and the distance at which they were placed from the residence of any individual.

2.2.3 Design Intervention

The issues identified during the data collection from the customers and vendors were analyzed and suitable design interventions were proposed. Individual problems were taken up from each stratum and a set of solutions was designed for each problem. All the proposed interventions were again discussed with customers and vendors to take their feedback. A framework will be formed with the most desired design solutions to strengthen each strategic parameter of design intervention to have a holistic approach towards smart city planning.

2.2.3.1 Product design

A low-cost vending cart cum cold storage for street vendors was developed first in the form of a 3D model and then in a full-scale prototype. 4 patents were granted on this product. A book chapter is also published in Springer on the outcome of this product.

2.2.3.2 System design

A Hybrid Transport system for Guwahati city was proposed, which will have multiple layers of transport system along with renewable power generation capacity. One patent is published on this concept and a book chapter in Taylor and Francis explaining the methodology is also published. This Paper was also awarded the best paper award at the **International Conference of Infrastructure development, 2021**(Taylor and Francis).

2.2.3.3 Service design

A mobile-based online marketing platform for street vendors was also formulated. A patent for this product is also granted and a book chapter is also published in Springer on the working of the service model.

2.2.3.4 Space design

With the help of the card-sorting technique, a tool was developed to formulate the layout of the city with the help of the end user inputs. A Book chapter on Springer Singapore is published on this tool. A solution for Beltola bi-weekly market was also proposed with the help of scenario planning.

2.2.4 Data Analysis after Design intervention and its Validation

2.2.4.1 SWOT analysis

In this method 4 quadrants are formed by splitting a page in equal halves vertically and horizontally along Y axis and X axis respectively. In the first top left corner quadrant all the strengths of any proposed intervention is noted down, in the second top right quadrant all the weaknesses are noted and at the bottom left quadrant all the opportunities are noted down and in the bottom right quadrant all the threats are noted . After noting down all the Strengths, weaknesses, Opportunities and Threats arising of the new intervention, it is analyzed and discussed in detail for the feasibility of the intervention. In case of multiple ideas, this method makes the decision much simpler with all the pros and cons of the interventions in front of the team for brainstorming and discussions. SWOT analysis was done on the design intervention related to the space design of the Beltola market, in which multiple solutions were proposed with the help of scenario planning. Here we can list out all the interventions in a single table in x axis and in y axis we can have the strength, Weakness, Opportunities and threats of all the interventions for proper comparisons. This will help in easy visualization and support in more analytical decisions.

2.2.4.2 Breakeven point analysis

BEP analysis is done to evaluate the financial implications of any project. This is done to calculate that in how much time the invested amount can be recovered. Initially the overall cost involved in making the product/project is evaluated and then the rate of return is evaluated

from the potential funds to be generated by the product/project in due course of time. The date or duration by which the entire amount invested is recovered is known as the Break Even Point of the project. Any income earned beyond the Break Even Point is the profit earned by the product/project. In system Design intervention a hybrid infrastructure system is proposed, to understand its financial implication the BEP analysis is done.

2.2.4.3 System usability scale

SUS is a scale to evaluate user satisfaction and the efficacy of any new product from the user perspective. The SUS scale was used to validate the product and service design interventions. The System Usability Scale (SUS) is a reliable tool for understanding and measuring the usability of any product. It has a standard set of 10 questions, scored on a five-point scale, ranging from Strongly Agree to Strongly Disagree. The scoring scale is as under from strongly Agree to strongly disagree. It was formulated by John Brooke in 1986. It can be used to evaluate a wide variety of services and products like hardware, software, mobile devices, websites and applications. SUS has been used in more than 1300 articles and publications and is adapted by Industries successfully. Its noted benefits include:

- It is a very easy scale to adopt and monitor.
- It can give significant, reliable and valid results on small sample sizes also.

Interpreting scores

Interpreting scoring can be complex. The participant's scores for each question are converted to a new number, added together and then multiplied by 2.5 to convert the original

scores of 0-40 to 0-100. Though the scores are 0-100, these are not percentages and should be considered only in terms of their percentile ranking.

The System Usability Scale (SUS) was developed by John Brooke in 1986.It was originally created as a "quick and dirty" scale for administering after usability tests on systems like VT100 Terminal ("Green-Screen") applications. SUS is technology independent and has since been tested on hardware, consumer software, websites, cell phones, IVRs, and the yellow-pages. It uses the following response format:

Scoring SUS

The scale values range from 0 to 4 (with four being the most positive response).For odd items,1 is subtracted from the user response. For even-numbered items, the user responses are subtracted from 5. The converted responses for each user are added and multiplied by 2.5. This converts the range of possible values from 0 to 100 instead of from 0 to 40.

Interpreting SUS scores

What is a Good SUS Score? The average SUS score from all 500 studies is 68. A SUS score above 68 would be considered above average and anything below 68 is below average.

The best way to interpret the score is to convert it to a percentile rank through a process called "normalizing." This process is similar to "grading on a curve" based on the distribution of all scores. For example, a raw SUS score of 74 converts to a percentile rank of 70%. A SUS score of 74 has higher perceived usability than 70% of all products tested. It can be interpreted as a grade of a B-.You would need to score above 80.3 to get an A (the top 10% of

scores). This is also the point where users are more likely to be recommending the product to a friend. Scoring at the mean score of 68 gets you a C and anything below 51 is an F (putting you in the bottom 15%).

SUS scores are not percentages

Even though a SUS score can range from 0 to 100, it is not a percentage. While it is technically correct that a SUS score of 70 out of 100 represents 70% of the possible maximum score, it suggests the score is at the 70th percentile. A score at this level would mean the application tested is above average. In fact, a score of 70 is closer to the average SUS score of 68. It is actually more appropriate to call it 50%. When communicating SUS scores to stakeholders, especially those unfamiliar with SUS, it is best to convert the original SUS score into a percentile so 70% really means above average.

SUS measures usability & learn-ability

While SUS was only intended to measure perceived ease-of-use (a single dimension), recent research shows that it provides a global measure of system satisfaction and sub-scales of usability and learn ability. Items 4 and 10 provide the learn-ability dimension and the other 8 items provide the usability dimension. This means you can track and report on both subscales and the global SUS score.

SUS is reliable

Reliability refers to how consistently users respond to the items (the repeatability of the responses). SUS is more reliable and detect differences at smaller sample sizes than home-

grown questionnaires and other commercially available ones. Sample size and reliability are unrelated, so SUS can be used on very small sample sizes (as few as two users) and still generate reliable results. However, small sample sizes generate imprecise estimates of the unknown user-population SUS score. We should compute a confidence interval around your sample SUS score to understand the variability in your estimate.

SUS is valid

Validity refers to how well something can measure what it is intended to measure. In this case, that is perceived usability. SUS has been shown to effectively distinguish between unusable and usable systems as well as or better than proprietary questionnaires. SUS also correlates highly with other questionnaire-based measurements of usability (called concurrent validity).

SUS for product design and system/service design

The 3D model of the vending cart and sample prototype was designed and shown to 42 street vendors/end users from Guwahati. Then, they were given the SUS questionnaire and asked to score their observations. Similarly for service/system design the concept was explained to the vendors/end users with the help of power point presentation handouts, and then they were asked to fill the questionnaire of SUS.

SUS Questionnaire score sheet

After showing the 3D models/prototype/ Presentations the end users were asked to fill the Questionnaire as shown in Table 2.2.

Table 2.2 - *SUS Questionnaire score sheet*

SL No	Questions	Scores	Remarks
1	I think that I would like to use this system frequently.		
2	I found the system unnecessarily complex.		
3	I thought the system was easy to use.		
4	I think that I would need the support of a technical person to be able to use this system.		
5	I found the various functions in this system were well integrated.		
6	I thought there was too much inconsistency in this system.		
7	I would imagine that most people would learn to use this system very quickly.		
8	I found the system very cumbersome to use.		
9	I felt very confident using the system.		
10	I needed to learn a lot of things before I could get going with this system.		

Depending upon the SUS score the usability of the intervention is evaluated.

For any product, system or service to be usable the minimum SUS score should be 68, this indicates that the usability of the product/ system/service is above average. A SUS score above 80.3 is considered as A rated with more than 90 percentile acceptance rate. Hence any score close to 80.3 and above may be considered as significant improvement in the product usability.

Chapter 3

Results and Discussion

In this chapter, the outcomes from different stages of research are discussed. As stated in the research methodology chapter, the entire research flow was broadly divided into 4 stages, and in each stage, we have got various outputs which will be discussed in detail in this chapter.

3.1 Data Collection

In data collection, the first stage is the literature review of smart cities, which is discussed in Chapter 1. In the second step we have done precise literature review of individual existing smart cities to understand their relevance with the generic literature review of smart cities.

3.1.1 Literature review of different Smart Cities

The pros and cons of multiple smart city projects were studied to get insights by comparing the different scenarios of Smart Cities. The first city studied is Singapore, it is globally accepted to be one of the most successful Smart City.

Case 1: Singapore. Out of all the Smart Cities in the world, Singapore is considered one of the classic examples of a great success story. “Smart Cities: the Singapore case” by Mahizhnan (1999) has mentioned the reasons why Singapore turned out to be a success story. Singapore, being an island country, does not have any natural resources to boast its economy. Even the drinking and everyday use water is pumped to Singapore from Malaysia. Survival on such an Island was really very tough. To understand the perspective of Singapore Smart city some basic details are listed in Table 3.1. The table shows the basic features, vision, execution details and reasons for end user perspective.

Table 3.1 – *Details of Singapore smart city*

Sl No	Category	Factors	Singapore
1	Basic Details	Area and location	1. Area 721.5 SQKM.
2		Salient features	1. Smart mobility. 2. Safety & Healthcare 3. Convenient administrative services.
3	Basic Details	Time line	1. Smart nation initiative was taken in 24 November 2014. 2. Singapore emerged top in the 2017 Global Smart City Performance Index by Juniper Research and Intel.
4		achieved occupancy / Designed for occupancy of how many users	1. The current population of Singapore is 5,815,385 as on Friday, September 27, 2019. 2. The smart nation initiative was not to increase the population of the nation but to provide essential services to the existing citizens. 3. It was a brown field project.
5	Top Visionaries	Primary Visionary	1. Smart nation initiative was taken by Prime Minister Lee Hsien Loong on 24 November 2014.2. Minister-in-charge Vivian Balakrishnan believes
6		Purpose	1.Big Data and Internet of Things are the Keys to Singapore's Smart Nation Dream. 2. Introducing cashless payments on a large scale. 3. Smart Nation Not About Technology But Boosting Quality of Life. 4. Optimium mix of culture, innovation, economy and social bonding.
7		Objectives	1. Harness solution through innovation and support the innovation system - The Government plans to dedicate $2.4 billion to working with the private sector in financial year 2017. It will support technology startups by doing business with them instead of grants to spur innovation
8		Problem statement	1. Limited natural resources. 2. Shortage of fresh water. 3. limitations on economic growth. 4. Shortage of land, being an island nation.
9		Funding of the project	Singaporian Government
10	Professional Team	Professional help	The Smart Nation and Digital Government Group (SNDGO) and Government Technology Agency (GovTech) under the Prime Minister's Office (PMO) lead the development of a National Digital Identity framework.
11		Problem identification by Professional	1. Accessibility of the information and services to the citizens to enable them to have optimized usage.
12		Vision of professional	1. The vision of the team was to improve the standard of living . 2. To provide best daily services to the citizens. 3. Make the citizens aware. 4. To provide and generate all possible information to the citizens.
13		Solution proposed	1. Adopting cashless economy. 2. Providing all services and facilities online. 3. Providing all the services at the door step of the citizens. 4. Promoting innovation and technology advancements for the development of the nation.
14		Execution Issues	Changing existing systems and life style of people and adopting new technologies was challenging for people of singapore.
15		Achievements	1. Singapore is an indisputable leader when it comes to smart mobility. 2. Safety & Healthcare 3. Convenient administrative services.
16	User	User prospective	Since the solutions were offered by the people and for the their own convenience, hence the citizens came forward and adopted the new technologies for the betterment of the society.
17		Reasons of satisfaction or dissatisfaction	The changes in the policies caused initial resistance from certain segments of citizens, but were adopted by all citizens in due course of time.

However, their only advantage is that it is located on the main trade route of the world. This is the major, and the only, game changer for Singapore which they inherited to survive. People and traders from around the world visited Singapore. Along with the people, different creative ideas and innovations also touched Singapore. This kept Singapore updated with global developments. They started to en-cash the stay of the travellers on their land. Singapore was very quick to adopt the latest technology. So, they grew along with time and with great vision in their eyes. Still, they did not have any cash cow which can independently support their economy until computers and Information technology entered the global market. This became the turning point for them. They realized that they did not require any natural resource for generating any income, only one piece of computer and some technical know-how is enough to generate capital. Singapore turned into an IT hub and slowly it transformed into a technological innovation centre. From the Singapore smart city literature, it can be infered that they were not blessed with any natural resources then only they realize that their people are their natural resource and they showed the world that they can not only survive but they can thrive in the development scenario of their nation with the help of education, innovation and creativity. So,it is the available resources which are holding us from development. More and more constraints should be imposed to get really meaningful output.

In Figure 3.1 we can see the architectural and technological marvels of Singapore city. This city is proper blend of advanced technology, cultural bonding and creative mindsets. Hence they have matched up with the pace of technological development around the globe to be one of the finest smart cities.

Figure 3.1 - Singapore is home to two of the world's three most expensive buildings (including the three-towered Marina Bay Sands, pictured).

Source:https://edition.cnn.com/travel/article/singapore-50-reasons/index.html(citedon10/12/2018)

Case 2: Songdo city - South Korea. After having a success story of a smart city project, it is also important to study a smart city project which is not as popular as it was intended to be. Songdo International Business district in South Korea was a 40 billion US dollar project. Some eminent features of this project are mentioned in the Table 3.2. Still, the entire city is a Ghost city since the people of South Korea are not ready to shift to these localities. Some Japanese citizens have bought some houses here and a few celebrities have also occupied residences, and the Government is hoping that more people will be attracted towards this city. The technology advancements are implemented by CISCO. For them, this city is more like a research and development test bed since the occupancy is almost negligible. All the technology and innovation are in place. The city is ready to be occupied but people are not willing to move there.

Table 3.2 – *Details of Songdo smart city*

Sl No	Category	Factors	Songdo City
1	Basic Details	Area and location	1. 600 hectares (1,500 acres) of reclaimed land. 2. 30 kilometres (19 mi) southwest of Seoul, South Korea. 3. It is 19.5million ft2 LEED certified project.
2		Salient features	1. Green city & Low carbon City 2. Pneumatic system for waste disposal and no garbage trucks. 3. State of the art and automated household and outdoor features. 4. Incheon Free Economic Zone. 5. With 106 buildings and 22 million sq ft. of LEED-certified space, the green building certification by the United States Green Building Council, Songdo IBD makes up about 40% of all LEED-certified space in South Korea.
3	Basic Details	Time line	1. Initiated in 2010 and completion planned till 2015.
4		achieved occupancy / Designed for occupancy of how many users	1. As on 2018 - 1,20,000 people are residing in Songdo. It was designed for 3,00,000 occupants. 2. The district was planned to contain 80,000 apartments, 5,000,000 square metres (50,000,000 sq ft) of office space and 900,000 square metres (10,000,000 sq ft) of retail space.
5	Top Visionaries	Primary Visionary	Songdo IBD was part of former President Lee Myung-bak's effort to promote green and low-carbon growth. And to open an economic gateway to the world for promotin business in south korea.
6		Purpose	1. To promote green and low-carbon growth as an avenue for future development
7		Objectives	1. To develop a sustainable city in terms of environment. 2. Songdo IBD was designed and created to be a "ubiquitous city", or a smart city. i.e. computers are built into the buildings and streets
8		Problem statement	1. Climate change. 2. Economic growth.
9		Funding of the project	Korean Government
10	Professional Team	Professional help	1. Gale International, holds a majority stake of 61%, Posco 30%, and the remaining 9% is owned by Morgan Stanley Real Estate.2. The plan was designed by the New York office of Kohn Pedersen Fox (KPF).
11		Problem identification by Professional	Inline with the korean Government
12		Vision of professional	Inline with the korean Government
13		Solution proposed	1. Emphasis on Electric vehicle, passive cooling, renewable energy sources. 2. Pneumatic system for waste disposal and no garbage trucks. 3. State of the art and automated household and outdoor features. 4. Tele calling facility and CCTV surveillance of entire city.
14		Execution Issues	Converting a reclaimed land in to a livable city and developing green belts in short period of time was a challenging job
15		Achievements	1. Songdo IBD is home to 106 LEED certified buildings that fall under 12 projects, or 22 million sq ft of LEED-certified space. 2. Pneumatic waste disposal system. 3. 25 km of bike paths. 4. Charging stations for electric vehicles throughout the city. 5. Hi-tech surveillance of the city for safety of people. 6. State of the art hi tech residence and societies are maintained to make all the necessary services available.
16	User	User prospective	1. People find it difficult to adopt in new place. 2. Since the population is less hence social security is questionable. 3. The technology is very advance, hence people are finding it difficult to cope up with it,all of a sudden.
17		Reasons of satisfaction or dissatisfaction	culture, art, music is missing, Being a new city it desnot have any heritage to cherish on, or to be attached with to feel the belongingness with the city.

Figure 3.2 – Songdo's U-Life Centre. Real-time footage from the CCTV cameras located throughout Songdo to monitor traffic and spot crime. (Ross Arbes)

Photo source: https://www.theatlantic.com/international/archive/2014/09/songdo-south-korea-the-city-of-the-future/380849

Figure3.3 – Songdo's 101-acre Central Park features captive deer in front of ultra-modern residential buildings. (Ross Arbes)

Figure 3.4 – Songdo "Third Zone Automated Waste Collection Plant," where it is automatically processed. (Ross Arbes)
Photo source: https://www.theatlantic.com/international/archive/2014/09/songdo-south-korea-the-city-of-the-future/380849/

In Figure 3.2 we can see the control room of Songdo city from where we can monitor the city and keep a track on the safety and security issues of the city. In Figure 3.3 a central park is shown which is established in a huge area of 101 acres to balance the pollution and urban heat with the natural and healthy habitat in the heart of the city. This green belt in the centre will pump healthy air in the city. Figure 3.4 shows the automated waste collection system installed in the city to collect the waste from every residence with the help of pipe network all across the city. And many more advanced features were installed in the Songdo city but still the city fails to attract desired number of occupants.

Case 3: Masdar city – UAE. Another similar example is Masdar city in UAE is a 22 billion US dollar project and the main features of the city are listed in the Table 3.3. Whereas some of the prominent features are being a Zero carbon City, Car-free township, Driverless shuttles, State-of-the-art township in terms of technology and architecture.

Table 3.3 – *Details of Masdar smart city*

Sl No	Category	Factors	Masdar City
1	Basic Details	Area and location	1. It was designed to cover 6 square kilometres (2.3 sq mi). 2. Masdar City is being constructed 17 kilometres (11 mi) east-south-east of the city of Abu Dhabi, beside Abu Dhabi International Airport.
2		Salient features	1. The city relies on solar energy and other renewable energy sources. 2. Masdar is a sustainable mixed-use development designed to be very friendly to pedestrians and cyclist. 3. The temperature in the streets is generally 15 to 20 °C (27 to 36 °F) cooler than the surrounding desert. 4. Travel will be accomplished via public mass transit and personal rapid transit (PRT) systems with few additional EV's.
3	Basic Details	Time line	1. Initiated in 2006 2. Construction began on Masdar City in 2008 3. Still in progress
4		achieved occupancy / Designed for occupancy of how many users	1. Designed for 40000 people residing and 50000 commuters. 2. As on March 2018 records 3500 people are working in Masdar and 1300 are residing there.
5	Top Visionaries	Primary Visionary	To develop a sustainable city in desert like OASIS, which is self-sufficient and comfortable for the dwellers
6		Purpose	The city is designed to be a hub for clean tech companies. Emphasise on green energy
7		Objectives	To develop a high-tech sustainable model for green cities. To attract more occupants and tourist for purchasing property here.
8		Problem statement	1. Global warming. 2. Reliability on conventional energy sources
9		Funding of the project	Government of Abu Dhabi
10	Professional Team	Professional help	1. Masdar, a subsidiary of Mubadala Development Company.2. And Designed by the British architectural firm Foster and Partners,
11		Problem identification by Professional	1. Outside environment is very hot and can't be used by the people to move in open spaces. 2. The energy requirement to cope up the harsh weather condition will rely on conventional energy sources and hence will increase the cost of living in long run. 3. Environment concerns for making the city habitable will further worsen the situation.
12		Vision of professional	1. To use passive cooling techniques. 2. To emphasise on green energy methods for energy requirements.
13		Solution proposed	1. To use shadow of buildings for keeping the outside environment cool in the city area. 2. To use only green energies forms. 3. Passive cooling and heat ventilation as primary goal. 4. Completely eliminate the conventional fuel based energy sources.
14		Execution Issues	Converting a desert in to liveable habitat was a big challenge.
15		Achievements	1. Masdar city manages to convert a desert into a city in which people can roam outside the building freely. 2. Developing green belts in the sands of desert was another achievement. 3. Completely green energy based townships. 4. Low carbon city. 5. Driverless shuttles. 6. Conventional fuel free transport system.
16	User	User prospective	1. Very few people are opting to stay there since job opportunities are very limited. 2. The residence was expensive and due to low population density social bonding was also less. Limited job opportunities.
17		Reasons of satisfaction or dissatisfaction	1. Employment opportunities are less. 2. Population density is low so social bonding is also limited.

Figure 3.5 – Township of Masdar city

Source:https://www.popsci.com/masdar-city-ghost-town-or-green-lab (cited on 11/12/2018)

Masdar is situated near Abu Dhabi where the outside temperature is unbearable and hence it is very difficult move outside the buildings freely. This was the biggest challenge for the town planner of Masdar city but they have built the city with passive cooling methods like wind towers and used the shadow of the buildings in the walking corridors of the city (as shown in figure 3.5) to keep the walking area outside the buildings 15 to 20 °C cooler than the temperature outside the city limits. This indeed is a great achievement that too in such a large and open area. Solar energy and other renewable sources of energy are used in the city for their energy needs.

In Figure 3.5a we can see how beautiful architectural members are designed to act as umbrella for maintaining shade in the open areas for the people. These architectural members can also be retracted in case they are not required. Multiple such features are inbuilt in the city to make it comfortable for the city dwellers to roam around the city.

Figure 3.5a – The Plaza of Masdar city

Source: http://88designbox.com/architecture/masdar-city-center-by-lava-685.html (cited on 10/12/2018)

The city turned out to be an OASIS in the desert as planned. But the city was designed for 90,000 people in the daytime and 50,000 full-time dwellers. In spite of the city being very well designed in terms of technology and environmental aspects, the actual population dwelling in this city is only 1300 by 2018, this has forced the governing bodies to roll back some of the features of Smart Cities. So, what went wrong here? Why are people not occupying this city?

Case 4: ***Ghost towns of china***

There are numerous cities in china which were well planned in terms of town planning practices and were also embedded with advanced technologies, details are listed below:

Table 3.4 – *Details of Ghost towns of china*

Sl No	Category	Factors	Case
			Ghost towns of china
1	Basic Details	Area and location	More than 40 cities all across the country
2		Salient features	1. Well built infrastructure. 2. Public transport system. 3. Wide roads, drainage network, etc.
3	Basic Details	Time line	1. Initiated in1980's still under construction.
4		achieved occupancy / Designed for occupancy of how many users	1. Initially the cities with 5,00,000 were almost nill. But in last decade the population has increased to 1,00,000 and is expected to increase in the coming decades.
5	Top Visionaries	Primary Visionary	1. The plan was to switch major population of China in urban infrastructure instead of rural based.
6		Purpose	1. The urban infrastructure should be sufficient to support majority of the population of China.
7		Objectives	1. To provide all modern facilities and services to the citizens of China. 2. To improve the Quality of living of the people of china.
8		Problem statement	1. Lack of modern infrastructure. 2. Development and growth of the people and nation.
9		Funding of the project	Government and financial institutions and Real estate developers. Kangbashi District - 161 USD project
10	Professional Team	Professional help	Multiple teams were working on the various project with distinct objectives. But their main aim was to develop urban infrastructure for the people of China.
11		Problem identification by Professional	
12		Vision of professional	
13		Solution proposed	
14		Execution Issues	
15		Achievements	
16	User	User prospective	
17		Reasons of satisfaction or dissatisfaction	Very costly and far from the place of employment. Out of the budget of the general public.

From the literature of Chinese Ghost towns it was found that it is not only the people but their socio-economic capabilities which can make this project more fruitful. These projects have not considered the pocket size of an individual or their buying capabilities. The financial support and aid were also not very supportive. The main factor was these townships are not having any employment opportunities. The employment opportunities in these cities should be

lucrative enough to ensure that the people employed in these cities should easily afford a residence in the locality. So, from the above three case studies, it is clear that one can have everything starting from advanced technology, innovation, funding, governance, transportation and all the features of Smart Cities in place but without the people in it everything is useless. On the other hand, even if you do not have anything other than people, still one can manage to develop the most successful Smart Cities.

Figure 3.6 – The Ghosts towns of China

Source:https://www.forbes.com/sites/wadeshepard/2017/01/04/a-look-at-chinas-ghost-cities/#c597c8a64b0f (Cited on 29/12/2018)

In Figure 3.6 we can clearly see that numerous huge infrastructure has been developed at multiple locations in china but still it is under-occupied. Hardly any person can be seen in the pictures. Here people are available in abundance but still the cities are not occupied due to the budget constraints and employment opportunities.

So, from the literature review of China, it can be understood that only developing Smart Cities is not going to solve our purpose. India has a similar problem in the National Capital Region area, where thousands of flats are vacant and there are no customers to occupy them. These flats are now more than a decade old. India is also on the same track as China.

For sustained development of Smart Cities, it is important to empower the citizens with employment opportunities. And those opportunities should be integral part of the smart city model. This will ensure that all the citizens have the potential to own a dwelling place in the same township.

Case 5: New York City – USA.

The land of dreams for many is the most expensive city in the world. However, people from all segments of society are still staying and settling there. This defies all notions that affordability and employment opportunities may be the reason why people avoid living in hi-tech Smart Cities built around the world. Then what else was missing in the equation? It was observed that even with all the hi-tech features and services embedded in Smart cities people are not willing to adopt the lifestyle. Even if a city has special economic zones for providing employment opportunities in the locality people are not comfortable living there. And on the

other hand, people are rushing towards a more expensive and highly competitive lifestyle, even if survival there is very tough. Here the entire population has joined the rat race and have become machines for earning money and growth opportunities. The city has converted into a mechanical device for manufacturing various products, money and services. So to make the New York city alive again a human touch was required.

Human scale **-** After the basic framework for a sustainable smart city is achieved then the next goal should be to make a smart city alive. Making it alive refers to filling the city with emotions and making it more human-like. It should interact with the people. The people should interact with the city and other people. Life should be visible in the city. This can be better explained with the literature of New York.

Jan Gehl, the Architect of New York City, re-modified the city to make an over-congested, very densely populated, stressed, and suffocating city into a liveable city with design intervention. How his approach is different from the other Architects of the world.

To understand his mentality and his approach, his biography needs to be explored a little bit. He was born on 17 September 1936. He completed his Masters in Architect from the Royal Danish Academy of Fine Arts Copenhagen in 1960. After that, he started designing beautiful buildings and cities. He was a conventional architect, designing spaces and shapes to the beauty of the eye. Then, he got married to a psychologist. They had two groups of frequent visitors. One group belonged to an architecture background and the other to psychology. Psychologists always questioned why architects did not design building and spaces for people instead of just making random shapes. Why the buildings were not more people-centric, making people interact with the structure and other people around?

He came to know about Jane Jacobs a Canadian journalist and activist. She was born on 4th May 1916, in Scranton, Pennsylvania, United States and died on 25th April 2006, in Toronto, Canada. She was very upset with the way Architects destroyed the entire neighbourhood culture in America because of the town planning model that existed in the 1950's. She raised her voice to make people aware of the drawback of the town planning models existing at that time. She was never taken seriously since she was not having any architectural background. She also wrote a book, "***The Death and Life of Great American Cities***.**"** It mentioned all the reasons why these town planning models create negative impacts on the human scale and the life of the city.

Under the influence of their psychologist friends and the vision of Jane Jacobs, Mr Jan Gehl realized that there was something very important missed by all the architects around the world and the institutes teaching architecture.

So, he started studying the flow of life in a city same as a traffic planner studies the flow of traffic. He established the importance of any city interacting with its people, otherwise, the life of the city will be lost.

He also quoted that when 3D models are made, the client and the designers are very satisfied to have them. However, when the actual buildings are ready, the same level of satisfaction is not observed. They realized that in 3D models, people are spotted in all the locations, making the model livelier whereas, when the building is ready and people are not present, the same level of satisfaction is not felt. So, the presence of people on the streets, buildings, in open areas, etc. makes it more alive.

The industrial revolution also played a major role in reducing the level of life in a city. More and more cars entered the roads. People stay in closed houses and, when required, they move in the car to reach their destination and again get inside their closed desired destination. This reduced human-to-human interaction. More cars mean more traffic, more pollution, more stress, etc. Less than 30% of the population owns a car and they consume more than 70% of the space available for transit. Hence, it is not a balanced equation. 70% of the population should get 70% of the area to transit and car owners should get 30% of transit space.

People should spend more time outside interacting with each other. And the architect should be responsible to generate comfortable pleasing spaces for the interaction of life. Some of his work in New York City is shown through pictures shown in Figure 3.7 to 3.14a.

Figure 3.7 – New York City before and after design interventions to make it more people-centric

Photo source: http://buildipedia.com/aec-pros/urban-planning/new-york-city-revitalizes-the-life-between-buildings?print=1&tmpl=component(Cited on April 2018)

Figure 3.8 – New York City, the busy road has been converted to a place for people to interact.

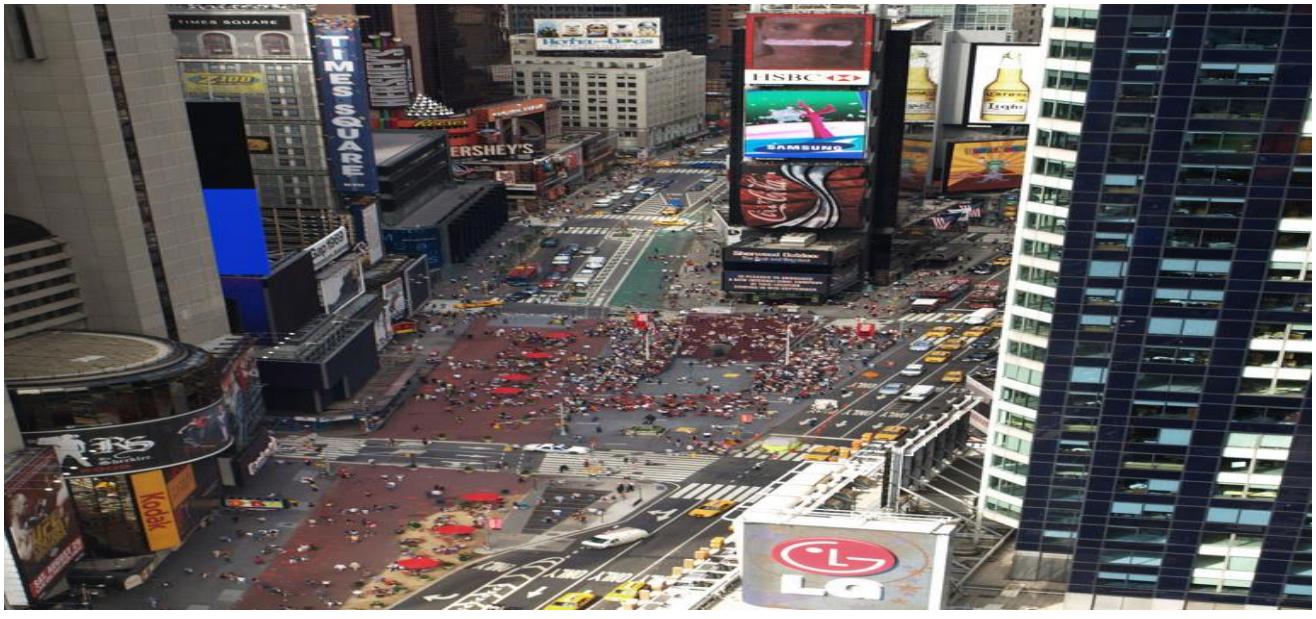


Figure 3.9 – New York City after design interventions full of public interaction interfaces

Photo source: http://buildipedia.com/aec-pros/urban-planning/new-york-city-revitalizes-the-life-between-buildings?print=1&tmpl=component (Cited on April 2018)

Figure 3.10 – New York City before design interventions

Figure 3.11 – New York City after design interventions

Photo source: http://buildipedia.com/aec-pros/urban-planning/new-york-city-revitalizes-the-life-between-buildings?print=1&tmpl=component(Cited on April 2018)

Figure 3.12 – New York City before design interventions

Figure 3.13 – New York City after design interventions

Photo source: http://buildipedia.com/aec-pros/urban-planning/new-york-city-revitalizes-the-life-between-buildings?print=1&tmpl=component(Cited on April 2018)

Figure 3.14 – New York City before design interventions

Figure 3.14a – New York City after design interventions

Photo source: http://buildipedia.com/aec-pros/urban-planning/new-york-city-revitalizes-the-life-between-buildings?print=1&tmpl=component(Cited on April 2018)

In the case of New York City it was found that the requirement of the city was completely different from all other smart city discussed earlier. Here the city was very expensive but still was overcrowded due to the growth opportunities. But people here were losing the human touch in their life. Hence it defied all the previous notions and findings from the literature. This also signifies that each and every smart city is very unique in their own ways and need to design accordingly.

Case 6: Tianjin Eco-City China

In similar lines when Chinese policy makers observed that their Infrastructure development and urban development are not getting the desired traction from the people, then they collaborated with Singapore to implement the successful concepts of Singapore and in same lines building a new city. Figure 3.15 shows the bird eye view of Tianjin Eco city.

Figure 3.15 – China-Singapore Tianjin Eco-city South District

Photo source: https://www.construction21.org/france/articles/h/sino-singapore-tianjin-eco-city-china-sustainable-city-grand-prize-winner-green-solutions-awards-2018.html (Cited on Nov 2023)

The salient features of Tianjin Eco city are listed below:

Table 3.5 – *Details of Tian Jin Eco smart city*

Sl No	Category	Factors	Tian Jin Eco City
1	Basic Details	Area and location	1. Area 30.0 SQKM. 2. 150 km from Beijing. 3. The Eco-City is located in northern China in Binhai New Area.
2		Salient features	($22 billion) project
3	Basic Details	Time line	1. Ground breaking ceremony in 28 September 2008. 2. Completion date 2020
4		achieved occupancy / Designed for occupancy of how many users	100,000 people occupied the city by 2019 and it was designed to accommodate up to 350,000 people.
5	Top Visionaries	Primary Visionary	1. Designed to be practical, replicable and scalable.2. Tackling environmental protection, 3. Resource and energy conservation4. Sustainable development 5. Serve as a model for sustainable development for other cities in China.6. An important instrument will be subsidised public housing
6		Purpose	Sustainable infrastructure model to be developed
7		Objectives	1. Create a detailed knowledge base on the project. 2. Provide policy advice on key issues, especially those related to the Global Environment Facility (GEF) project. 3. Estimate SSTEC's Greenhouse Gas (GHG) emission reduction potential. 4. Contextualize the project among the broader ecological urban development initiatives in China.
8		Problem statement	Green and environment friendly town with high quality of living
9		Funding of the project	SSTEC enjoys a great variety of funding sources. Bank loans, corporate bonds, international assistance programs, Government grants and tax refunds, and private capital are the main ones. Starting from Governments of both China and Singapore, many MNC's, private and public sectors were involved.
10	Professional Team	Professional help	1. The master plan of Sino-Singapore Tianjin Eco-city was jointly developed by the China Academy of Urban Planning and Design, the Tianjin Urban Planning and Design Institute, and the Singapore planning team led by the Urban Redevelopment Authority of Singapore. 2. Mott MacDonald
11		Problem identification by Professional	Environmental friendly town planning required and affordable housing for appealing to the budget of the citizens.
12		Vision of professional	The Eco-City which encompasses green building, green transport, and industrial and commercial strategies all underpinned by education options and stakeholder engagement to encourage 'low energy' living
13		Solution proposed	1. Innovative public transport and pedestrian-oriented urban design to limit the use of private motorised transport (to less than 10% of journeys). 2. A wetland to provide natural treatment for recycled wastewater. 3. The use of organic waste to produce heat and power. 4. 60% of the city's waste being recycled. 5. In addition, management of power and water consumption combined with clean and renewable electricity generation will be used to limit carbon emissions.
14		Execution Issues	To keep the construction cost less but still manage to get good quality of life and construction.
15		Achievements	1. Ambient Air Quality 2. Quality of Water from Taps 3. Carbon Emission Per Unit GDP 4. All buildings to be Green Buildings 5. Green Transportation 6. Barrier-Free Accessibility - The Eco-city should have 100% barrier-free access. 7. Proportion of Affordable Public Housing 8. Usage of Renewable Energy - geothermal energy, hydropower and solar power. 9. Usage of Water from Non-Traditional Sources. 10. Jobs generated in the Eco-city
16	User	User prospective	1. Job opportunities. 2. Affordable housing. 3. Quality of construction and living. 4. Comparatively healthy environment.
17		Reasons of satisfaction or dissatisfaction	Value for money, Job Opportunities and standard of accommodation

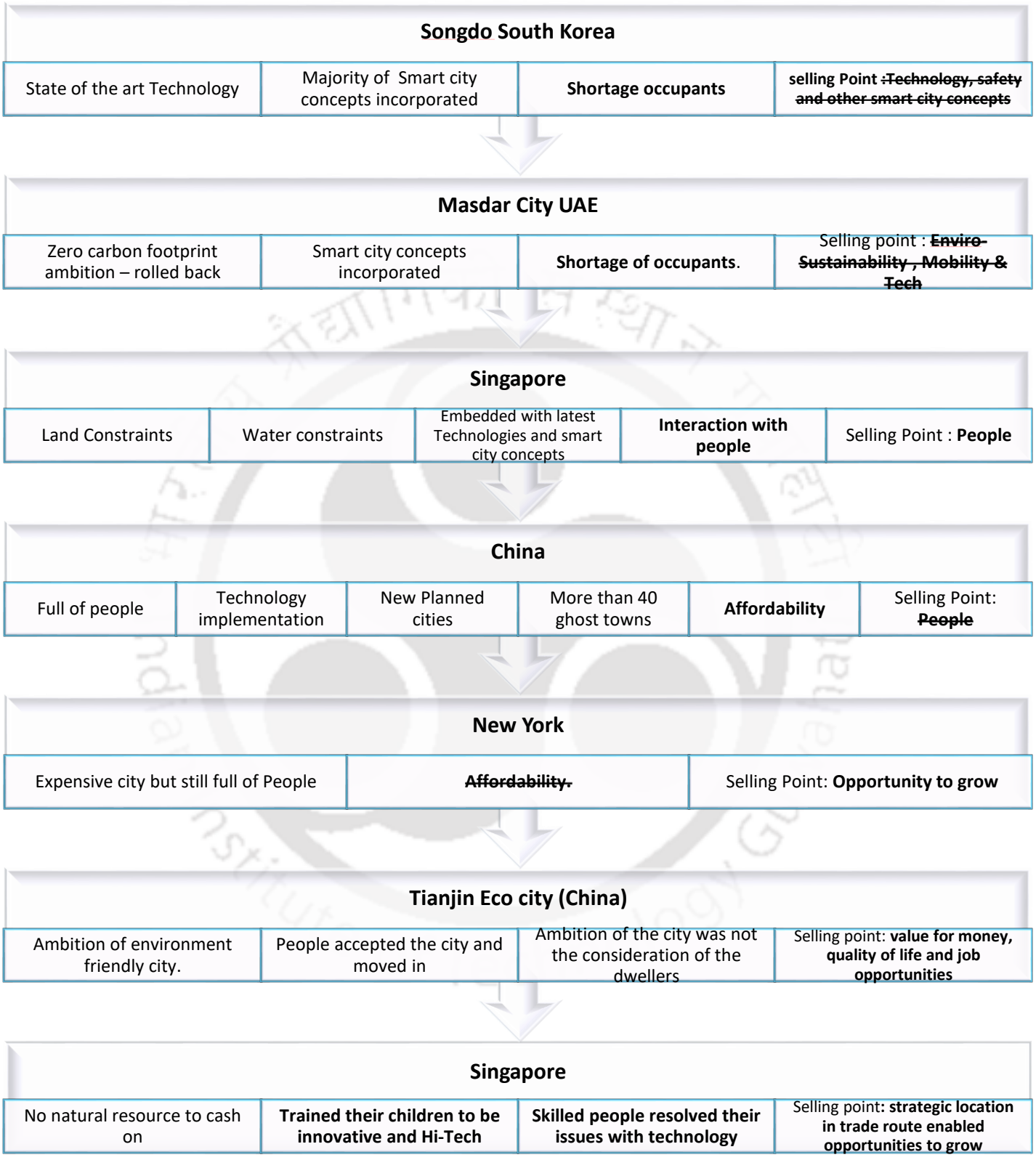


Figure 3.16 –Findings from the individual existing smart city literature

3.1.1.1 Insights of Literature review of existing Smart cities

The figure 3.16 compare various smart cities as discussed in this chapter and from this data it can be inferred that city like Songdo might have all the latest technology and incorporated with all the latest smart city concepts but these features are not able to attract occupants as expected.

In a similar case of Masdar city, where Environment sustainability, mobility and technology features were enhanced and embedded in the smart city concepts, but they still fail to attract the occupants with these features of smart cities.

Where as a city like Singapore where there is land constraint, water constraint and limited or no natural resources but still the people developed themselves and developed the technologies in the city. So the main asset of the city was found to be the people and with the growth of people, the city was also growing. But when we consider the Ghost Towns of china it can be seen that in spite of having huge population and abundance of people still more than 40 cities of china were under occupied. This new finding raises the question that why the cities of China are under - occupied even after having one of the largest population in the world.

So our inference that people makes a city successful is not applicable here. In some of the literature in Chinese smart cities affordability of the houses were observed to be one of the major concern. Policy makers tried to provide job opportunities in these cities for attracting occupants. But people have adopted an alternative to it. They used to stay in small villages and small town near by these cities and used to come to work in these big smart cities in order to avoid wastage of money by living in expensive localities. So from literature of Chinese cities it

was found that non - affordability is one of the reasons for losing the popularity of these cities among the citizens.

But when we studied the literature of New York City, then it was found that it is the most expensive city in the world but still people keep on moving in the city. So what is the missing link between the smart cities literature discussed earlier and the New York City? Here population density is very high in-spite of being one of the most expensive cities of the world. So as per the Chinese ghost town literature, it should have been under-occupied. It is observed that the growth opportunities in New York city is very high and the per capita salary of the people of New York city is also very good hence they can afford the expensive living standards. So it's the balance between the salary of the people and the living standard, this is the governing factor here. Here people are moving after growth opportunities and have a mechanized life style in race to earn more and more money. Though the New York City is over occupied and moving very fast but few researchers and town planner like Mr Jan Gehl observed that there is no Human scale in these city. It is more like mechanical interaction rather human interactions.

Smart city projects executed from scratch and formulated with latest technology and services fail to attract occupants. Since Technology is reducing the need of human interaction. Over all human scale of these cities are questionable. Smart cities are context specific and vary from city to city around the globe. So there cannot be a general formula for all types of cities. All cities have their own personas still they might have similar aspirations to be among the elite class of smart cities. The important part in this context is introspection of prevailing conditions of the cities and their requirements. For example a city facing flash floods every year might

have a hi tech ICT embedded township but if the traffic is disturbed during the flash floods disturbing everyday life then in such case the smarter option will be to mitigate the flash flood first. So to understand the city or country first we need to know the geography followed by the demography and their requirement. Basic utilities like water, power, transportation, food supply, residential communities and waste management are the primary requirements followed by services like healthcare, education, job, safety & security in which environmental concern are intrinsic character. If basic infrastructure is available then factors like ICT or big data can be embedded in the system to make life easier. There is a huge difference in opinion of architects on the basis of their perceptions. Some architects from Europe consider human scale a more important factor of a city. Whereas others believe that technology is the answer to all the problems. The architects in favour of human scale consider burst in the use of personalized motor vehicle as an obstacle in human interactions and converting the city to a more mechanical form than Human. Those cities have learned from the Hi tech and well planned ghost towns that human scale is an important aspect of a city. The aspiration of a people varies as per their status. In case study of Sino Singapore Tianjin Eco City, the city was designed around environmental concerns with aspiration of positive impact on the environment. The quality of life of people has improved but the main motive of the city is contrary to their new lifestyle. When the motive of the people moved to live in Tianjin Eco city were analyzed, it was found that 46% of population moved here because of good value for money of accommodation, 35% population liked the quality of accommodation, 8% population moved due to job requirements and remaining 11% of people had mixed opinion. So it is clear

that people priorities for moving in any city is Cost, value for money and Job. Remaining all aspirations of smart cities are not the deciding factors for the citizens.

Whereas when we re-introspect the Singapore city with similar observations of other smart cities discussed in the chapter we can say that Singapore is also having a balance of growth opportunity, standard of living, income and cost of living. The main opportunity with them is the exposure to the international trade route which keeps their population updated with the latest Global trends and accordingly the Singapore population adapts and grow rapidly.

In the literature analysis of different cities, it was found that the cities which evolve with time and along with the population of the city were more successful than the cities which were very well planned, high tech and build from the scratch. Case studies of Sangdo, Masdar city, Chinese ghost towns and infrastructure developed in the national capital region of India are the classic example of top to down approach. Where the policy makers had a vision and the vision was embedded with technology and funding to develop extraordinary products but was not accepted by the population for whom it was designed for. So it is very important for any smart city project to be successful, it should understand the demography and the requirement of the people for which it is designed for.

Case study of New York city is one of the classic example and the future of all the growing cities. If the growth and employment will be the only vision for the city and for the dwellers of the city, then soon the city will start to lose its social values and convert itself into a mechanical tool box for generating money only. The luxuries will keep on isolating the people and reduce the level of human interaction. It will affect the overall social health of the city as a whole.

Similar to the literature review it can be inferred from the city specific literature review that all Smart Cities should be local context specific. Hence mere replication of any success smart city model to another city without understanding the local context and requirement of the city may lead to disaster. Since each city is unique in its own way and may have different issue to be addressed.

While planning a smart city project in a country like India, it is a big challenge to cater the need for its huge demography and its further difficult to incorporate all the segments of the society in a smart city planning. The Indian Government has launched 100 smart city projects throughout the nation. Is this the right track? China also had similar ambitions 2 decades ago. As per their plan, they have developed numerous cities and townships in the last 2 decades. Out of which, 30-40 ghost cities exist in China now. So, where did they go wrong? What about these Smart Cities are scaring the people of China away?

3.1.2 Field Survey

One of the primary data collection methods adopted in the research is field survey in which the selected site was visited and the local data was collected. The data was recorded in the form of diary entry and observation notes while movement of the researcher in the selected sites. Following data was recorded - types of interactions within the locality, type of people interacting in the locality, the approximate dimensions of the locality, and variation in traffic flow. The main groups of people interacting in both the selected sites were vendors, commuters (for office, schools, travelers, etc), customers of the vendors and the regulatory bodies. The type of interaction observed in these parts of the city were sell and purchase of

goods, movement of people going to job, schools, business, travelers, etc. Other methods used for recording primary data are test walks and site photographs.

3.1.3 Test Walks and Site Photographs

Paltan Bazaar. While conducting test walks the area from Paltan Bazaar to Lachitnagar was covered multiple times to understand the traffic flow and customer flow. The photographs were taken in continuity from starting point in Paltan Bazaar to the Lachitnagar flyover. Photographs were taken at definite intervals of time and at the time of minimum traffic movement, to cover maximum open spaces of interaction and the details of physical infrastructure. During office hours, the traffic in the area is very high, in-spite of converting the road to one way, the waiting time in peak traffic hours may extend from a few minutes to an hour in the entire stretch of 3 - 4 km. Multiple traffic controllers are deployed to regulate the traffic.

It was evident from the photographs, test walks and some personal interviews that the passengers moving in the area were being diverted towards the railway station, bus stop, nearby Government offices, corporate offices, customers for shopping, and commuters to the airport, Kamakhya, riverside, or outside Guwahati, etc. The sample photographs with Google map tagging are attached for reference. More than 300 photographs were taken to understand the existing circumstances and issues. Figure 3.17 to 3.28 shows the real time picture of the Paltan bazaar site for better understanding of the actual site conditions and how is the traffic movement in the area.

Figure 3.17 – Paltan Bazaar site photographs taken on a Tuesday @11:00 AM

Figure 3.18 – Paltan Bazaar site photographs taken on a Tuesday @11:10 AM

Figure 3.19 – Paltan Bazaar site photographs taken on a Tuesday @11:30 AM

Figure 3.20 – Paltan Bazaar site photographs taken on a Tuesday @11:40 AM

Figure 3.21 – Paltan Bazaar site photographs taken on a Tuesday @ 11:45AM

Figure 3.22 – Paltan Bazaar site photographs taken on a Tuesday @11:50AM

Figure 3.23 – Paltan Bazaar site photographs taken on a Tuesday @ 12:05 PM

Figure 3.24 – Paltan Bazaar site photographs taken on a Tuesday @ 12:15 PM

Figure 3.25 – Paltan Bazaar site photographs taken on a Tuesday @ 12:20 PM

Figure 3.26 – Paltan Bazaar site photographs taken on a Tuesday @ 12:25 PM

Figure 3.27 – Paltan Bazaar site photographs taken on a Tuesday @ 12:30 PM

Figure 3.28 - Paltan Bazaar site photographs taken on a Tuesday @ 12:35 PM

Beltola Market. Similar to Paltan bazaar, the traffic movement in the Beltola market is also affected adversely during the biweekly market in the area on Sunday and Thursday. These photographs were taken during the bi-weekly market to understand the existing situation. It was evident from the photograph and test walk that the vendors have occupied 2 out of 4 driving lanes. This leads to leaving only 2 lanes for the movements of commuters. People are also walking along the narrow road and sitting on the roadside edge for shopping. This makes it very difficult for vehicular movement. It was also observed that many two-wheelers were parked on the roadside for shopping and blocking the traffic of the road. Figure 3.29 to 3.36 shows the area coverage of the market by the biweekly vendors and their customers and leaving very narrow space for the vehicle movement.

Figure 3.29 –Beltola Market site photographs taken on a Thursday @ 02:00 PM

Figure 3.30 –Beltola Market site photographs taken on a Thursday @ 02:05 PM

Figure 3.31 –Beltola Market site photographs taken on a Thursday @ 02:10 PM

Figure 3.32 –Beltola Market site photographs taken on a Thursday @ 02:15 PM

Figure 3.33 –Beltola Market site photographs taken on a Thursday @ 02:20 PM

Figure 3.34 – Beltola Market site photographs taken on a Thursday @ 02:25 PM

Figure 3.35 –Beltola Market site photographs taken on a Thursday @ 02:30 PM

Figure 3.36 –Beltola market site photographs taken on a Thursday @ 02:35 PM

3.1.4 Satellite view analysis

To have better understanding of the area we have also taken the screen shots of the satellite images from Google Earth and analyzed the traffic movement and the people's movement in the area. It was evident in all stretches of the Beltola Market that compared with the daily market, the biweekly market encroachment of the roads is very high, accounting for more than 60% of the road during peak hours. This leads to hindrance in the smooth traffic flow and causes heavy traffic congestions in the entire stretch of the Beltola market. To have better understanding we have compared the satellite image of the same areas on regular day market and bi weekly market. Figure 3.37 to 3.44 shows the comparative occupancy and congestion of the Beltola market areas on these two different days. The pictures clearly indicate very high level of occupancy of biweekly markets as compared to regular market days.

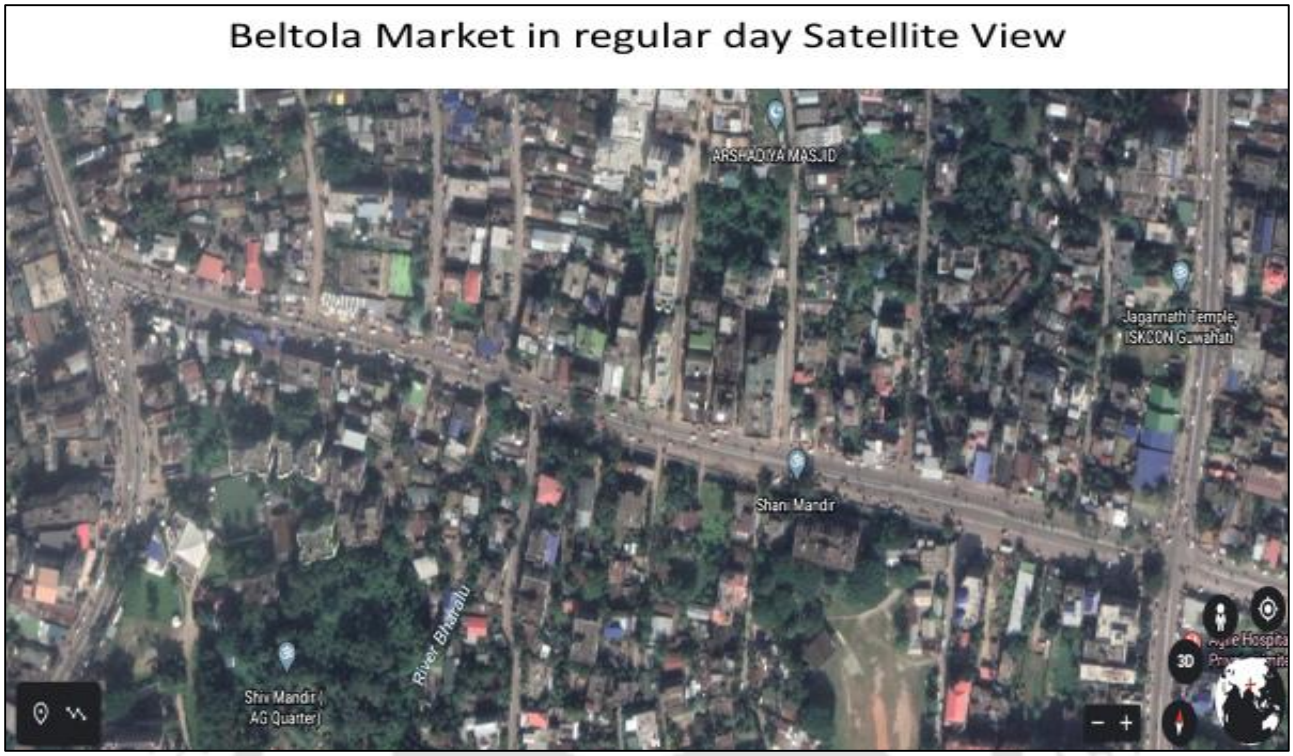


Figure 3.37 – Satellite view of the Beltola market on regular day

Figure 3.38 –Satellite view of the Beltola market on bi-weekly market day

Figure 3.39 – Satellite view of the Beltola market on regular day

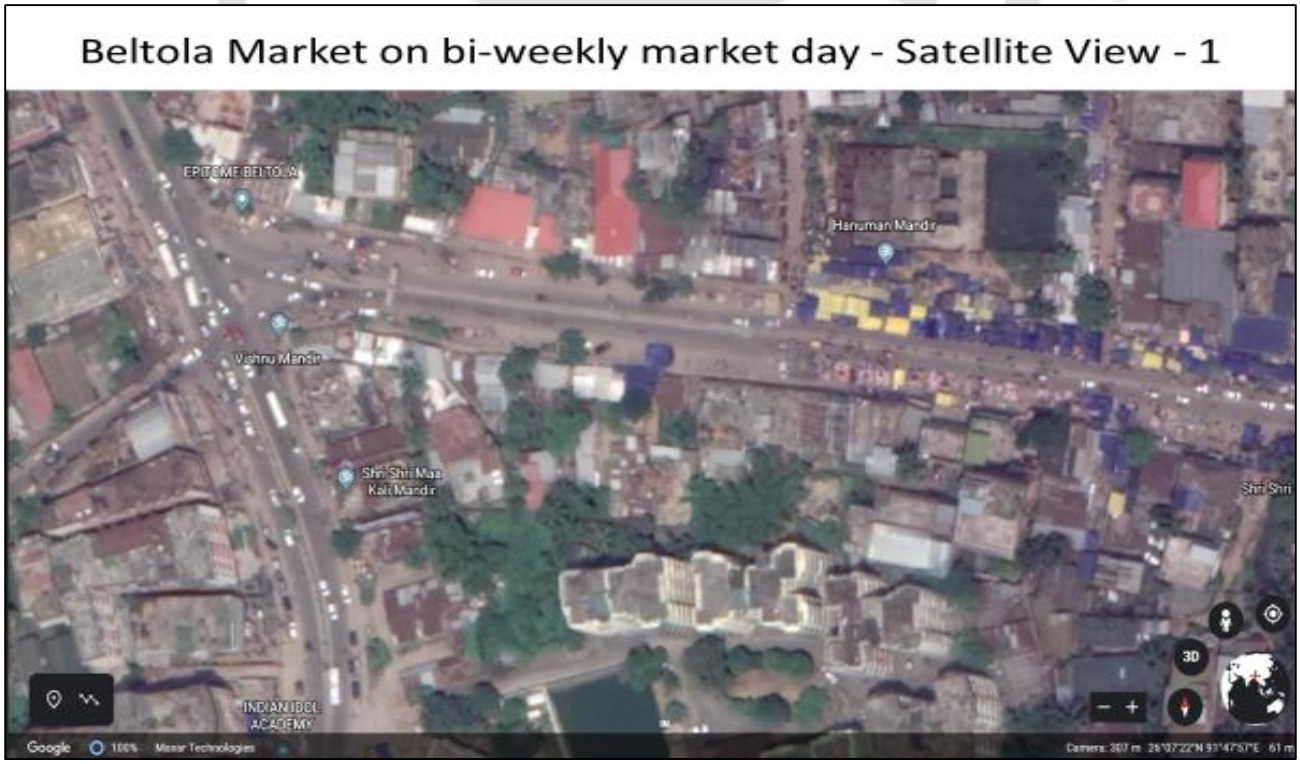


Figure 3.40 – Satellite view of the Beltola market on bi-weekly market day

Figure 3.41 - Satellite view of the Beltola market on regular day

Figure 3.42– Satellite view of the Beltola market on bi-weekly market day

Figure 3.43- Satellite view of the Beltola market on regular day

Figure 3.44 – Satellite view of the Beltola market on bi-weekly market day

The crossroad at the extreme right end in Figure 3.38 is the Jayanagar Chariali and the cross road at the left end of the Figure 3.38 is the Beltola Tiniali. These small blue, black and yellow patches on the road are temporary biweekly shops. In Figure 3.38 we can clearly asses that the area coverage by the temporary market sheds along the length is more than 60 % and in this 60% of the covered length the market has also occupied more than 60% of the width of the road. This creates heavy traffic movement in the area and discomfort for vendors and customers also.

Figure 3.45 – Satellite view of the Paltan Bazaar

3.1.5 Google Map Analysis

Google maps were used to locate the nearest amenities and services offered by Guwahati Muncipality Corporation (GMC). The public toilet and drinking water facility in the market were not available in the close vicinity. The Paltan bazaar market area is all around the Sports authority of India Stadium, here it can be seen that there is no toilet located in the Paltanbazar area. Hence, the

vendors as well as customers moving into the area are devoid of basic facilities like toilets and portable water specially in the Northern and Eastern part of Paltan bazaar. It is very difficult for the female tribal vendors to sell in the area without proper sanitation facility. It can be observed in the Figure 3.46 , the Paltan Bazar area is marked in red circle. The nearest toilet to the north east corner of the Paltam bazar market is half Km away.

Figure 3.46 – Location of Toilet in the Paltan Bazaar

Where as in case of Beltola market the toilet can be seen more than 1km away from Beltola bi-weekly market on either side of Jayanagar chariali and Beltola Tiniali as shown in Figure 3.47. The Biweekly market area is also marked with red elliptical. In this area there is no

toilet or portable water facility for the vendors or customers. Hence the Tribal ladies vendors have to leave their shop unattended and travel more than 1 km just to go to toilet.

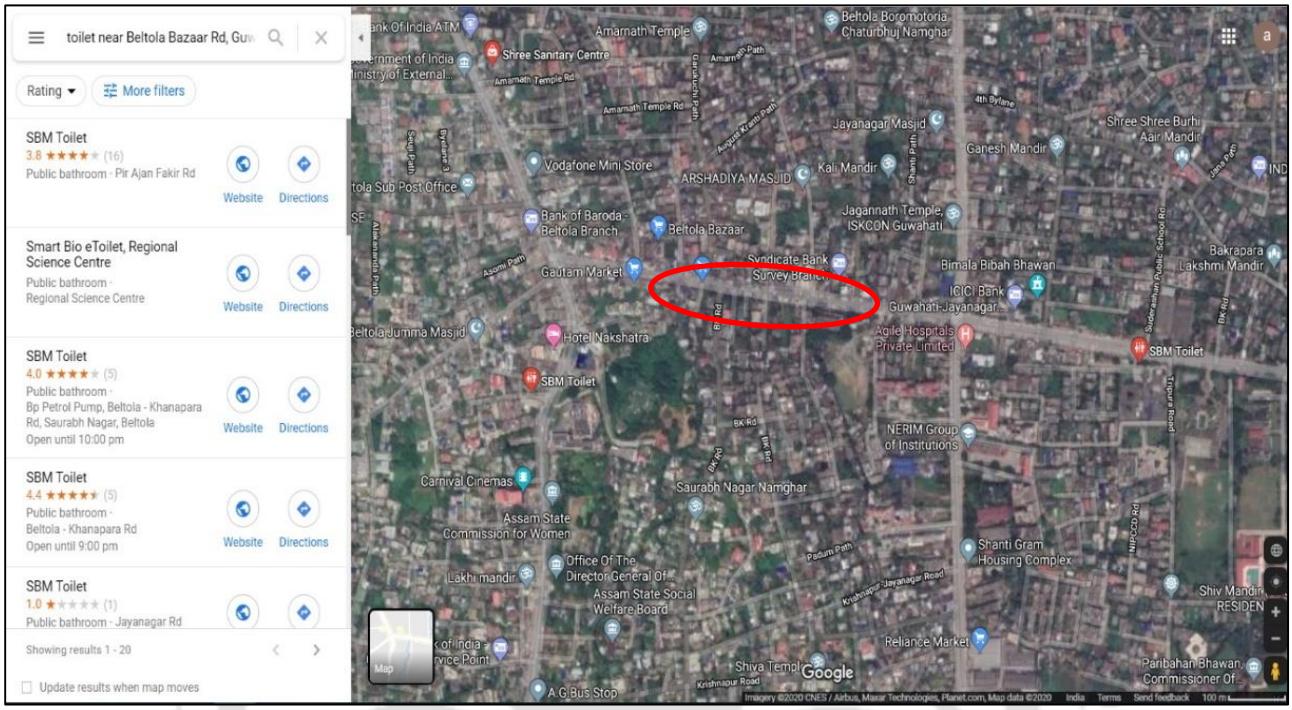


Figure 3.47 – Location of toilets in the Beltola market

3.1.6 Personal Interviews

Another method to collect primary data adopted in this study was personal interviews. Interviews were conducted with customers, vendors and commuters in the Paltan Bazaar area and the Beltola Market. Random people were selected on-site and asked about the issues faced by them in the two selected market areas. Multiple people were interviewed until the new participants were not able to identify any new issues other than the ones identified by the previous subjects.

3.2. Data analysis before design intervention

In our research we have used two data analysis methods before design intervention i.e strategic categorization of data collected from personal interviews and Card Sorting. In case of strategic categorization of the interview data, the data collected in section 3.1.6 of the thesis was segregated on the basis of type of end user who gave the data and the type of design intervention required for resolving the issue.

Beltola Market - The issues related to the Beltola market are identified and segregated below. The first set of interviews was with vendors in the area.

3.2.1 Categorizing the input data into strategic parameters

All the data collected from the personal interview were strategically segregated on the basis of the data collected from street vendors, customers, commuters of the city. The data was further segregated on the basis of type of design intervention required to cater these issues.

Vendor's point of View **-** The major issues of vendors were further divided into 4 categories - space, financial issues, safety and security, and amenities with service. The list of issues identified under all the mentioned by them are as under -

Space **-** The number of vendors is increasing but the vending space is limited. Hence, the major issue identified by all vendors was space scarcity. In the Beltola market, during the bi-weekly market, space scarcity is at its peak. The fight for space between the daily vendors and biweekly vendors is very common. Due to a lack of space, biweekly vendors occupy parking

lanes of the entire Beltola market and two lanes of the Beltola market road. This leads to four out of the total six lanes of Beltola market road being covered, including the parking area. Multiple vendors also occupy the footpath, causing difficulty for the customers to walk through the market. There is no space allotment facility. Daily workers have maintained their location and have formed a boundary with mutual understanding. However, the dispute is more between the new vendors, biweekly vendors, and irregular market vendors.

The data collected found the following issues related to space management:

- Shortage of space for vending.
- No space allotment mechanism.
- Disputes between daily and weekly vendors
- Dispute between tribal women and community-specific vendors from Kharupetia, Nagaon, and Barpeta.
- Lessee supports these community-specific vendors who pay higher taxes as compared to tribal women.
- Lack of space for storage of material.
- No place to stay at night.
- Occupy footpath space for vending.

Financial issues - The margin of the local vendors and the small-scale vendors are very limited and any additional financial implications means huge burden for them. Apart from the charges levied by the municipality corporation, an additional burden is also inflicted on the vendors. The Beltola area is given on lease and the lessee collect excessive taxes. Similarly, chanda by local youth club goons are another issue faced by the vendors.

- Fees & Charges
- Excessive tax collected by lessee.
- Chanda collected by local youth clubs for festivals.
- Lack of monitoring on lessee by GMC.

Safety and security - Apart from collecting extra taxes and chanda the youth clubs, lessee and goons also assault the vendors when they fail to comply with their demands.

The list of safety and security issues are listed below:

- Assault by youth club for chanda.
- Assault by lessee for excessive taxes.
- By local goons on people staying at night.

Amenities & Facilities - Basic facilities like toilets, portable water, covered shelters, lighting facility, first aid centre, etc., are also not available in sufficient quantity.

The list of basic amenities is listed below:

- Lack of toilet.
- Lack of portable drinking water.
- No covered shelter from sun or rain.
- No light facilities at dark hours
- First Aid Centre is not available
- GMC is not interested to provide a conducive environment for vending.

Customer point of view -

- Shortage of parking space

- Shortage of space for movement of vehicles
- Discomfort in the movement of customers due to rush and lack of space in peak hours
- Motor-free street shopping area
- Unhygienic conditions
    - Shops are next to garbage bin
    - Drain water is choked and smelling
- Have to carry heavy baggage for long distances
- No place to sit and rest
- No designated parking for rickshaws or mini public transports
- Poor visibility in selecting vegetables at late hours from roadside vendors.
- Amenities and Facilities
- Toilets are not available

Passenger point of view -

- It is the main road connecting Beltola Tenali to GS road. Heavy traffic.
- Two-wheelers are parked on the road causing hindrance for traffic.
- People are sitting on the road edge for shopping and may get hit by a vehicle.
- Other by-pass is narrow and cannot be suggested for heavy traffic.
- Alternative routes are long distances.
- No public transport like bus moves on this route.
- Only tracker or e-rickshaw is available for passing.

On the basis of data collected from personal interview and strategic segregation of the data collected an issue identification and categorization matrix was formed. This will help in

systematically resolve the issue. As discussed in chapter 2, all the data collected was segregated and brain storming sessions were conducted for all possible solutions.

Table 3.6– Issue identification and categorization Matrix

		Stake Holders			
		Vendors	**Customers**	**Commuters**	**Policy makers**
Design Intervention categories	**Product**	Lack of space for storage of unsold goods. Vegetable and fruits get damaged during transportation. No place to stay at night. Lack of portable drinking water. No covered shelter from sun or rain. No light facilities at dark hours	Poor visibility in selecting vegetables at late hours from road side vendors.	Vendors on streets expand their area as per requirement. Where as vendors with carts restrict themselves to limited space.	Tracing of registration and tax collection from vending carts are easier than from vendors without any cart and teams should be available throughout the day to check and collect taxes
	Space	Shortage of space for vending occupy footpath space for vending. Lack of toilet.	Shortage of parking space. Shortage of space for movement of vehicle. Toilets are not available No designated parking for rickshaw or mini public transport No place to sit and take rest. Unhygienic conditions – Shops are next to garbage bin The drain water is choked and smelling	It is the main road connecting Beltola Tinali to GS road. Heavy traffic. Two wheelers are parked on the road causing hindrance for traffic. People are sitting on road edge for shopping and may get hit by vehicle. Other by pass is narrow and not suggest able for heavy traffic. Alternative routes are at long distance. Public transport like bus movement is less on this route. Only tracker or E rickshaw is available for passing.	Space and funding for basic amenities Numbers of vendors are high but space is limited. Weekly vendor's population is very uncertain. No of vendors increasing day by day Heavy traffic. Parking space scarcity

		Stake Holders			
		Vendors	**Customers**	**Commuters**	**Policy makers**
Design Intervention categories	**Service**	Safety and security from youth club for chanda. lessee. local goons on people staying at night. First Aid Centre is not available conducive environment for vending	Have to carry heavy baggage to long distance. Availability of products at door step. Tracing and tracking of transit vendors. Comparative rates of products in the market Online status of product availability in local market.	Traffic regulations Restrictions on unorganized parking Organized road side vending in allocated spaces	Basic amenities like toilet portable drinking water. Covered shelter. Shelter for overnight stay safety and security Conflict management Price control Citizen grievances Vendors grievances
	System	No space allotment mechanism. Disputes between daily and weekly vendors. Lack of monitoring on lessee by GMC Excessive tax collected by lessee. Vendors grievance system	Portals with all product and vendors details online. Fresh products availability ensured on day to day basis. Customer grievance system	Market area should be isolated from traffic area.	Space allotment Mechanism Collection of taxes Registration for vendors Online portals for monitoring and services
	Policy	Relaxation in taxation Social security for the vendors Easy loan facilities Transit accommodation facility on nominal charges for overnight stays.		Identification of vending zones and heavy traffic zones	Funding and approvals from the Government for schemes formation of cooperative societies for grievance redressing of the vendors, customers, commuters and communicate the issues to policy makers.

Paltan Bazaar - The issues identified in Paltan Bazaar are more related to traffic regulation since the area is the central hub of road and railway connectivity. This area is monitored by GMC

directly hence the issue related to lessee, excessive taxes is not a major concern as compared to the Beltola market. The major concern in this area was related to space management. Hence the perspective of space was identified in terms of users of the space. The major users of the space were:

- Train passengers
- Bus Passengers
- Daily commuters
- Through passers to Kamakhya, the airport, or outside Guwahati, etc.
- Market customers and vendors

The rush in the junction leads to heavy traffic which forces the roads to be converted to one-way roads. Taxi & cabs are parked on the roadside for train and bus customers in spite of multilevel parking available in close vicinity. There are multiple Government offices, the court in the nearby area, and hence, traffic is very high during office hours. This is the main router for the local buses as well as for the buses starting from the ASTC bus stop to other cities.

Due to a shortage of parking, customers face difficulty in shopping. Either they have to travel a lot after parking their vehicle or they have to look for alternative shops near their parking area. The priority of the customers is to find a convenient parking spot. The sale of the shops is also affected due to the discomfort of the customers for easy commute and accessibility.

3.2.2. User Study – Card Sorting Technique

It was clear from the literature review and literature of individual Smart cities that the formulation of smart city policy should be city and people-specific. Hence, to understand the smart city requirement in the Indian context, three things are to be considered:

1. The demography
2. The geographic requirements
3. The requirement of the population

The demography of India is already discussed in chapter 1. The geographic condition is very diverse in India and keeps on changing from place to place, hence it would be difficult to generalize the geographic conditions. Whereas we can understand the general notion of the people of India and can attain a general consensus in terms of their expectation from their city. In same lines a user study was conducted to understand the requirement of the people. The motive of the study was to let the people design their own cities. General public is not an expert in this field of town planning but they are an expert in their own daily requirements and day-to-day activities. They interact with the city 24x7 and 365 days a year from birth to the last day of their lives. So, on the basis of their experiences, everyone has a list of services and utilities in their mind. The tough part is to convert those mind maps into blueprints for town planning. There can be multiple concerns faced by citizens in their existing towns and they might have a good solution to resolve them, but the tough part was to collect data from large population of end user and within a limited time frame. The data collected should also give some meaning full results to be further used in town planning. Hence as discussed in chapter 2 we have used card sorting method for collection of data.

As discussed in chapter 2 we have made a chart of various distance ranges from the residence of the end user. The subjects were given a set of cards in which all the possible services available in any city were marked. The subjects were asked to place these cards in the desired zones of the chart to understand their preference. The data collected from 45 subjects were tabulated for analysis in Table 3.7. The first column of the table indicates the Serial number, the second column of the table indicates the list of services. The third to seventh rows of the column indicates the various distance ranges i.e Range A 0-1 Km, Range B 2-5 Km, Range C 6-10 km, Range D 11-20 Km, Range E above 20 Km. As per the data collected from 45 subjects the percentage preference of each service in each zone was tabulated. The calculation of preference is done by calculating the percentage of the total number of times the service was sorted in a particular range divided by the total number of participants in the sorting. In the eighth column the most preferred range for each service was identified and marked. Ninth column of the table shows highest percentage of the service with respect to the most desired zone for the service. It can also be said that the second column indicates the service; the eighth column of the table shows the most preferred zone for the service and column nine shows the preference percentage of zone identified in the eighth column. The range and highest percentage columns declare the preferred range and the level of preference in percentage, respectively.

Table 3.7 - *Analyzed data from card sorting*

Sr. No.	Description	A 0 – 1 km	B 2 – 5 km	C 6 – 10 km	D 11 -20 km	E Above 20 km	Range	Highest Percentage
1	Agricultural land	8%	8%	25%	25%	**33%**	E	**33%**
2	Airport	0%	0%	33%	**50%**	17%	D	**50%**
3	Auto & Rickshaw stand	**83%**	17%	0%	0%	0%	A	**83%**
4	Bank	25%	**67%**	8%	0%	0%	B	**67%**
5	College & University	0%	33%	**50%**	17%	0%	C	**50%**
6	Corporate offices	0%	0%	**58%**	25%	17%	C	**58%**
7	Court	0%	0%	**50%**	25%	25%	C	**50%**
8	Fire-fighting Station	17%	**42%**	33%	8%	0%	B	**42%**
9	Grocery	**100%**	0%	0%	0%	0%	A	**100%**
10	Gym	**50%**	33%	8%	0%	8%	A	**50%**
11	Haircut	**58%**	42%	0%	0%	0%	A	**58%**
12	Hospital	25%	**75%**	0%	0%	0%	B	**75%**
13	Industries	0%	0%	0%	17%	**83%**	E	**83%**
14	Insur. & Invest. Off.	0%	8%	**75%**	17%	0%	C	**75%**
15	ISBT	0%	**50%**	42%	0%	8%	B	**50%**
16	Malls	0%	8%	**75%**	17%	0%	C	**75%**
17	Metro station	17%	**75%**	8%	0%	0%	B	**75%**
18	Movies	0%	42%	**50%**	8%	0%	C	**50%**
19	Museum	0%	0%	42%	**50%**	8%	D	**50%**
20	Office	8%	**75%**	8%	8%	0%	B	**75%**

Sr. No.	Description	A 0 – 1 km	B 2 – 5 km	C 6– 10 km	D 11–20 km	E ABOVE 20 km	Range	Highest Percentage
21	Park	**75%**	25%	0%	0%	0%	A	**75%**
22	Picnic Spots	0%	0%	0%	42%	**58%**	E	**58%**
23	Police station	0%	**67%**	17%	8%	8%	B	**67%**
24	Post Office	25%	**50%**	25%	0%	0%	B	**50%**
25	Railway station	0%	**50%**	42%	8%	0%	B	**50%**
26	Ration Shop	**75%**	25%	0%	0%	0%	A	**75%**
27	Recreation centre	33%	**42%**	8%	17%	0%	B	**42%**
28	Religious places	**42%**	25%	25%	0%	8%	A	**42%**
29	Restaurant	33%	**58%**	8%	0%	0%	B	**58%**
30	School	8%	**75%**	8%	0%	8%	B	**75%**
31	Service & Maintenance	33%	**67%**	0%	0%	0%	B	**67%**
32	Spa	0%	33%	**42%**	17%	8%	C	**42%**
33	Street food	**67%**	33%	0%	0%	0%	A	**67%**
34	Swimming Pool	**50%**	42%	0%	0%	8%	A	**50%**
35	Workplace	17%	**67%**	8%	8%	0%	B	**67%**
36	Zoo	0%	0%	33%	**58%**	8%	D	**58%**

From the data tabulated in table 3.7, we have also plotted some graphs to have better understanding and pictorial representation of the services and their respective ranges preferred by the subjects. The graphs are plotted with population percentage on Y axis and the name of the service in X axis. In the graphs we have kept the most preferred service of the range in the extreme left and the services are plotted from left to right with decreasing population distribution. Here population percentage means how many subjects have preferred a given service in a particular divided by the total population participating in the data collection.

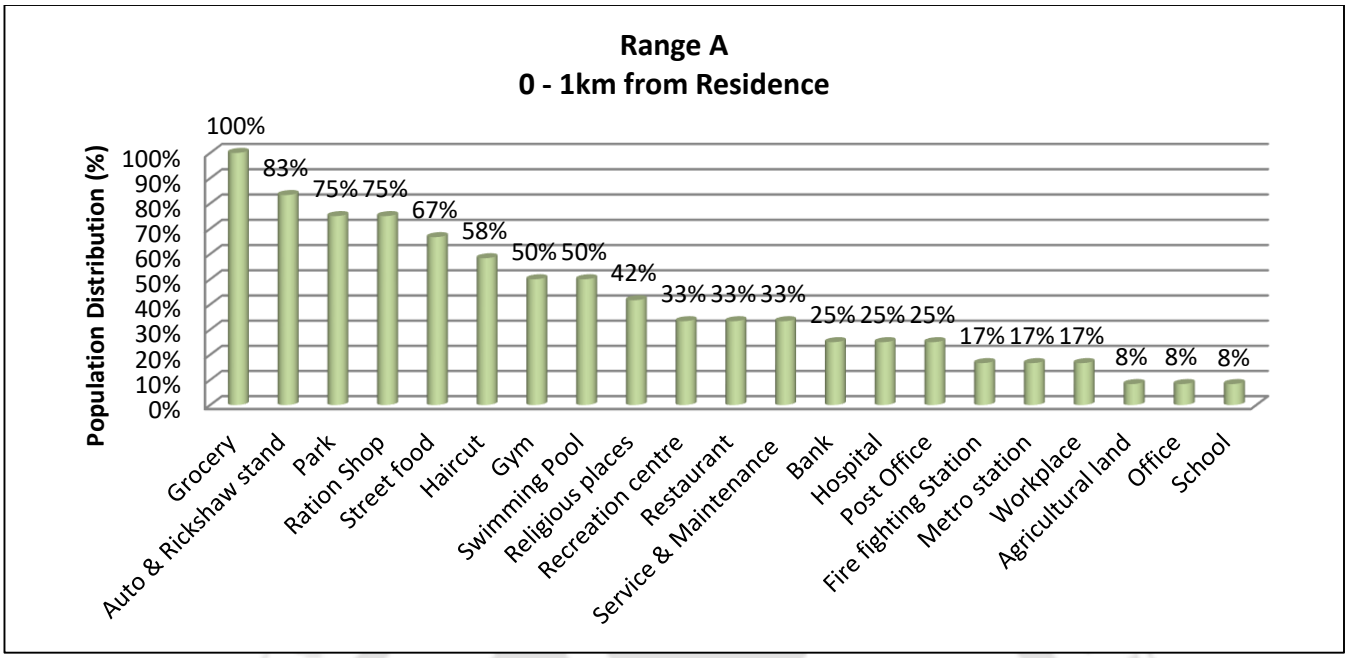


Figure 3.48 – Range A Services ranking

In Figure 3.48, the percentage of preference for services was plotted in the graph. This range belongs to the area accessible by walk or activities of frequent nature. This range has special preference since the users decide which services will hamper the sanctity of any residential area and need to be discarded. At the same time, they should not be dependent on any transport facility, public or private, to access this range. The comfortable range of walking is considered a 1 km radius, as found in the literature study. Out of 36 services, users have opted to keep 11 services strictly out of the range with common preference. The remaining 21 were ranked as per their preference in range A. In the table,the most preferred starts from the left and the level of preference decrease as we move towards the right. The top scorer among all services was grocery, with 100% preference in range A. It shows that all the participants want groceries to be available within walking distance from their residences.

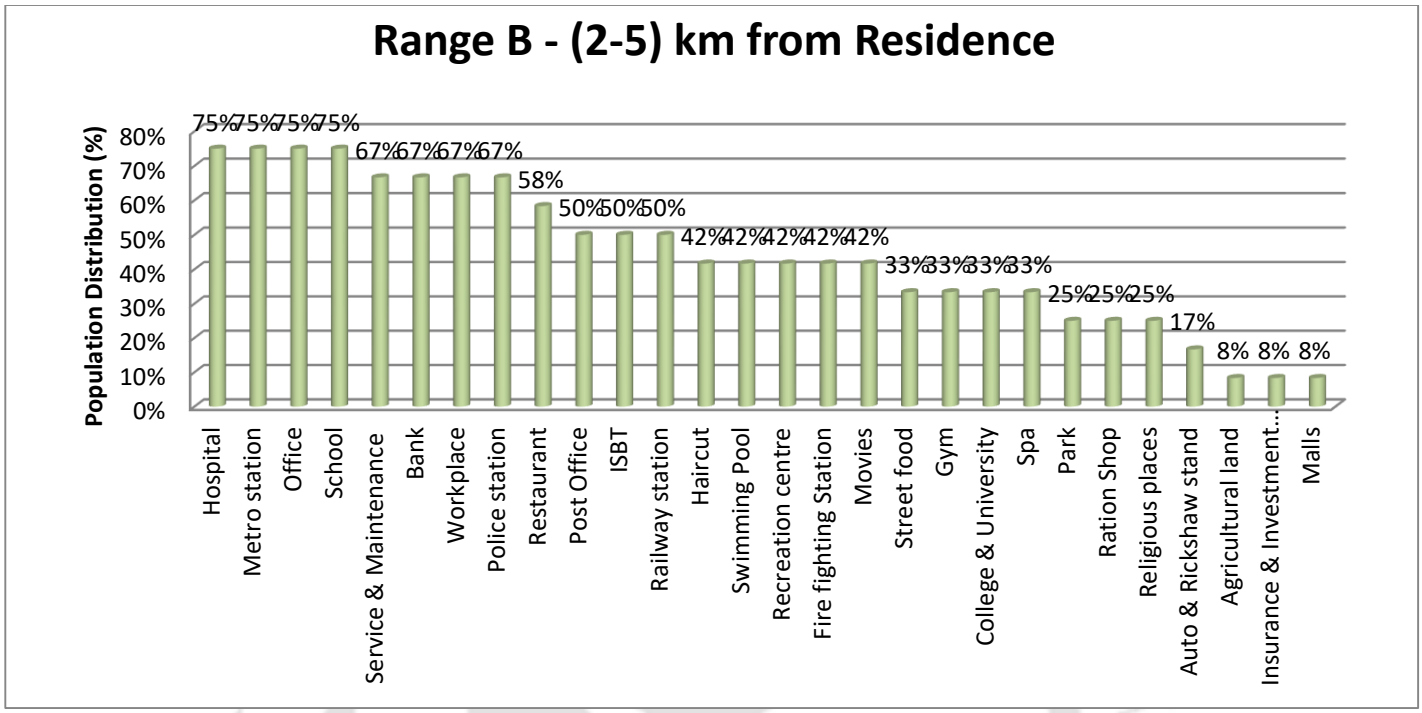


Figure 3.49 – Range B Services ranking

The Figure 3.49 indicates the Range B, it was more focused on the range that can be accessed by bicycles, rickshaws, auto-rickshaws or any private vehicle mobility area. The services in this range are also considered frequent-use services but should be kept at some distance from the residential area. There may be various concerns linked with this decision. As per the discussion with the participants, some of them stated that these services are important but increase the density of traffic when kept near a residential area. It generates the risk of accidents and makes the residential area an unsafe place for children and elderly people while they use the roadside for leisure. This also increases the disturbance due to the use of horns, traffic noise, etc. It will generate more dust and pollution in the residential area. The service considered in this range caters service to a large population. Hence, these are to be positioned at common points where people from different residential zones can access them easily and, at the same time, residential zones remain undisturbed.

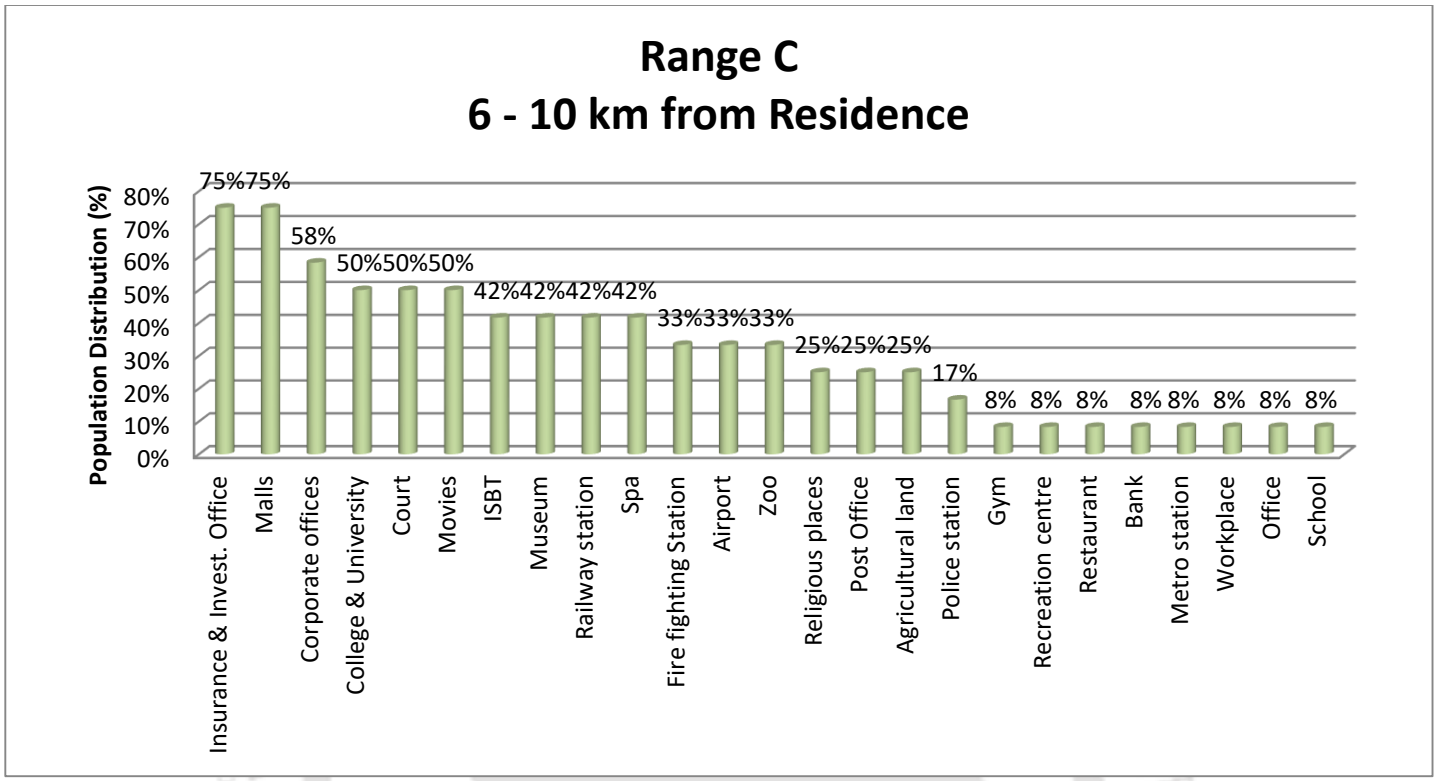


Figure 3.50 – Range C services ranking

The figure 3.50 represents Range C, It was considered by the participants for services which are not very frequently used. Still, some participants kept schools and offices in this range but their percentage is very low. The highest preferred services in this range were insurance or investment offices and malls, followed by corporate offices, courts, movies, etc. The services with higher preference in this range are three types –offices that need to be accessed at fixed intervals of the day, leisure and entertainment, and long-distance transport network. The two exceptions are corporate offices and colleges and universities, which may be accessed on daily basis. Most participants had stayed at college hostels during their exposure to college and may have biases in this regard. Per the discussion with the participants, the preferences of mobility in this range were private vehicles or public transport.

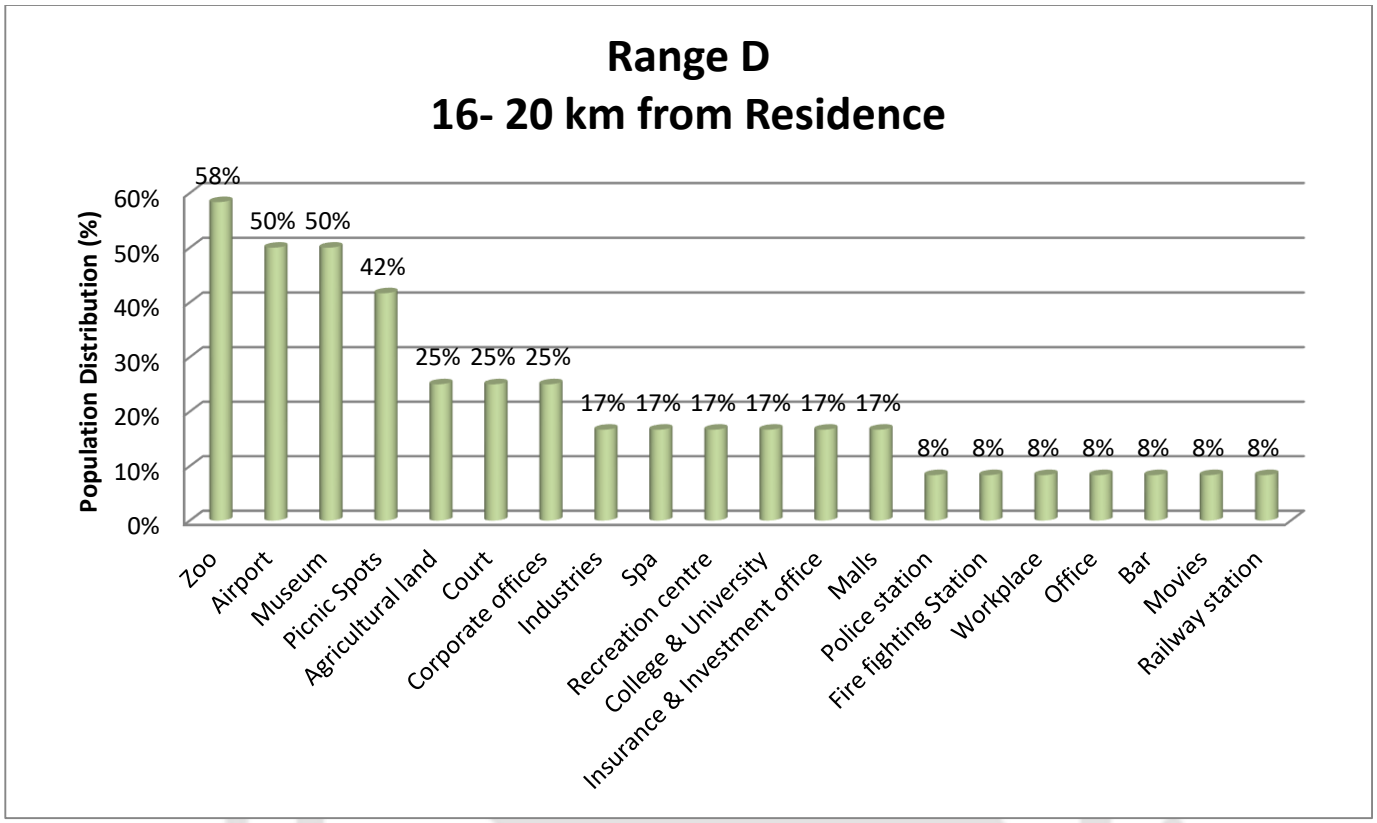


Figure 3.51 – Range D services ranking

Figure 3.51 shows the preference for Range D services sorted by the participants. As per the standard size of Indian cities, this range will be on the outskirts of any city. So, the service sorted here-were used after a long duration of time. Places like zoos, museums, and picnic spots are the top scorers of the range and are a part of leisure activity which may be preferred once a month or year depending on the other leisure activities available in the city. The airport is another most preferred service of the range since its technical requirements have kept airports on the outskirts of most cities; hence, the participants have perceived the same and considered it in the range. In general, airports are used for long-distance travel and their access is not frequent; hence, the additional distance is not a major concern.

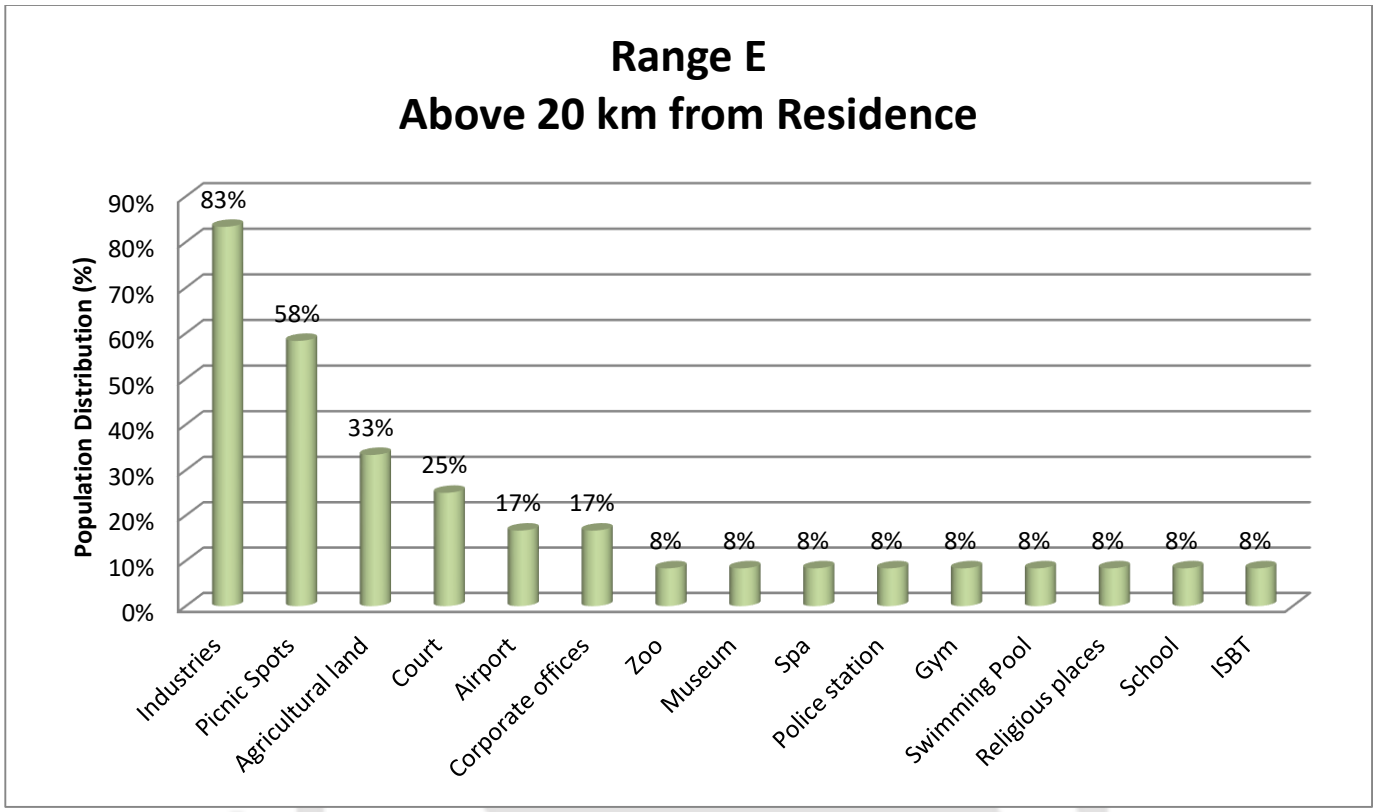


Figure 3.52 – Range E services ranking

Figure 3.52 shows the services which were opted for beyond the radius of 20 km from the residence of the user. In the Indian context, most city limits are within a radius of 20 km from the centre (it is assumed that the cities are in a circle or some symmetrical shape). As discussed with the participants, these are the services they want to keep out of the bounds of their city. The top preferred services of the range are Industries, picnic spots, agricultural lands, and courts. Industries are kept out of the city's bounds to keep the pollution and heavy vehicle movement away from their residential areas. Whereas, picnic spots are kept in this range so that when they are out for a picnic, they get a peaceful environment away from the busy city life. Agricultural land is kept in this range due it its huge land requirements and the agricultural setup does not jell very well with city life since crops will be affected by the dust and pollution

of the city and city dwellers will find these huge, lonely lands awkwardly unsafe. Court is considered in this range because of their perception of staying away from any disputes and unlawful acts. This notion is debatable and seems biased from the user perspective since their reasoning is not in-line with logical thinking.

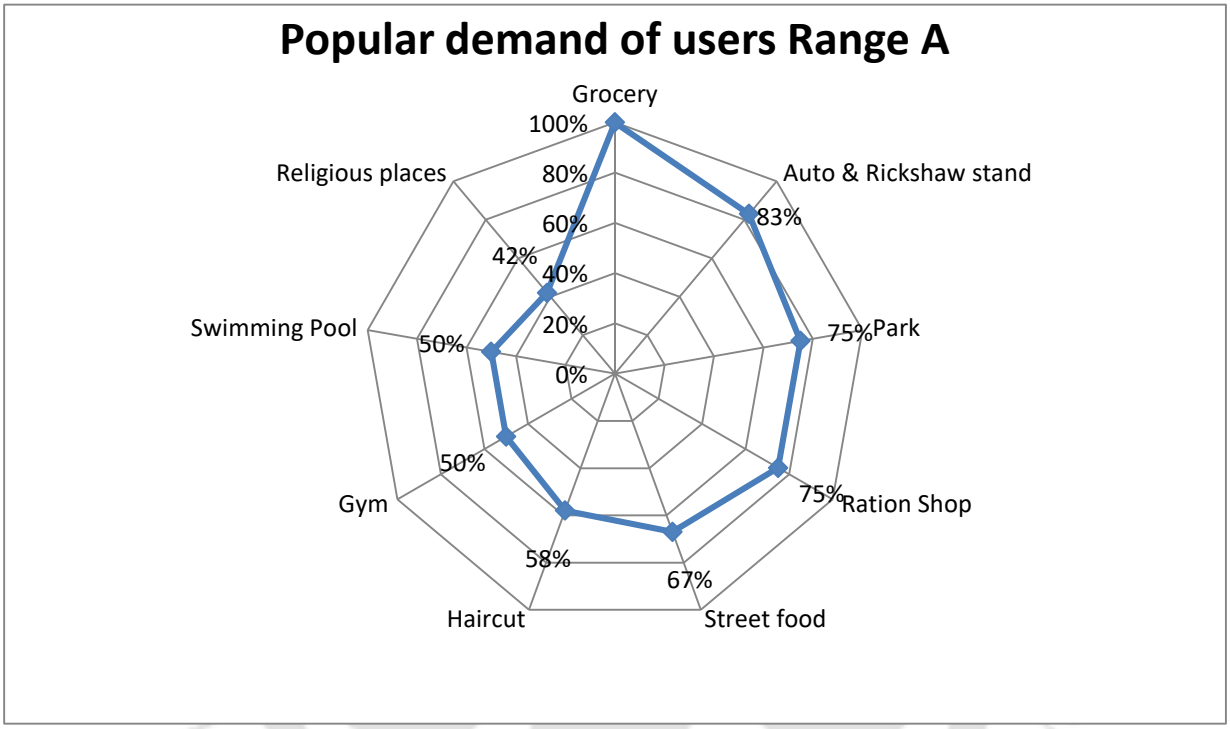


Figure 3.53 – Range A Popular demands

Figure 3.53 is a spider chart of range A, showing the top preferred services per the collected data. If the service receives the highest preference in this range, only then are they placed in the spider chart. It signifies that these services will be considered an integral part of this range only. These services will be not considered in other zones unlike the range service ranking charts discussed before. Similarly, Figures 3.54, 3.55 and 3.56 identify the designated services for their respective ranges B, C, D and E.

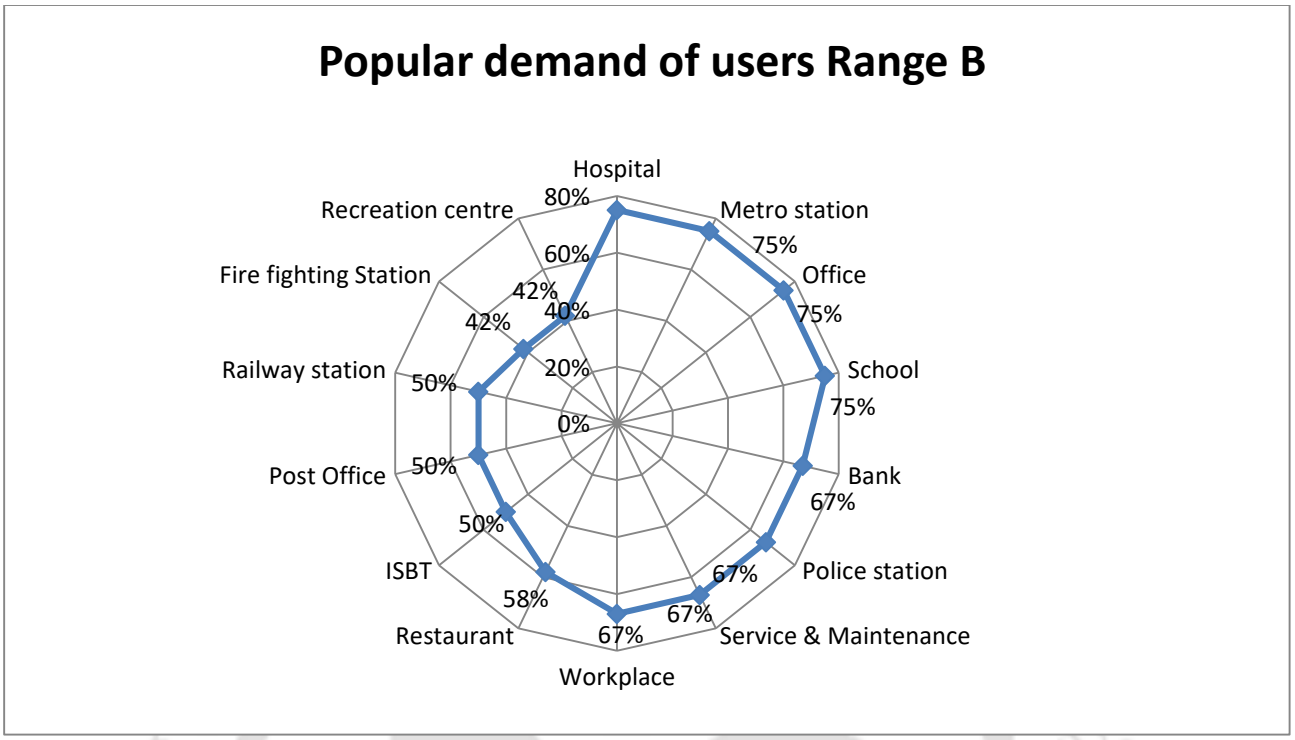


Figure 3.54 – Range B Popular demands

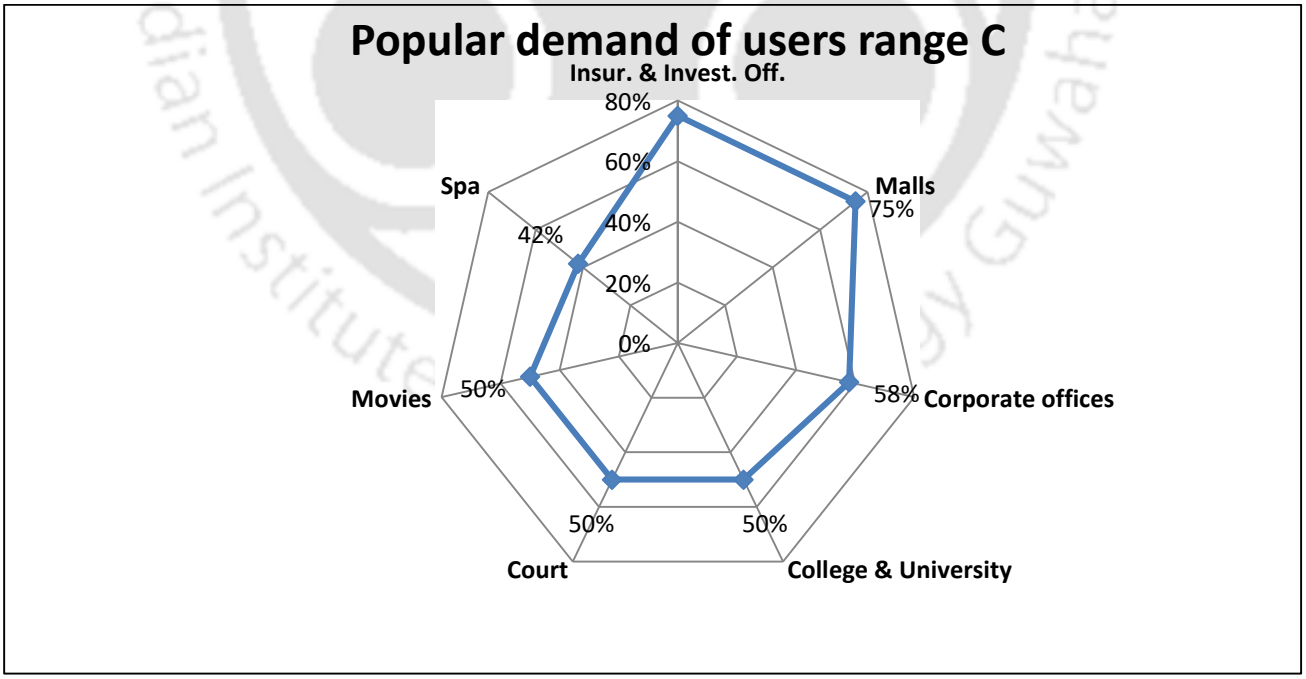


Figure 3.55 – Range C Popular demands

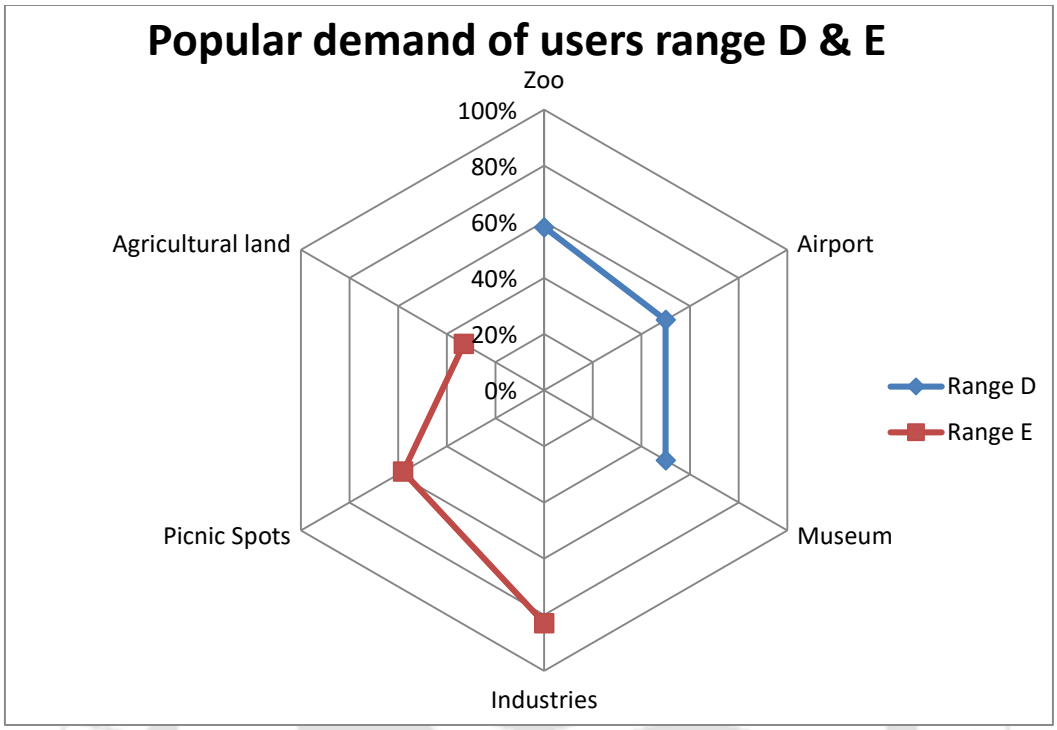


Figure 3.56 – Range D and E Popular demands

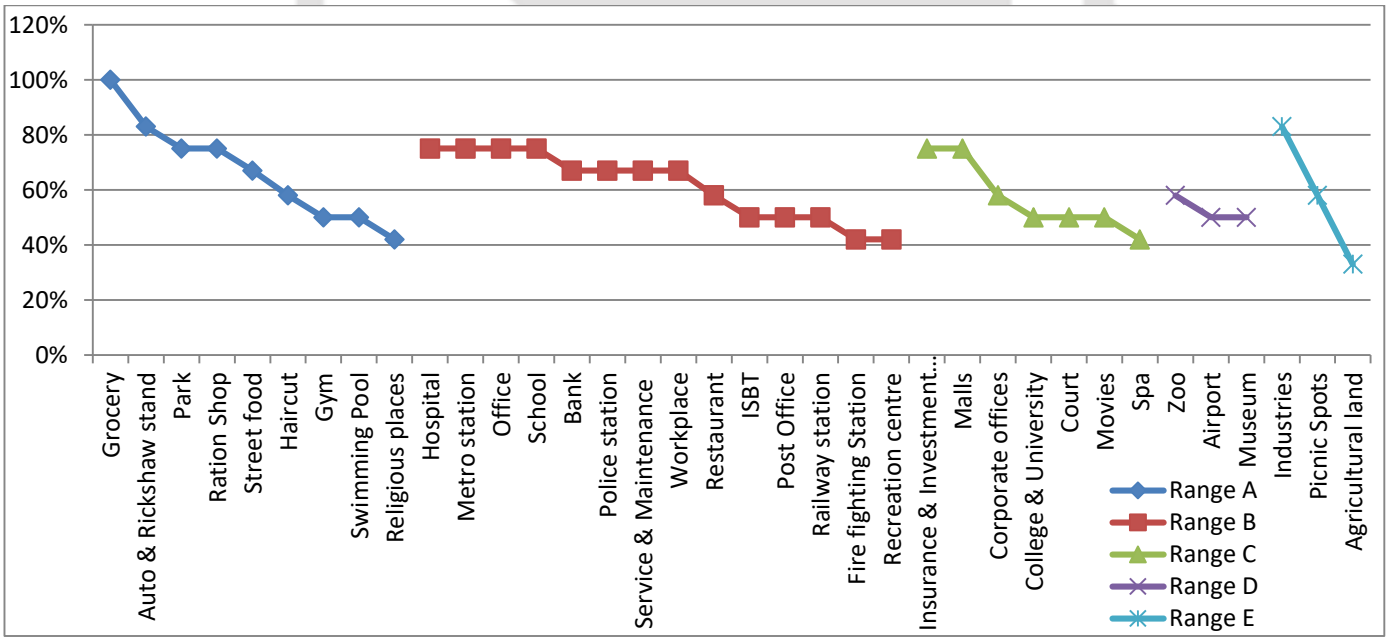


Figure 3.57 – Range wise popular demands

Figure 3.57 gives an exhaustive list of all the services with their associated ranges established from the data. Different colour codes are used to differentiate the ranges of the

services. And services belonging to the same range are clubbed together. It gives a clear bifurcation of ranges; their preferred percentage and the sequence of services are in decreasing order of rank in the designated range. Multiple interpretations can be established from the data shown in Figure 3.57.

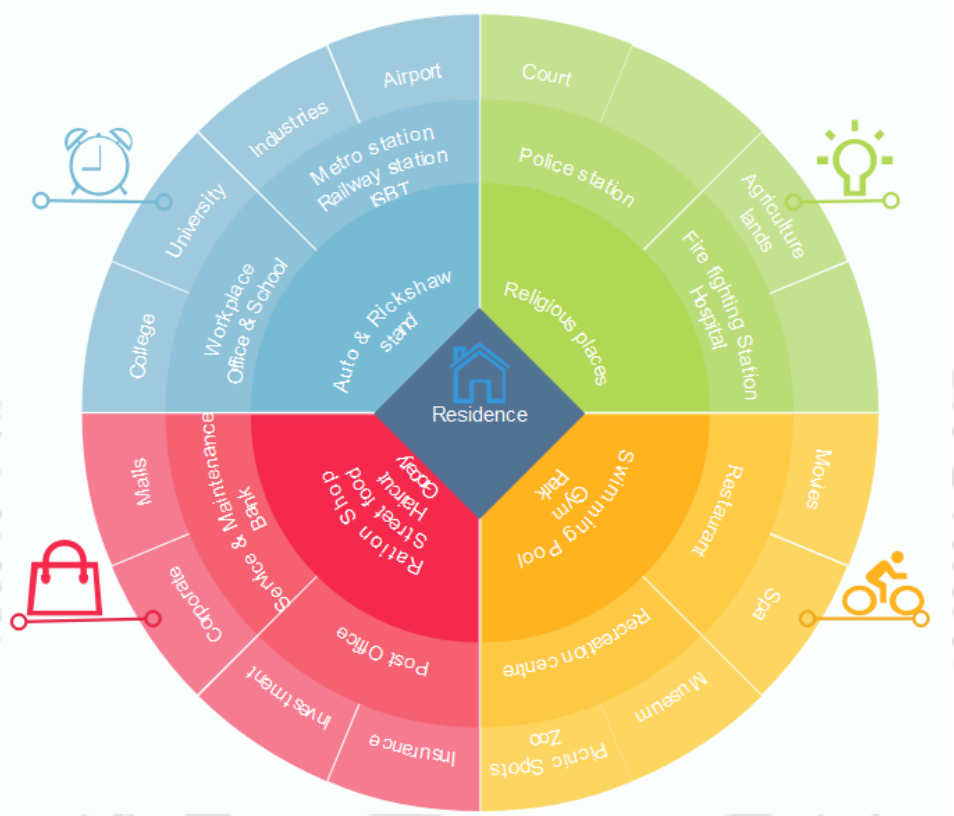


Figure 3.58 – Zoning of utilities

Figure 3.58 plots the perceived generalized mind map for the town plan of users. Their home is the epicenter of their planning perspective since, for an individual, their residence is a point of reference from where they view their city and access each and every service of the city. The services placed in the blue sector are generally time bound services with fixed time of movements and are part of daily routine. The services placed in green sector are not required to be visited on daily basis but have high importance for smooth running of the city. The

services placed in orange are for leisure, health and recreational services. The services placed in red sector indicate the services which rotate the economy of the city and maintains the cash flow from one hand to the other. Hence this zoning represents the average mind map of all the subjects taken together. In a similar way we can collect data from large population of the cities and convert them into a systematic mind maps as per the people's requirement. It should be the most logical point to start town planning from the user perspective. Hence, town planners can use this perceived town plan of an individual to build a more user-centric city.

Insights of user study- card sorting technique

- The user study found that most services falling in range A of 0-1 km were of the unorganized sector, out of which unorganized retail is a major segment.
- Religious and health-related activities were also prioritized in range A for easy and frequent access.
- Auto and rickshaw stands were also prioritized in range A to have easy access to other ranges. It was observed that there is a link between the transportation networks depending on the distance of the destination. Starting from the auto-rickshaw stand in range A to metros and railway stations in range B followed by the airport in range D.
- During personal interviews, it was also found that the priority of distance is often linked with the frequency of the service requirement.
- The zoning established in Figure 3.58 can be used to establish a basic model of a township with respect to the user perspective. This can be a switch from the conventional way of designing any township.

- This tool is very simple and less time-consuming and can be used to collect large amounts of data from user perspectives within a minute or two. The maximum time taken by the participants to do the sorting was three minutes only.
- The participants felt very comfortable and enjoyed the activity; it reduces the chances of getting biased data linked with the user's mentality to complete the task quickly without much consideration.

3.3 Ideation of Solutions and Detailing

After getting the requirements to form the users with the help of card sorting techniques and the personal interview data have further pinpointed the pain points of the end users. While segregating the issues of the users it was observed that a single intervention will not be sufficient to cater to all the needs of the users hence it was proposed that multiple interventions to cover the diverse spectrum of issues are to be formulated. During the ideation process, multiple interventions were proposed in the research to cater to different issues of the users and the city dwellers. It was observed that these interventions can be strategically categorized into 5 segments to have comprehensive and holistic coverage of all types of issues to be addressed in the type of Smart Cities:

i. Product Design
ii. Space Design
iii. Service Design
iv. System Design
v. Policy Design

The issues identified were converted into mind maps and converged to get outputs for various issues. A series of brainstorming sessions were done to identify the solutions to various issues. The final outputs were converted to 3D models and their working was formulated.

3.3.1 Prior art search

The new ideated technology was formulated and compared with all the existing prior art in all the patent offices of the world. After verifying that our designed interventions have product or system novelty, the patents were filed for all the ideated technology developed in our research.

3.3.2 Smart Technology

To incorporate the solutions in Smart Cities, it needs to be future-ready. The solutions should be formulated in such a way that only solutions are not sufficient to adapt to the technology. It should be smart in terms of multitasking, intelligent to predict future requirements, and finally, able to make its own decisions to enable its artificial intelligence.

At the grass root level, the requirement of artificial intelligence may not be the need of the hour. But the solutions offered should be data-driven and could be easily convertible to artificial intelligence. Hence the solutions proposed should be future-ready for the future Smart Cities in all forms of development.

3.3.2.1Product design

After analyzing all the issues of the vendors and the customers, starting from the transportation of the vegetable or fresh products, drying and decay of vegetables during

transportation, storage of potable water, shed from sun and rain, lighting facility during late hours, a place to stay at night, source of power, fan for comfort during hot days, cost-effective, safe storage for earnings, etc. All these issues were correlated with all existing products in the market. Then their cost-effective alternatives were designed and formulated. With multiple iterations and numerous brainstorming sessions, the final products were conceived.

Our product is a multipurpose vending cart, it is low-cost cold storage working on the principle of evaporative cooling. It is in the form of a tricycle and, hence, is easy to transport the vegetables throughout the city. It is a portable type of cart which can be converted into afull-fledged vegetable shop at any location with sufficient space. It is having an extendable shed to protect the vegetables and customers from hard sun and rain while shopping. It has solar panels and batteries to provide light in the late hours and a fan during warm weather.

These solar panels are also used to convert the cart into cold storage when it is not moving since while in transit, the air draft caused by moving the cart is sufficient to cause the cooling effect. The covering plate of the cart is a thin PVC tank which is having a valve at the bottom, just behind the driver seat, which can be used for drinking water or for dripping down the (dried grass cushions) Khus material provided at the front wall of the cart with holes. When the cart is moving, air enters from the front wall and passes through the wet Khus with dripping water and gets cooled down due to the evaporative cooling of water. This air passes through the netted containers of vegetables keeping them cool, humid and fresh throughout the day. When the products are sold and the remaining vegetables are again packed in the cart, a small fan at the rear wall (with holes) of the cart acts as exhaust and produces negative pressure

inside the closed cart and the air is sucked in from the front wall with holes and passes through wet Khus causing the cooling effect when the cart is not moving. During the day time, the same fan can be used by the vendors for their comfort and the battery attached with solar panels provides power for the fan and led lights for vending at late hours.

The carts can be converted to electric carts also by adding heavy-duty batteries and can be charged at the residence; it can be attached to an electric motor to drive the carts and when the battery is low the vendor can cycle it and use solar power for charging the batteries for lighting and fan while vending the vegetables.

Components - A tricycle, cold storage cabins, two detachable water tanks, front and rear cabin walls with holes, layers of Khus (dried grass), solar panel, LED light, fan, exhaust fans, Batteries, 1 perforated PVC channels, 1 half slit PVC Channel, Geogrid or PVC mesh containers, portable shed with tarpaulin rolls, valves to control the flow of water.

Assembly - The arrangement consists of three cabins. One main cabin is mounted on the chassis of the tricycle and two small cabins, forming the second layer of the cabin. All three cabins consist of PVC mesh baskets filled with vegetables. The front wall toward the driver in all three cabins is having multiple openings to let the air enter through it. Just behind the front wall, a layer of Khus (dried grass) is positioned. The Khus is aligned with a perforated PVC channel in the top cabin and a semi-slit PVC channel at the bottom of the main cabin. When the cart is retracted and ready to drive then all the components of the water cycle fall under the same alignment, i.e., at the top is the intake tank with a valve to control the flow of dripping water, which is connected to the perforated PVC pipe for uniform water distribution on the Khus of

the top layer. The water drips from the top cabins of the vending cart to the bottom cabins through an opening in the floor of the top-shelf floor. The water dropping through the PVC floor of the top cabin falls in the Khus of the bottom cabin and, finally, is collected in the semi-slit PVC pipe placed at the bottom cabin to recover the balance water. The balance water is collected in the collection tank through a semi-slit PVC pipe. The water collected in the bottom tank can be refilled in the intake tank through a manual pump attached to the tricycle.

The positioning of the vegetable baskets is to be done in a zig-zag manner so that the air flows through all the corners of the cabin. At the rear end, the top cabins are having holes for letting the hot air escape. The floor of the top cabin is made of PVC mesh at both the front and rear ends. The front is for dropping water and the rear is for passing hot air from the bottom cabin to the top cabin, followed by the holes in the rear wall.

The top of the cart is covered with solar panels and the batteries are stored just below the solar panels in a concealed box. The batteries are connected with LED lights, a half HP pump, a fan, and two exhaust fans attached at the rear opening.

Working - The setup is functional in both conditions, with solar panels and power backup and without solar panels and without any power backup.

In the latter case, the cooling system will work without any power requirement. The vendor will load their cart with vegetables in PVC mesh baskets. After complete loading, the shelves are retracted and locked to make the cart ready for driving. Both the water tanks are attached at their position as shown in the diagram. The vendor will start cycling and open the

valve of the intake tank. Depending on the outside temperature the flow of water is to be regulated. While cycling the air will enter from the front wall openings, at the same time water will be dripping through the Khus of both cabins. The air will pass through the wet Khus and evaporate the water after consuming the heat from the air. This will make the air cooler and the air will pass through the vegetable corridors made by alternate positioning of the vegetable basket in the cabin. The cold and moist air will preserve the vegetables from drying and decaying. The air from the bottom cabin will reach the rear wall and move through the ceiling of the bottom cabin made of PVC mesh. The cold air will remain in the bottom cabin releasing the hot air from the rear wall of the top cabin. Whereas the air entering the top cabin from the front wall opening will move out from the rear end openings of the top cabin. This arrangement is made to keep one cabin moist and the other cabin only cool with little less moisture. The green leafy vegetables, which need moisture, are stored in the bottom cabin and dry vegetables like potato, onion, ginger, garlic, etc., are kept in the top cabin since the said cabin will be a little less cool and moist in comparison. Once the top tank is empty, the bottom tank is lifted and the top tank is recharged from the recovered water. The cart also consists of a shed for protection from direct sun.

When the vendor reaches the location where the products are to be sold, they will draw the cabins with the help of handles and hinged arms on either side of the cart. The cart will convert into a stationery vegetable shop. The driving seat and handle are also retractable and hence can be retracted as shown in the diagram. The shed is also extendable to the limits of the shop. Tarpaulin rolls are attached at all the edges to convert this cart into a tent for staying and spending the night comfortably. All 4 rolls can be the attached to each other with

the help of a zip. The entire frame is made up of hollow tubes and sheeting done with the help of glass fibers to make it light-weight, water-proof, and a good insulator, but strong enough the carry sufficient loads. Four pillars are provided at the end of the top cabin. So that, when the cabins are drawn out to form a shop, strong support can be provided to the cabins.

In the second scenario, solar panels as the roof and batteries concealed within the roof were proposed. The roof of the cart will have a small charging point, LED light, half HP pump, and a pair of exhaust fans attached to the rear wall of the top cabin to cause an induced draft in case the cart is not moving and is parked in some location. Then, the induced draft will cause negative pressure and force the outside air to enter from the front wall openings, the valve of the intake tank will be opened and the water will start dripping the water will drop through the Khus, where the heat exchange will take place and the balance water will be collected in the recovery tank at the bottom. When the water level reaches a sufficient height in the recovery tank, the pump will automatically pump the water into the intake tank. The remaining process is the same as in the first setup.

In another setup, the intake water tank is placed below the solar panels throughout the panel area in a thin layer. In this scenario, the solar panels are supported by 4 pillars at the corners. This will also maintain the temperature of the solar panel and will also work as a coolant for portable cold storage.

The cart can be easily convertible into temporary accommodation for the vendors to stay in the city at night, during heavy rainfall, or in emergency conditions.

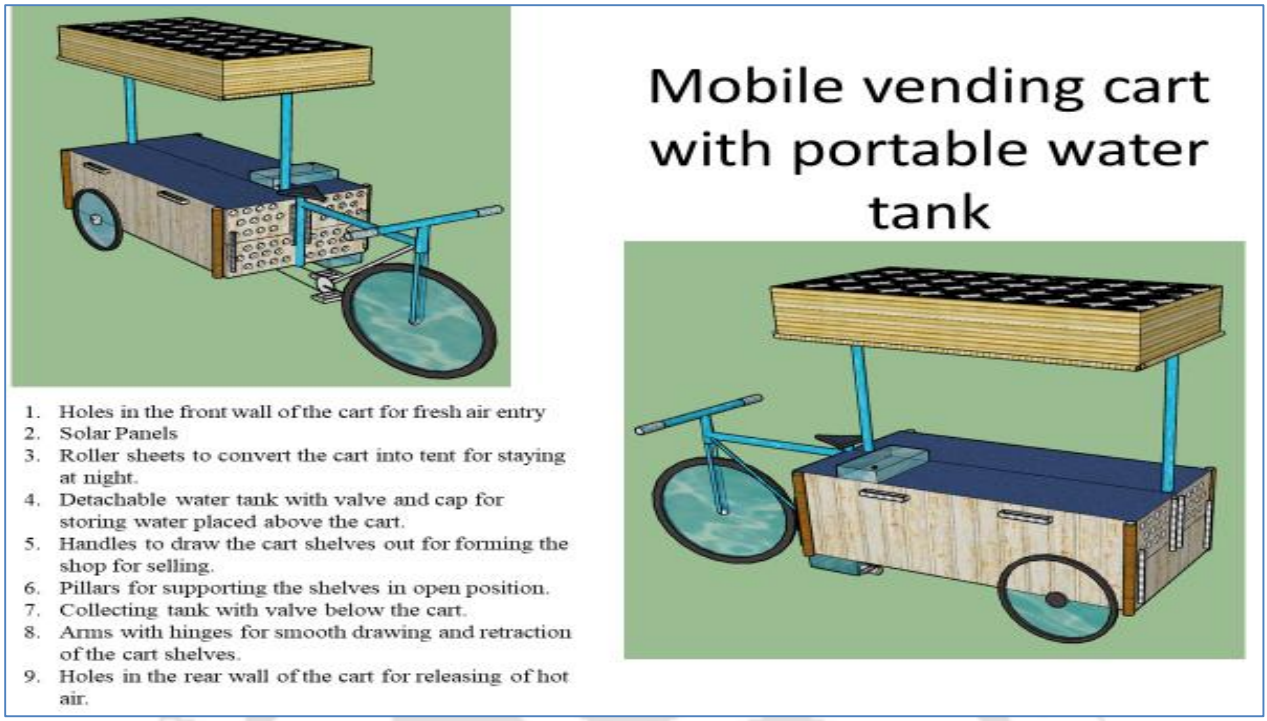


Figure 3.59 – Vending cart detailing

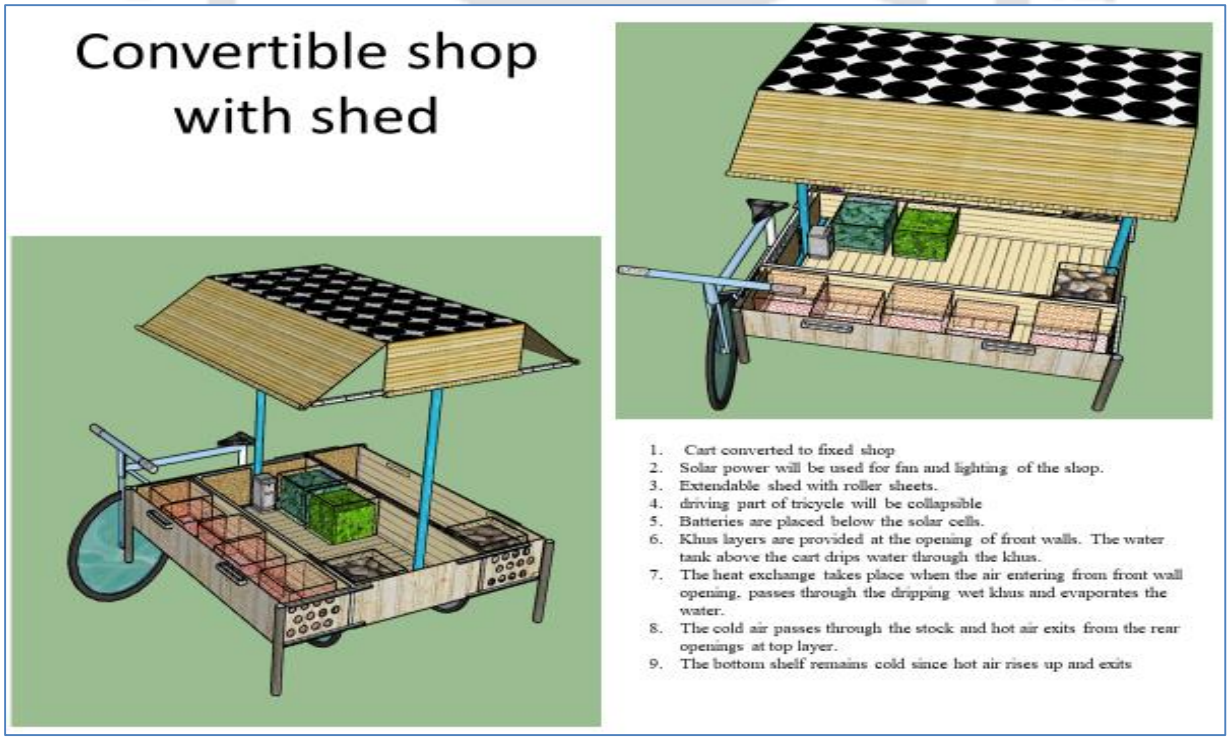


Figure 3.60 – Convertible shop with shed

Figure 3.60A – Convertible shop with shed

Figure 3.60B – Convertible shop with shed

Figure 3.60C – Convertible shop with shed

Figure 3.60D – Convertible shop with shed

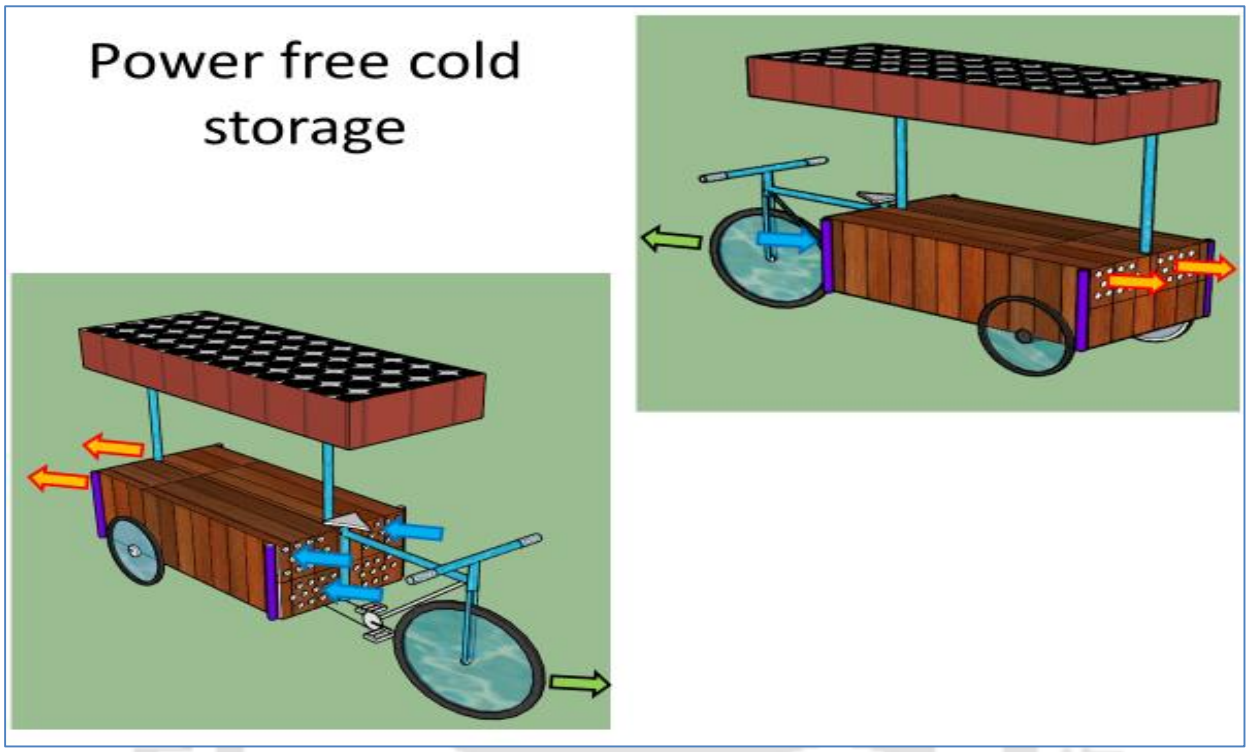


Figure 3.61 – Airflow profile of the vending cart

Figure 3.61A – Airflow profile of the vending cart

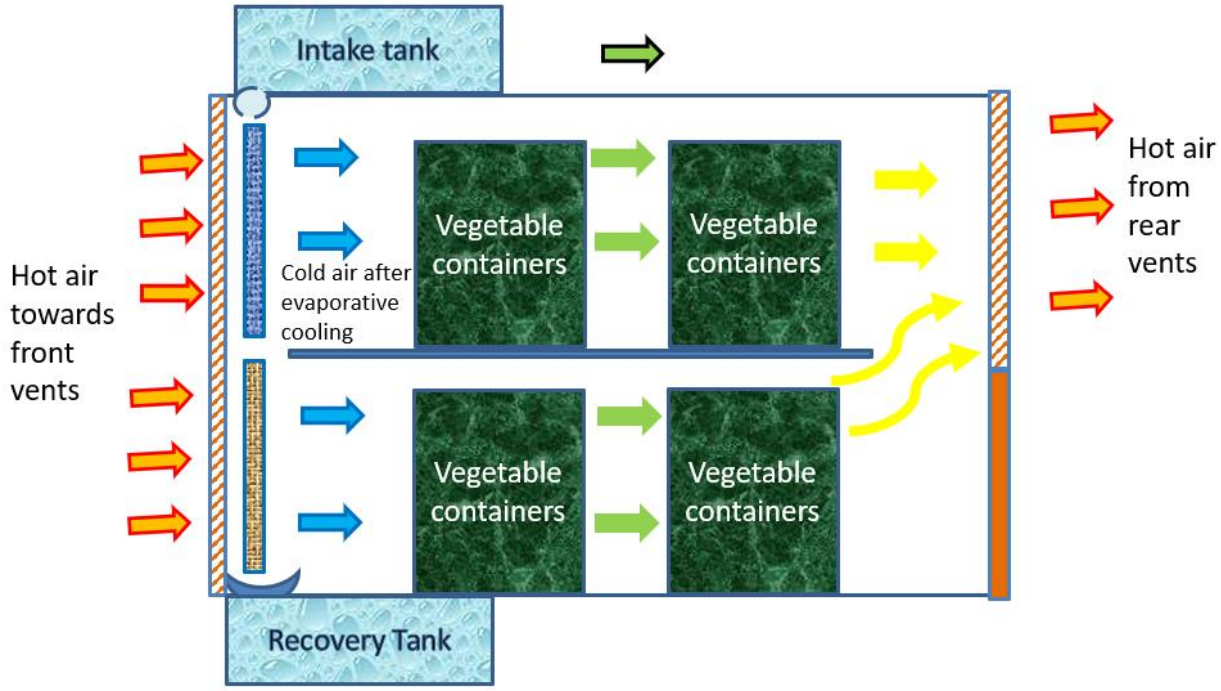


Figure 3.62 – Cross-section of the vending cat showing the airflow profile

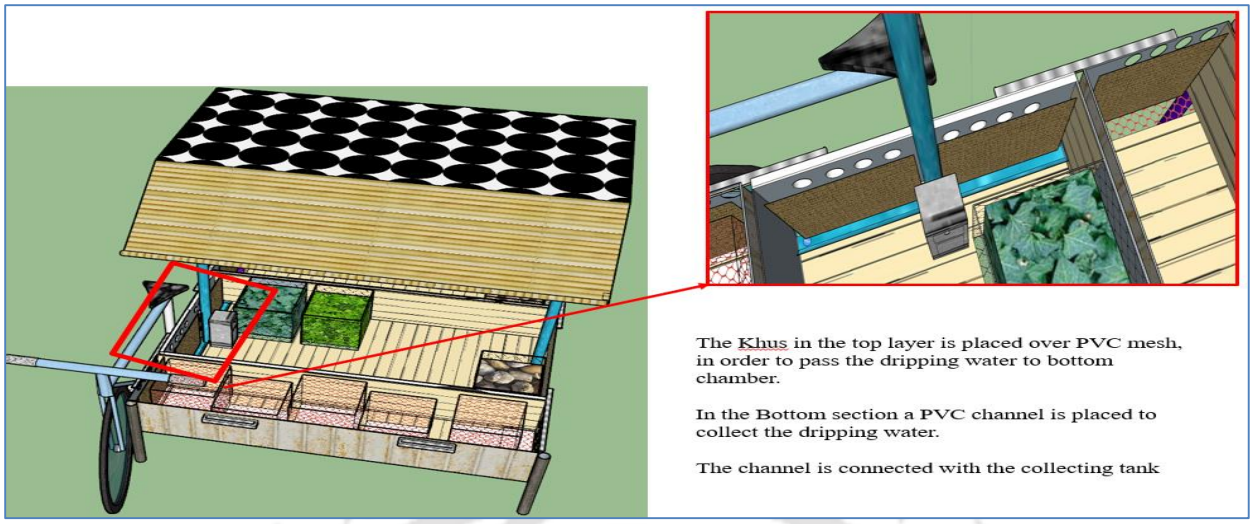


Figure 3.63 – Evaporative cooling setup

Figure 3.63A – Evaporative cooling setup (Without khus to show water flow)

Figure 3.63B – Evaporative cooling setup

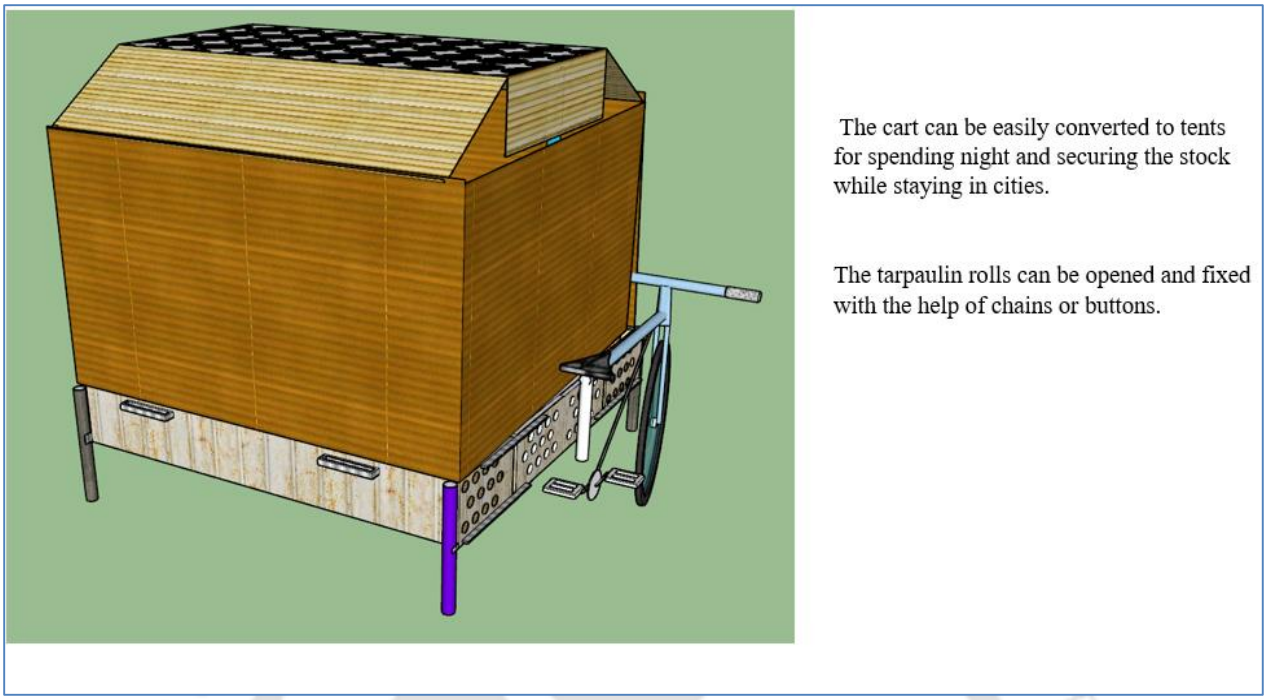


Figure 3.64 – Cart convertible to temporary accommodation

3.3.2.2 Space design

The space design intervention was proposed in two locations Beltola market and Paltan Bazar area. Requirement specific solution were worked out in both th the cases.

Space management in Beltola market

The issue of space management in the Beltola market is at its peak during the biweekly market. GMC is constructing a market complex for all the street vendors, which was initially proposed for a multi-storey building. But later the building was revised to the ground and first floors only. The daily vendors may get sufficient space as of now. However, the rates of vendor increase in this area are very high. By the time the building is ready, the capacity of the building will be already exhausted. On the other hand, the building will not be able to handle the population of the biweekly market vendors and they will again occupy the streets. Hence, a

creative solution for the area is to convert 3 lanes of the market road into a barricaded market zone. Whereas the remaining 3 lanes will be open for traffic, and the entire stretch of road open for traffic will be identified as no parking zone. This way the movement of the traffic can be controlled and at the same time unwanted parking, shopping at the edge of the roads, etc., will be put under check. An additional facility of parking in the market area can be provided with counters of shopping carts for the customers to shop in the area. The area will also have a food court, with seating arrangements and covered sheds. At the end of the parking, the stands for E-rickshaw will be available, to facilitate the customers for an easy commute to their residence.

Access to the markets will only be permitted through the ends of the road. The entry from the roadside will be completely sealed to control the parking of the vehicles on the other side of the road by the customers, where the traffic movement is permitted. Controlled entry and exit points will help in controlling the misuse or stealing of the shopping cart, issued for the comfort of the customers. If the market is organized with entry and exit then the taxing of the vendors can be easily managed without any harassment to them. Space allocation can also be done since the bi-weekly market has multiple stretches where no vendor occupy space due to entry or exit points of roads or getting away from the main market area are their concerns. However, once the entire stretch is barricaded, these issues are addressed and hence more space can be utilized for shopping. In the food court area, provision of portable water can be provided. The shopping complex under construction can provide a toilet facility for the vendors and customers. After numerous alterations, this setup seems to be more feasible than the other proposal. After the bi-weekly market is over, only the road exit points need to be opened,

the remaining barricades will help control unwanted movement on the road from one side to the other. Only the road crossings will be accessible.

The 3D model was prepared to provide an outlook of the proposal and collect feedback from the vendors and the customers.

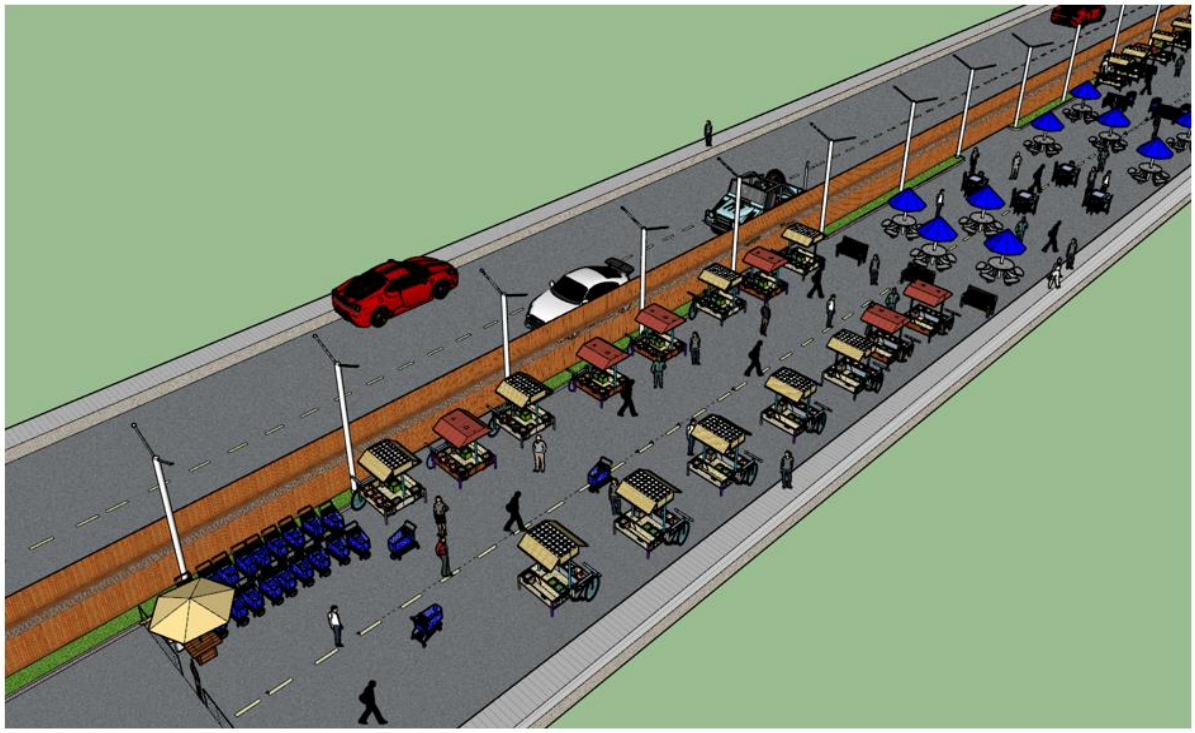


Figure 3.65 – Traffic area and shopping area are isolated for the bi-weekly market

Table 3.8 – *SWOT Analysis*

	Proposal 1 – clare the area as itage market	Proposal 2 – Isolate the d side market on both the es	Proposal 3 – Market nplex by GMC	Proposal 4 - One side road completely lated for biweekly rket
Strength	•The vendors will get more facilities. •Basic amenities will be provided by additional funding. •will have place to sit and enjoy	• Will isolate road and market area. • Traffic flow will be more fluent • Space allocation for all vendors	• Covered structure • Multi-storey with toilet and other facilities. • Full area for traffic movement. • Parking • Space allocation forregular vendors only	• Designated parking. • Space allocation for all vendors. • Zones for vending • Shopping cart facility. • Place to sit and rest. • Food court • Portable toilet • Uninterrupted traffic
Weaknessss	•Parking and traffic will persist. •Biweekly market will cause mis-management.	• Parking problem will persist. • More infrastructure will be required to isolate the market on both sides. • Still have to carry luggage to long distance • Is applicable for biweekly market only	• Space for biweekly market wont be sufficient. • Vendors are not ready to move in higher floors.	• Will need staff to manage cart facility. • Is applicable for biweekly market only. • Isolation on the market day need to be done but only at road openings.
Opportunity	•Will attract tourist. •Get more funding for development.	• Will provide protected areas for biweekly vendors.	• Better infrastructure for storing and staying at night	• Will have better facilities for vendors, customers and commuters
Threats	•Weekly or irregular vendors might loose their vending spot.	• Isolation may require large funds every week. And space for keeping the barricade will be an issue.	• The size is already reduced. • The market capacity is not enough to accommodate all existing vendors.	• The shopping carts need a storing space. • Threat of carts and other facility being stolen.

Figure 3.66 – Parking and cart counter

Figure 3.67 – Place to sit and rest

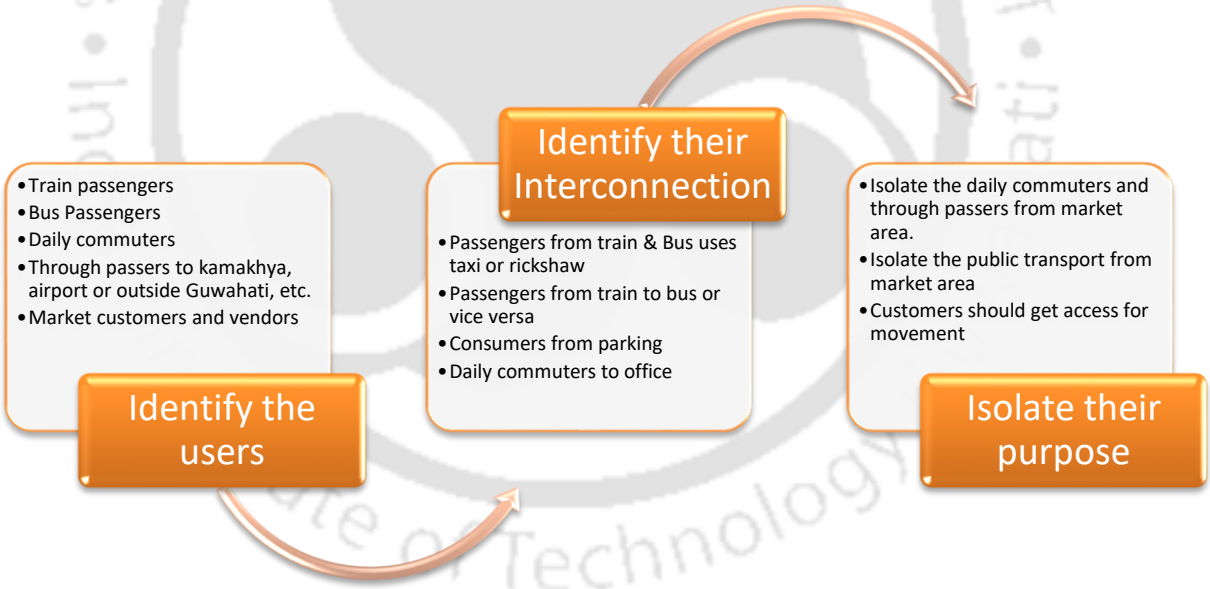
Figure 3.68 – Shaded area for vendors and customers in the food court

Figure 3.69 – Proper allocation of space

A questionnaire will be prepared to collect feedback from the vendors and the customers and the significance of the space design will be tested. In case the test results are significant, the same will be put up in the policy framework to incorporate bi-weekly arrangements of the Beltola Market.

Space management in Paltan Bazaar

The Paltan Bazaar area was studied for space scarcity issues. It was found that the scenario in the Paltan Bazaar was completely different from the Beltola Market. In Paltan Bazaar the traffic is more due to multiple reasons listed earlier. To tackle the issue first all the types of commuters in this area need to be identified.



Flowchart 3.1 - Isolating the traffic density in Paltan Bazaar

As per the Government proposal, there is a metro line under discussion. The plan and maps for the routes of the metro lines were collected by the GMC division. While construction of the metro line the width of the road, which are currently insufficient to carry the traffic, will

be further reduced. By the time metro will be commissioned the number of vehicles will increase very rapidly in this city. Hence, it will be very difficult to regulate the traffic in that scenario. Paltan Bazaar area is already converted to one way only but still in peak hours the traffic density is very high.

Hence, it is proposed that an additional road along with the metro rail line. The same pillars of the metro rail will also carry an elevated road throughout the city, to avoid all unwanted traffic. Such facilities are already available in many countries where heavy traffic roads have by pass roads in an elevated form to provide access for an emergency, the needy, and the people willing to pay extra for the use of such roads. These roads are toll-based and generate their income on a built, operate, and transfer model. However, in this proposal combining the metro and the road project in the same package will make it more economical. This will save land in multiple folds. It will save cost for the foundation of the road network and, at the same time,it is proposed to cover it with a solar roof, embed the metro tracks and the road with piezoelectric floors and the side walls of the metro line with a vertical shaft wind turbine. The entire setup has a capacity of 50 MW. The power generated from the setup can cover its construction and embedment charges within 15 years from commissioning. After that point, the system will produce free energy of 50 MW for many years. At the same time, the setup will support the road and metro rail network of the city.

The same line will be used to carry all the transmission lines, water supply network telephone lines, sewerage network, etc. Hence, one line will be the lifeline for the entire city. In

a single project and excavation of the city, all the services can be installed instead of executing multiple projects throughout the city.

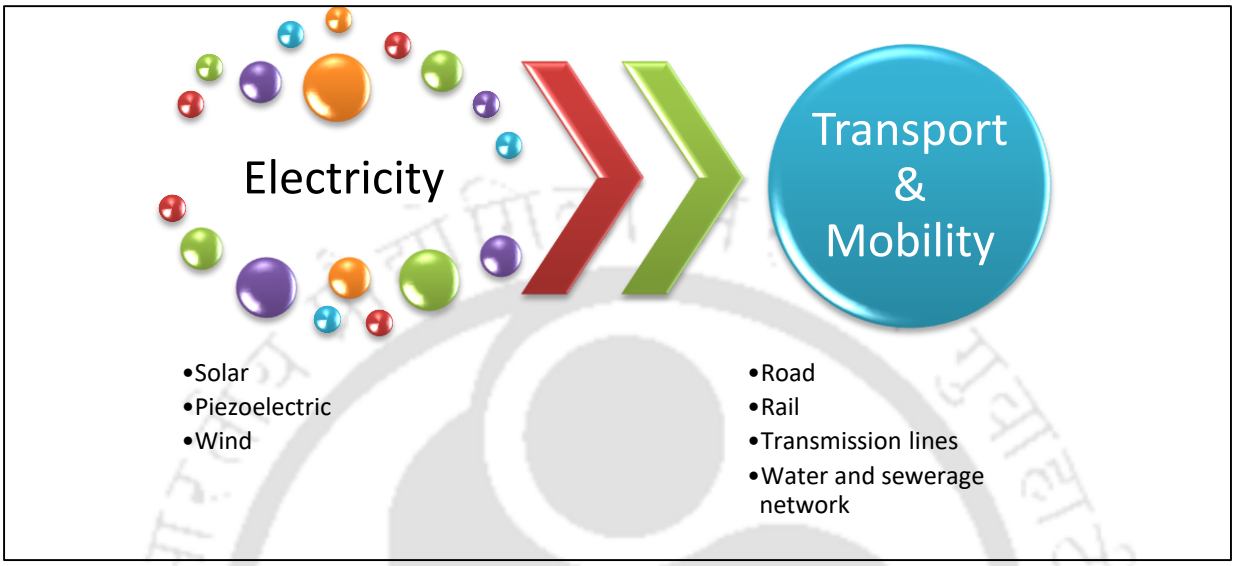


Figure 3.70 – Integration of multiple services to make it a smart infrastructure

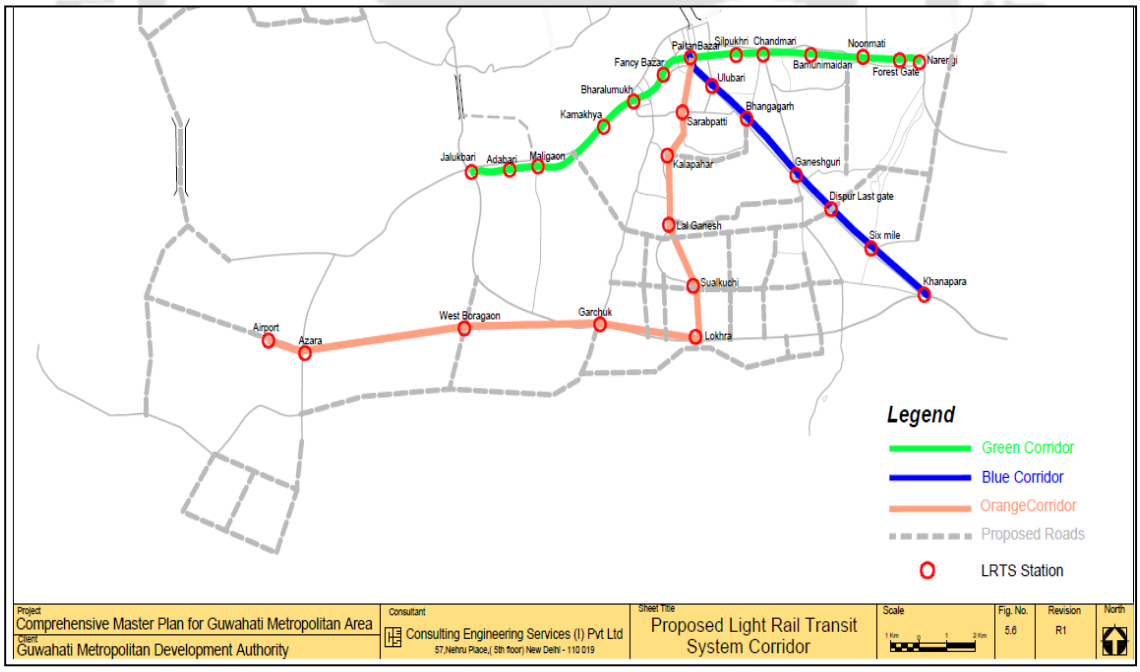


Figure 3.71 - Proposed route maps of Metro line

The corridors of both proposals are as under:

- Proposal A
  - Corridor 1:Dharapur to Narangi to airport = 35 km
  - Corridor 2: MG Road to Khanapara = 11.5 km (underground)
  - Corridor 3:Jalukbari to Khanapara = 25 km
  - Corridor 4:ISBT to Paltan Bazaar = 10 km

    Total = 81.5 km
- Proposal B
  - Corridor 1:Narengi to Jalukbari = 22.7 km
  - Corridor 2: Paltan Bazaar to Lokhra to Airport = 30 km
  - Corridor 3: Paltan Bazaar to Khanapara =9.3 km

    Total = 62 km

Cost of Metro Rail Project

- Cost for km 1of elevated Metro line * = Rs 250 crore/-
- Cost of 1 km of underground Metro line * = Rs 400 crore/-
- Proposal A cost = 70 x 250 + 11.5 x 400 = Rs. 22,100 Crores/-
- Proposal B Cost = 62 x 250 = Rs 15,500 crores/-

Solar Power Potential

- Area requirement for 1 MW of power generation = 24,281 sqm (6 acres*)
- Proposal A
  - Area available= 81500 X 15 =122.25 X 10^4 sqm

- Peak Power generation potential =1222500/24281= 50.34 MW

- Proposal B
  - Area available= 62000 X 15 =93 X 10^4 sqm
  - Peak Power generation potential = 930000/24281= 38.3 MW

Piezoelectric Power Potential

- Area requirement for 400 KW of power generation = 1 km, 7 m wide lane.
- Proposal A
  - Power potential= 81.5 kmX 2 (two lanes of 7 m) X 400 KW = 65.2 MW
  - Proposal B
  - Area available= 62 km^2 (two lanes of 7 m) X 400 KW = 49.6 MW

Total Power Potential

- Proposal A
  - Solar Power potential = **50.34 MW**
  - Piezoelectric Power potential = **65.2 MW**
  - Approx unit generations
    - by solar power/year = 50.34 MW x 4 hrs x 365 days = **73.5 MU**
    - by piezoelectric power/year = 65.2 MW x 16 hrs x 365 days= **380.76 MU**
    - **Total units produced per year = 454.26 MU**
- Proposal B
  - Solar Power potential = **38.3 MW**
  - Piezoelectric Power potential = **49.6 MW**

- Approx unit generations
  - by solar power/year = 38.3 MW x 4 hrs x 365 days = **55.9 MU**
  - by piezoelectric power/year = 49.6 MW x 16 hrs x 365 days= **289.66 MU**
  - **Total units produced per year = 345.56 MU**

Comparison of Power generation

- Thermal power plant of 50 MW produces

  =50 MW x 24 hrs x 365 days

  = 438 MU/ year

- Proposal A produces = 454.26 MU/Year
- Proposal B produces = 345.56 MU/Year

Cost of Thermal Power plant

- Fixed Cost
  - 1000 MW power plant installation cost *=Rs 6000 Crore
  - Land requirement for imported coal-based power plant**= 1 Acre/MW
  - Cost of land per Acre = 8 - 10 Lakhs/Acre
  - Cost of 1 MW Thermal Power Plant = Rs. 6.1 Crore/-
  - Cost of **50 MW** Thermal power plant = **Rs. 305 Crores/-**
- Variable Cost
  - Cost of Coal for 1 MW plant per hour*** =$ 35 / hr = Rs.2380 / hr
  - Cost of coal per year per MW = 2380 X 24 X 365 = Rs. 2.08 Crore/yr/MW
  - Cost of coal per year for **50 MW** = **Rs. 104.25 Crores/yr**
  - **Plus, service and maintenance cost**

Cost of Solar Power project

- Area requirement for 1 MW of power generation = 24,281 sqm (6acres*)
- Cost for installing 1 MW power plant **= Rs 4.50 Crores/-
- Prefabricated factory shed cost per sqm = Rs 2690/-
- Cost of fabrication per MW= 2690 X 24281 =Rs 6.5 Crore/-
- Cost Of Solar Power setup per MW =4.5+6.5 = Rs. 11 Crore/-

Cost of Piezoelectric Power project

- 1kmof piezoelectric installation in road (14 m wide) cost * = Rs 4,42,000 X 400

  = 17,68,00,000/- = **Rs. 17.68 Crores/-**
- Cost of Piezoelectric installation in proposal A

  = Rs 17.68 crore x 81.5 km = **Rs 1440.92 crore/-**
- Cost of Piezoelectric installation in proposal B

  = Rs 17.68 crore x 62 km= **Rs 1096.16 crore/-**

Calculation

Cost of HYBRID-Metro Rail project

- Cost for 1km of elevated Metro line = Rs 250 crore/-
- Cost of 1km of underground Metro line = Rs 400 crore/-
- Approx. cost for 1km multilayer metro rail and road line= Rs 250*1.7 = Rs 400 Crore/-
- Total cost for solar, piezoelectric, and multilayer transport system:

– Proposal A = 81.5 x (6.8+17.68+400) = **Rs. 34595.12/- Crores**

– Proposal B = 62 x (6.8+17.68+400) = **Rs. 26317.76 Crores**

Table 3.9 - *Comparison sheet*

Sl NO	Description	Thermal Power Plant (50MW)	Proposal A			Proposal B		
			Solar Power	Piezoelectric power	Total	Solar Power	Piezoelectric power	Total
1	Electricity generated per year (Million Units)	438 MU	73.5 MU	380.76 MU	454.26 MU	55.9 MU	289.66 MU	345.56 MU
2	Construction cost	Rs.305 Cr.	Rs. 553.74 cr.	Rs. 1440.92 Cr.	Rs. 1994.66 cr.	Rs. 421.3 cr.	Rs. 1096.16 cr.	RS. 1517.5 cr.
3	Variable cost / Fuel cost	Rs. 104.25 cr. /Yr.	nil	Nil	nil	nil	Nil	Nil
4	Service and maintenance	High	Low	Low	Low	Low	Low	Low

It was found that the net cost implication for converting the infrastructure into smart infrastructure will be recovered within 15 years and after that, the same infrastructure will generate continuous income with very nominal maintenance cost.

The land required for multiple services like roads, metro networks, solar power plants, and other services are very huge and it can be saved by smart and Hybrid infrastructure. The cost of hybrid infrastructure is very less as compared to the conventional infrastructure built individually, even if the cost implication due to land is not considered. The renewable energy embedded in it will earn carbon credits for the project.

By the time conventional infrastructures are constructed and commissioned the demand of the locality increases, making the infrastructure obsolete within a few years of

commissioning. Hence, the policymakers should have a futuristic vision because, without their will and level of understanding, it is not possible to have smart and Hybrid infrastructure. Huge solar farms and other power generation facilities can be built in the heart of the city, reducing the cost of transmission since the source of generation will be very close to the point of consumption.

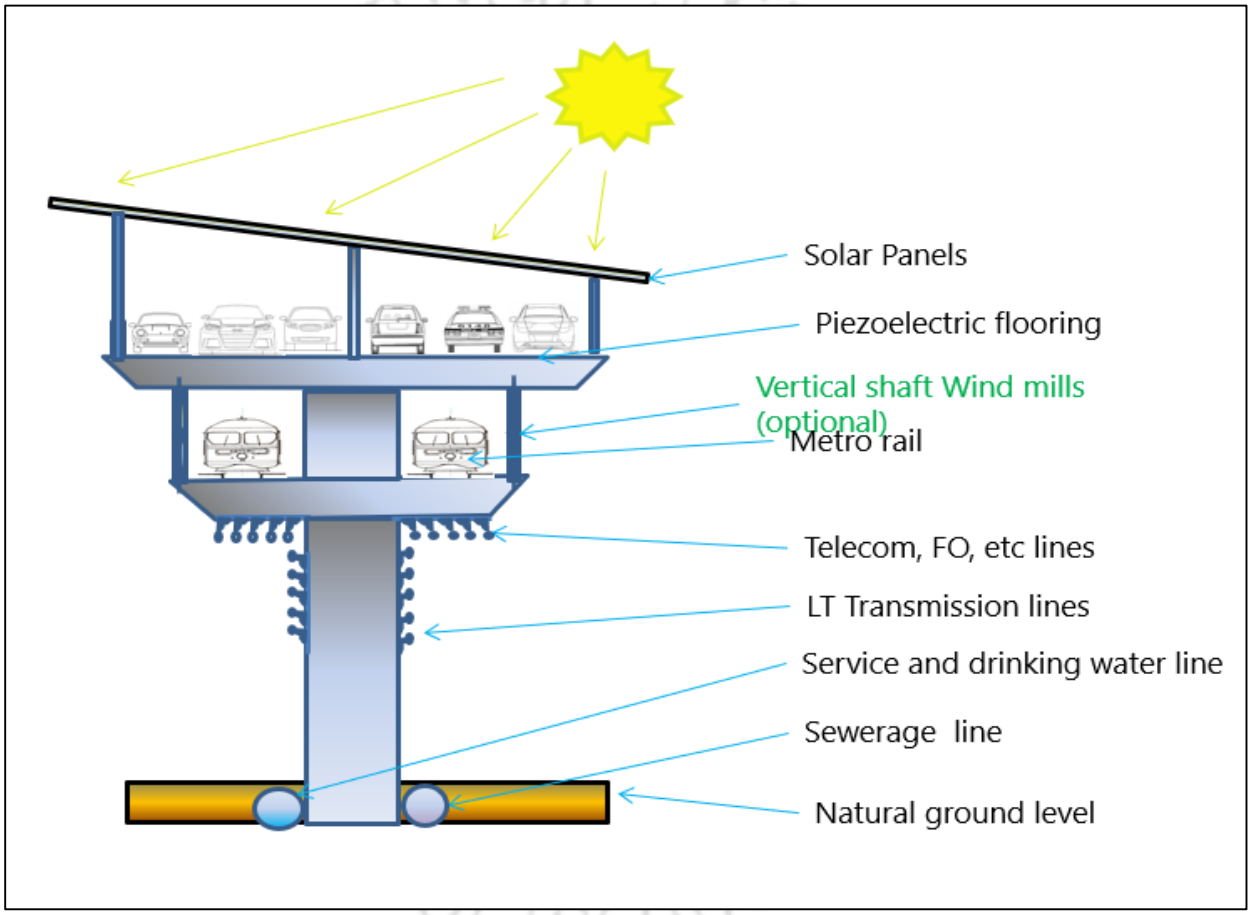


Figure 3.72 – Proposed Hybrid metro rail project

Figure 3.73 – Satellite view of the Bus stop at Paltan Bazaar

Figure 3.74- 3D Model of the Bus stop at Paltan Bazaar with a metro rail network

The combination of three technologies - photovoltaic (PV) cells, piezoelectric floors, and vertical shaft wind turbines -on roads, railways, and metros can produce electricity with higher efficiency compared to the three working individually. The PV cells will be mounted on the roofs of the roads/railway/metro. It will prevent damage to roads due to rain and harsh weather conditions. At the same time, it will cast a shadow on roads/railway/metro, keeping it cooler. The cooler area will cause pressure differences from the area exposed to the sun, causing wind flow. The sides of the roads/railway/metro will be mounted with a vertical shaft wind turbine. It will rotate with the wind flow and by the wind caused by moving vehicles/trains/metros and generate electricity. Hence, the solar roof, will complement the vertical shaft wind turbine. The floor of the roads/railway/metro will be embedded with piezoelectric transducers to generate electricity.

It will generate renewable energy from roads/railways/metro. The solar roof will increase the life of roads by protecting them from rain and harsh weather conditions. The solar roof will generate electricity without wasting large chunks of land. The solar roof will keep the road area cooler, causing a pressure difference from the neighbouring exposed area to the sun. The vertical shaft wind turbine placed at the edge of the road will rotate and produce electricity from the wind generated by pressure difference. The same vertical shaft wind turbine will rotate every time a vehicle/train/metro passes by it. The solar roof will also direct the wind drafted vertically caused by moving vehicles to the vertical shaft turbine for better efficiency. The vertical shaft wind turbine need not wait for the vehicles all the time, since the pressure difference will ensure that the vertical shaft wind turbines are rotating.

The floor of the roads will be embedded with piezoelectric transducers for generating power from moving vehicles/trains/metros. The solar roof will protect the piezoelectric composite from getting damaged due to rain or harsh weather conditions along the road surface. With solar roofs, the same road can be used to generate piezoelectric power also unlike PV-embedded road surfaces. Solar roof roads are better than PV embedded in the roads because each time there will be a shadow on the road due to a vehicle, the voltage will drop. To maintain PV-embedded roads, traffic has to be diverted in case it is embedded in roads. Whereas, solar roof roads can have temporary suspended platforms to do the maintenance work without disturbing the traffic. Solar roofs will also prevent accidents due to rain, overheating of vehicles, and tire-bursting accidents due to hot roads and direct exposure to the sun. PV-embedded in roads are also costly to make since transparent concrete is required and, in case the panel is damaged, the roads have to be recast after repair. On the other hand the solar roofs, the panels can be easily maintained using the service bay and the provision of a suspended platform.

Figure 3.75 – Propose multilevel hybrid transport network in Paltan Bazaar

Figure 3.76 – Guwahati railway station

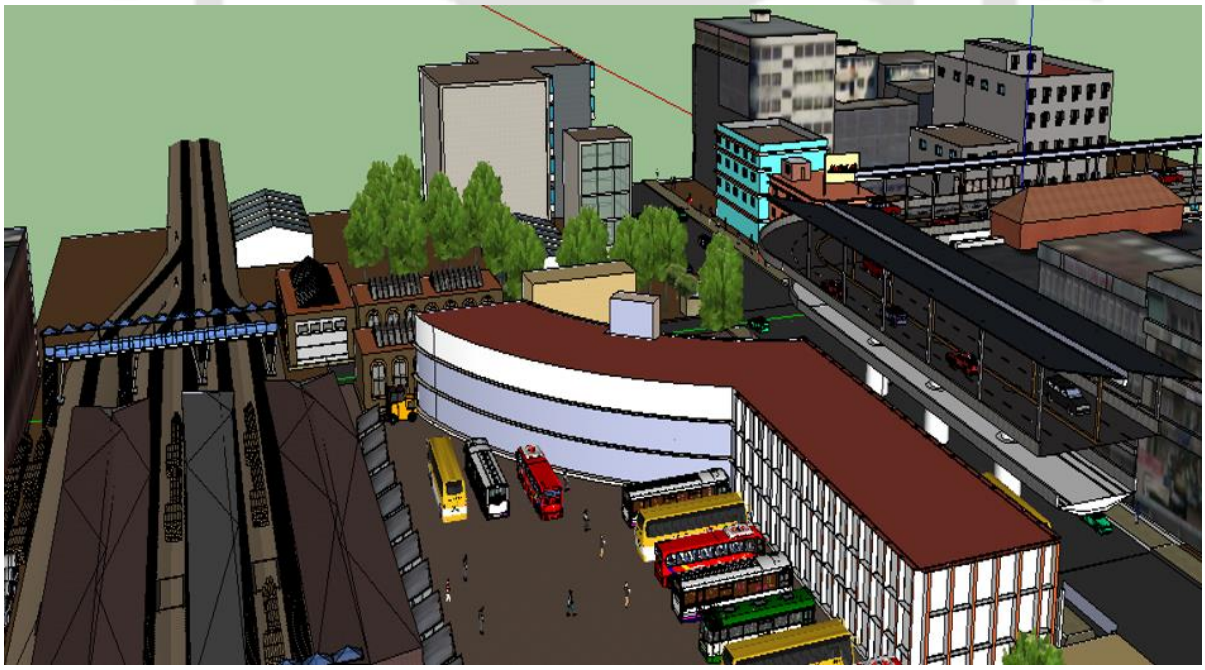


Figure 3.77 – 3D model of the railway station with hybrid metro network

Figure 3.78 – Proposed 3D model of Paltan Bazaar metro station

3.3.2.3 Service design

Our technology consists of a mobile app which is integrated with a camera and a digital weighing machine. The app is integrated with a smart algorithm to analyze and identify the vegetables with the help of a camera. The weighing machine can be connected to a mobile directly also. The battery of the weighing machine will charge the mobile and will feed the weight to the app directly. The vendor can select the vegetables from the dropdown list and generate online bills for the customers. The app will automatically update the balance stock online and will also have a pay online option through which customers can pay directly through mobile. The vendor can also maintain the credit records of the customers and can give them reminders. The app is also linked with GPS for tracking the route and live location of the street vendor.

This technology will integrate real-time data of a street vendor and make it accessible to customers to ensure that the availability of the products and the vendors passing by the localities can be tracked by the customers. And accordingly, they can place their order. This way the sale of the street vendors can be increased and assure that no customers miss their supply.

The technology enhances the visibility of unorganized vendors and supports their sales. The technology is very cheap and easy to use. Any smart-phone with a camera and GPS can be used as a tool in collaboration with a digital weighing machine. A small module is connected to the weighing machine to transfer the weight data to the mobile. Or, we can even collect the data from the weighing machine with the help of the mobile camera. The app will record the vegetable photo and weight data from the photo and convert it into an inventory of available stock. And, as the stock is purchased, the inventory is updated accordingly.

Benefits of the service design formulated are listed below:

- Digitization of a big unit of an unorganized sector.
- Improve the availability of the materials and stock for the customers.
- Improve the visibility of the small vendor and their products.
- It will strengthen street vendors to compete with online stores.
- Systematic approach of the vendors in a cost-effective way.
- This system will generate paper-free billing.
- Actual and authentic bills can be generated.
- It will help in collecting a huge amount of data for Sensex and policy framing.
- It will control the unjustified price hike since all the vendors are on the radar.

- The customers can compare the price and the quality of products online and take a decision easily.
- Same-day delivery as compared to another online portal.
- Can interact with the vendor directly, which is not possible in online stores.
- Any dispute arising due to the quality or quantity of the product can be resolved immediately since the vendor is directly interacting and they have the power to take the decision immediately unlike other online stores.
- The customer can track the actual movement of the vendor and their live stock status to take a quick decision or place orders in advance.
- The machines available in retail for weighing and billing are very expensive for streetvendors and need a continuous power supply. Our set up is a very cheap arrangement without any printer requirements. Since it is linked with daily use mobile and a basic digital machine which can last for a very long time after a charging the battery.
- These billing machine waste paper for billing, whose print also fades off with time. In our machine paper is not required and the records are safe in the portal and can be accessed anywhere with a login id and password.

Components - Smart Phone, in built camera, inbuilt GPS, Digital weighing machine, mobile app, and Internet.

Working – The working of the app will start in the morning, the vendor will weigh all the vegetables/products in the cart and take photographs of the vegetables on the weighing

machine, with digital weight displayed on its screen. The camera of this app has a frame positioned in such a way that the weight display is clearly visible. The algorithm will help identify the vegetable/products and its displayed weight is recorded in the log as taken during the photograph. There is a dropdown list consisting of all the available products, it can be easily customized as per the requirement and the vendor. They can feed the details of the stock of their cart in the portal and the details will be uploaded online. Then, the vendor will set their route on the map and the notification will be online with the inventory of vegetables and available stocks with actual photographs. The customers can send an expression of interest to the vendors and book orders online directly with the location of their delivery on the map.

All the customers with the app can track all the vendors crossing their neighbourhood and can easily browse through the available vegetables and the daily products with the help of GPS. Each time a product is sold, the app will generate an online invoice with the help of the digital weighing machine and photos taken by the camera and send it to the customer with the help of a mobile number of the customer or via the portal profile of the customer. The inventory of the balance stock will be automatically updated. The app will generate weekly, monthly, and yearly financial analyses for both the vendor and the customers on the basis of their transactions throughout the year. Online payment options will be linked with the app for easy transactions. Both the customer and vendor will have their profiles in the app and will be notified about their requirement and orders.

Technical description - The mobile is linked to a weighing machine with a data cable to transfer the weight data of the products to be sold. The unit rates are already fed into the portal. After

recording the weight, either the photo of the product to be purchased is taken, then the software will compare the photo from the uploaded photos in the morning by the vendor and suggest the closest resembling products in the list or the vendor can select from the drop-down list directly. The second option is that the products are kept on the weighing machine and a photograph is taken by the vendor by positioning the product in the product frame and the displayed weight in the weight frame is visible in the camera option of the app. Both the frames will automatically convert the photographs into useful data and generate a bill. The vendor will keep on adding the products and taking the photographs, the bill will be automatically generated and the balance stock of the vendor will be updated in the portal too. When all the products for the customer are selected then the vendor will opt for payment. The bill will be generated and transferred to the customer portal and ask for online or offline payment and the purchase can be completed with the desired payment option.

The app will also have a credit system in which the vendor can sell products on credit and later on get the payment. The app will also send reminders and rate the vendors and customers on the basis of credit payment frequency to build confidence between the vendor and the customers.

The app is linked with the map and GPS of the mobile, which will help track the live movement of the vendor. The customers can place their interest and as the vendor reaches the location of the vendor, and a notification is sent to the customer for shopping. The vendors can also place the order online and the vendor will deliver the products to the doorstep.

This project is taken up to develop a cost-effective online system for digital street vending with minimum human-computer interaction and maximum visibility of the street vendors to the customers. In this project, machine learning techniques are used to identify the products and the weight data without anyone feeding the same manually. The basic objectives of the project will be to:

- To identify the vegetables or fruits to be purchased by the customer once it is placed in the weighing machine.
- To record the weight data of the products without manually feeding them.
- To generate online bills and process online payments of the purchase.
- To update real-time stock data to the customers.
- To give the real-time location of the vendor and the proposed routes.
- Since the street vendors are not tech savvy hence to minimize their interaction with the technology.

List of items

- Digital weighing machine
- Structural arm to mount the picture-taking device
- Tricycle cart.
- Human-computer interaction module
- Machine-to-machine interaction module
    a. Visual data collecting tool - Camera

b. Data cable -for physical data transfer from the weighing machine to the HCI module

c. Cloud data

- Data analysis tool

a. Convolutional Neural Networks

i. Identification matrix

Arrangement - A digital weighing machine is placed on a tricycle vending cart. The weighing machine is attached with a frame to mount a picture-taking device. The position of the picture-taking device should be such that it can clearly take the picture of the weight displayed on the digital weighing machine along with clear pictures of the vegetables or fruits.

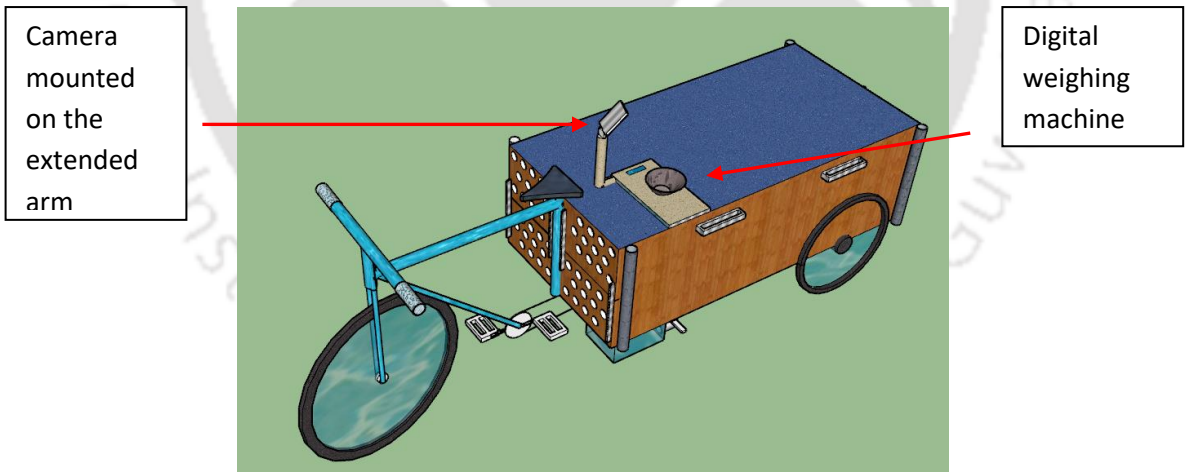


Figure 3.79 - Vending Cart with a fixed digital weighing machine, extended arm for holding the camera

The position of the camera is fixed. To do so, a frame is fabricated which is attached to the vending cart and the weighing machine is placed on the frame. The frame will have an extended arm for mounting the camera as shown in Figure 3.79. While the camera is mounted and the setup is ready, calibration of the position of the frame is done. Three red dots are marked on the corners of the weighing machine and three blue dots are marked on the corners of the digital display section. While the calibration pictures are taken the algorithm will identify the digital display section and the weighing machine area. These three points will help in identifying the digital frames of the pictures to be analyzed. The only care to be taken in this procedure is that the basket in which products will be placed should be ensured to be kept within the digital frame of the picture as shown in Figure 3.81 or it can be said that it should not be projected outside from the weighing machine.

Every time the picture is taken from different angles**.** In this procedure, the picture device is mounted on a fixed frame from where the display of weight machine and the materials being weighed are clearly visible and their pictures can be taken easily. In this procedure, the photograph will calibrate with the picture every time with the weighing machine, digital display and the basket in which the product is placed. The periphery of the basket will also be calibrated based on a similar identification system or with the help of convolution neural networks theory.

The third way for data collection of the weight is with the help of a data cable; the data is transferred in the form of an electrical signal recorded and displayed on the weighing machine and the mobile linked to it. When the product is placed on the weighing machine the

data will not be recorded but will only be displayed on the mobile. However, when the deal is finalized, then a picture of the product will be taken. The same console taking the photo will send a signal to the module to record the weight data in the inventory at the time of taking the photo.

Figure 3.80– Picture taken from a random angle with predictive frames calibrating setup

Methodology - The methodology is divided into three steps and is listed below:

The Data Analysis Flow Diagram as mentioned in Figure 3.81 shows the working of the mobile app and how the hardware and software will work.

*Data input source***.** Data is gathered in two forms, i.e., through a camera (in the form of pictures) and a weight machine (in the form of digital numbers).

Data sorting. Segregation of the weight data and the product data -both the data are isolated depending on which digital frames are they recorded.

*Data analysis***.** The analysis of the data is done with the help of Convolutional Neural Networks. As shown in Figure 3.80 the picture in the product frame/basket frame marked with green dotted circle is analyzed for identification of the products. The picture within the frame constitutes numerous small pixels. Each pixel carries a set of RGB values. These values decide the actual colour of the pixel and all the shades of colours have a very distinct combination of the RGB value. Similarly, a set of neighbouring pixels with distinct colour combinations form various patterns of shape, texture, line, edge, etc. Hence, by identifying the set of pixels with their distinct RGB value, the position in the picture of any of the physical shapes or other properties can be formed.

Even if the shape or pattern was formed, the computer or any other device cannot identify what it was. Hence, distinct identifiers were linked with distinct sets of parameters and were fed into the computers or the systems in advance. For example, a red-coloured item, somewhat round in shape, with a depression on the top can be an apple, cherry, strawberry, etc. but if it is further filtered with yellow dots and a pointed bottom, then it can be identified as strawberry. If the filter is to identify a depression at the top and bottom and the bottom portion consists of ridges then it can be identified as an apple. In the case of cherry, it should be completely round from the bottom, and then it can be identified as cherry unless something else also has the same identifiers. The level of accuracy increases with an increased number of filters and with increased data of exceptions added to the system. On the other hand, it can also increase the accuracy level by limiting the variations of parameters and giving very distinct identification for every variation available. In our case, a vegetable vendor selling vegetables on the streets is not going to carry 100 items but hardly 15-20 items due to space restrictions on their vending cart.

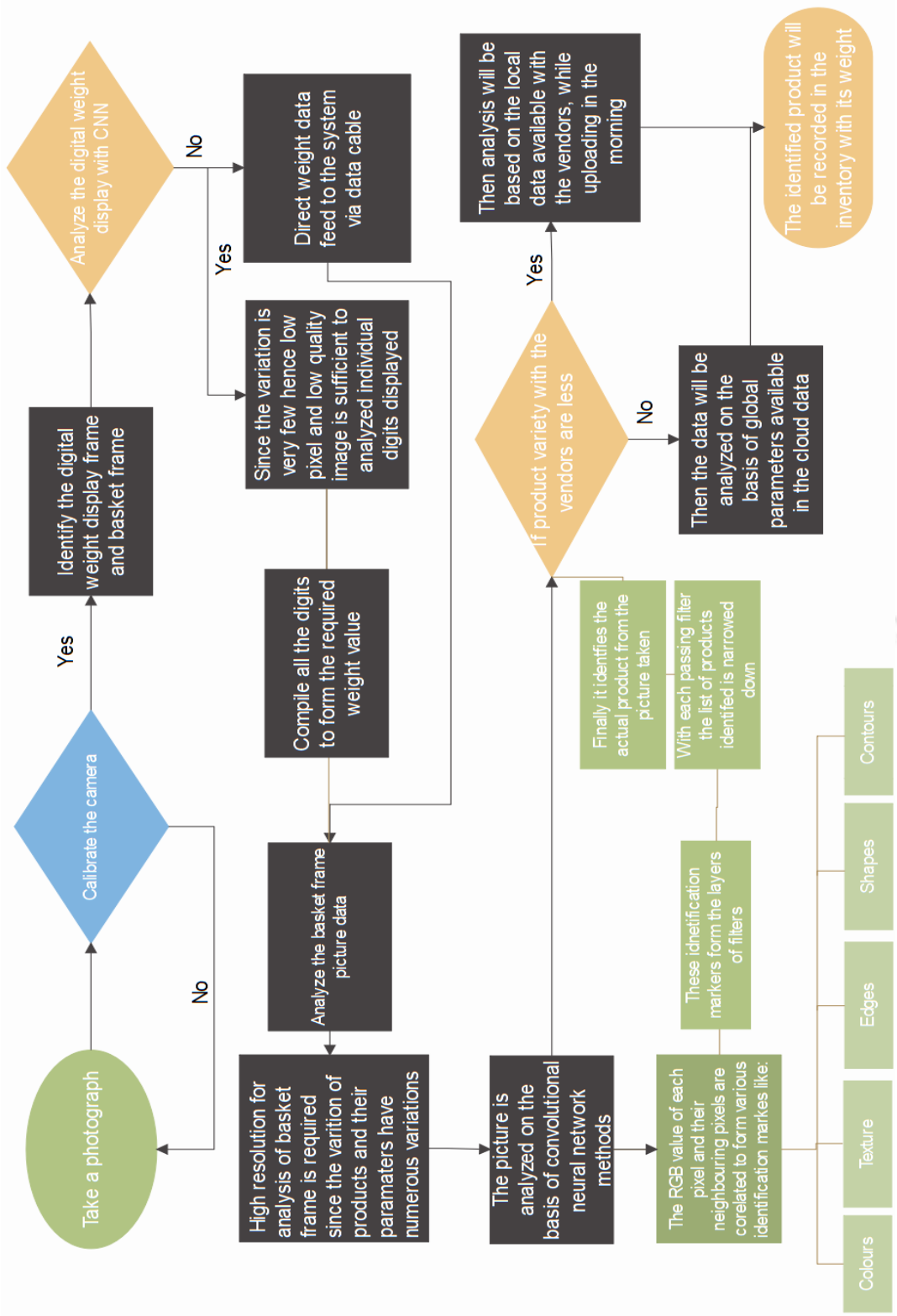


Figure 3.81 - Data Analysis flow diagram

It is very easy to segregate the product on the basis of the below-mentioned parameters. If a matrix is formed with a list of vegetables and their respective parameters, then most of the vegetables can be identified with very high accuracy within 2 to 3 layers of filters itself. Hence, with the help of convolutional neural networks, it can easily identify the products from the local data available with the vendor itself from the data generated when recording the inventory at the beginning of the day. In case of any conflict, CNN can analyse the data set from the global data available in the cloud network. By keeping the global data analysis as the second option the system can be kept light and much faster as compared to the system analysing the data directly from the global cloud network.

Daily varying parameters of products:

a. Colour
b. Texture
c. Edges
d. Shapes
e. Contour

Identification matrix - The basket frame is analyzed to identify the vegetables or fruits. The shades of the basket are pre-fed and hence the same is discarded. The remaining area inside the basket is analyzed, and the prominent colours of the vegetable placed are identified depending on the RGB score of each pixel. By mapping the pixel scores on the picture, the texture, edges, shapes, and contours of the product can be easily identified. Any given vegetable or fruit will have a distinct set of these parameters and hence can be easily identified when these filters are applied.

It can be easily understood with the help of the identification matrix mentioned in Table 4.3.

The nomenclature of each parameter is also mentioned below:

Colours: G- Green, Y - Yellow, R -Red, B-R - Brown, Etc.

Texture: S - Smooth, SS –Semi-smooth, R - Rough, Sh -Shiny, etc.

Edges: L - Linear, LC - Linear and Circular at edges, LP- Linear & pointed edges, NL –Non-linear.

Shape: C - Circular, O - Oval, I - Irregular, B - bulb, E - Eye shaped, etc.

Contour: S - Spherical, R - Ridge, P - Plateau, U - Uneven, D - Depression, etc.

Table 3.10 - *Sample Identification matrix*

SL No	Vegetable	Colour	Texture	Edge	Shapes	Contour
1	V1	G	S	L	I	S
2	V2	R	SS	LC	C	S
3	V3	G	S	L	O	R
4	V4	Y	R	LP	C	P
5	V5	G	Sh	NL	E	R
6	V6	B	S	LC	B	D
7	V7	R	SS	LC	I	D
8	V8	G	S	NL	B	U
9	V9	Y	R	L	C	U
10	V10	B	Sh	L	C	P
11	V11	G	R	LP	O	P
12	V12	B	Sh	LP	B	D
13	V13	G	R	L	B	D
14	V14	Y	SS	NL	E	S
15	V15	B	Sh	NL	E	S

Each vegetable will be having a set of parameters to exactly identify the product even after multiple variations. In any case, if the product is having a dispute, then it will be compared to the global database to give the exact identification of the product. And with each exception added to the system, it will become more accurate.

Data transfer -

- Visual data to mobile network to cloud computing - the visual data in the form of a picture is transferred through a mobile network (long-range communication) or via a short-range network with the help of blue tooth or WiFi.
- Data Cables -The weight data from the weighing machine can be transferred via data cable to the HCI module.

Data Storage -

- Cloud storage
- Within the memory storage of mobile
- Dedicated system - DBMS & RDBMS

Data retrieval **-** HCI module – Mobile in this instant case.

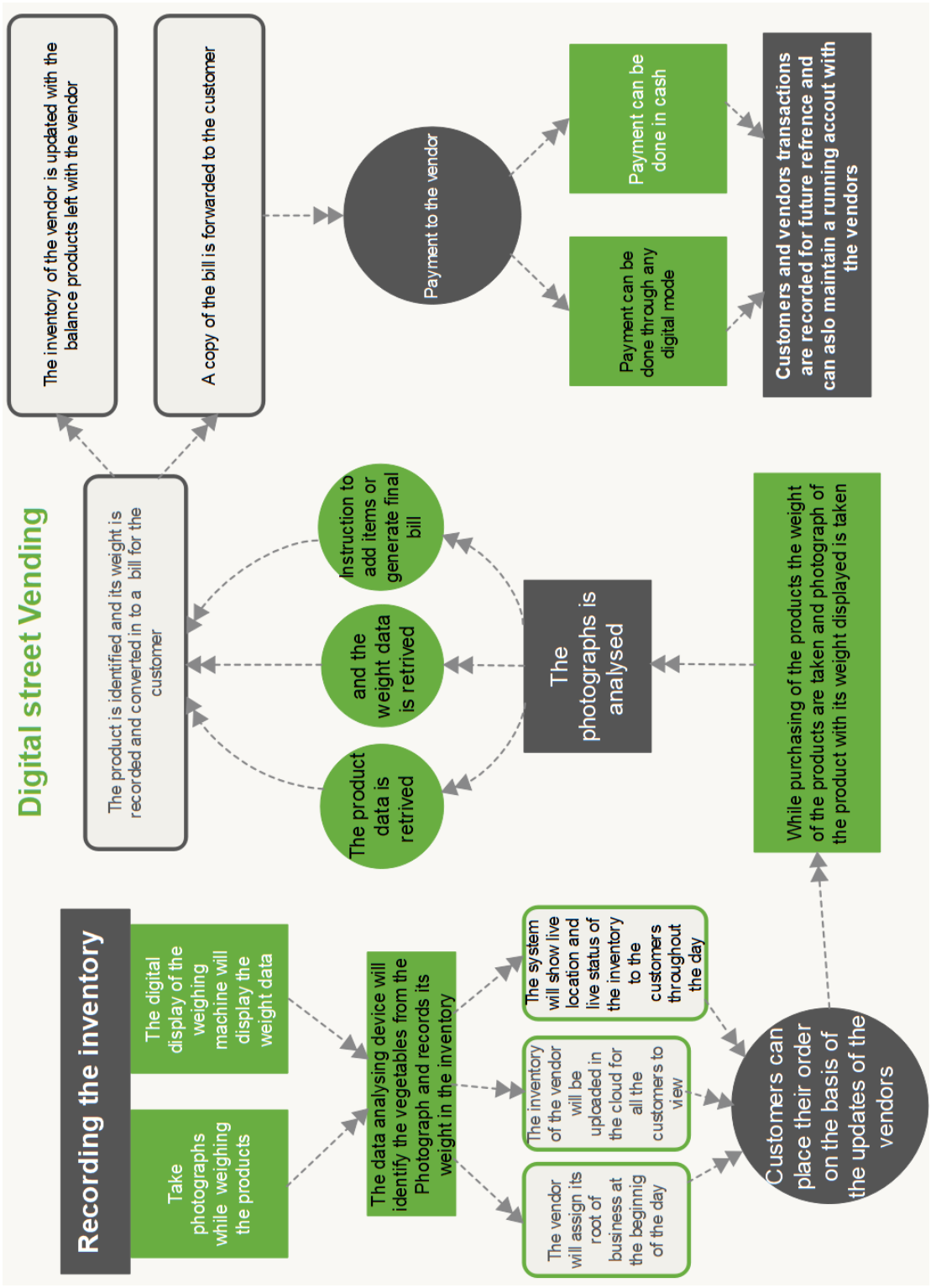


Figure 3.82: The process flow diagram of digital street vending

The process flow diagram is mentioned in Figure 3.82. The process starts with recording the inventory in the morning by the street vendors. The vendor will take the photographs of the raw material on digital weighing machine with weight displayed in the photo. The app will identify the product as well as the weight of the product and create and inventory of all the items being loaded in the vending cart in the morning with the help of digital weighing machine and photographs. Then the vendor will decide their route in which they want to sell with the help of three to four landmarks. The inventory and the route of the vendor will go on line and will be displayed to all the customers in those roots. The customers can place advance orders also from the mobile app. The vendor will get the notification with location of the customer. The vending cart will have a frame to hold the mobile above the digitl weighing machines for recording the inventory and generating the bills.. And every time any customer purchases anything the vendor will click a photo on his mobile mounted on the frame, while weighing the products. The app will again identify the product and the weight of the product and it will automatically generate the bill. The bill is forwarded to the customer and the balance inventory of the vendor is automatically updated in the app. The app will show the live location and the live inventory stock of the vendor. The vendor will get a link for online payment or can also pay in cash. The bill will be recorded for future reference and the customer can also have their running account with the vendor for daily purchase and settle the amount weekly or monthly if agreed by both vendor and customer. In this way the step by step online transaction can be done. The only work of the vendor will be to mount his product on the digital weighing machine and keep on clicking photos remaining everything will be taken care by the Mobile app.

3.3.2.4 System design

All the product design, space design, service design overall system design, cooperative society should be upgraded with more power and facilities to resolve vendor, customer, and commuter issues, among others. Consequently, cooperative societies should consider the following goals:

1) Formation of Smart Cooperative society - This will help in empowering the vendors and they themselves can work together with the administration for their betterment. A cooperative society will ensure that their issues are put up to the policy makers. A cooperative society can very effectively resolve all the minor issues at their own level with dialogue and discussions. Since all the people will be from same background so they will understand the issues more effectively. Other advantages of the cooperative society are:
    a. They can have their own Grievance redressal system
        - For customers
        - For vendors
    b. For the safety of the Vendors and customers from local goons, lessee, police, local chanda, etc. They can fight and stand united for all these issues and they will have their own security circle. They can generate minor funds and can have their own control room with CCTV monitoring with the help of administration.
    c. For clarity in policies and increasing awareness, a mobile app with pictorial news updates for all the vendors should be promoted. The same app will also have other facilities as discussed in the upcoming section of digitizing of the sector.

d. For providing basic facilities like -Shed, toilet, water, overnight stay, storage facility, etc. they can put up the matter collectively to the administration in a systematic manner and emphasis so that the positive results are ensured.

e. Elimination of the lessee system and the society itself will manage the taxing system through mobile apps. Train the vendors and the locals about the smart cooperative systems.

f. Cooperative society can work on the Health and hygiene requirement of the male and female vendors.

2) Digitization of the sector – Digitization of the sector will help in bringing transparency in the system. In the current system there are multiple grey areas which are being exploited by the mediators.

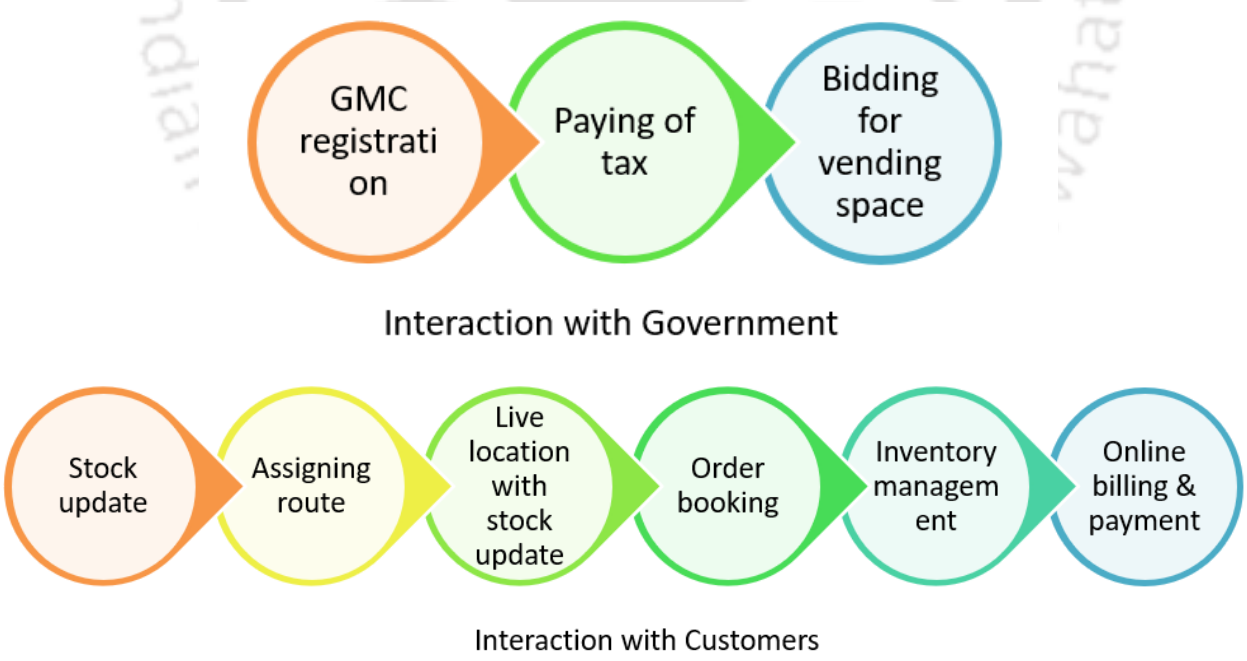


Figure 3.83 - Process Flow diagram

The system being proposed works in two parts, first one covers the interaction of the vendors with the policy makers and the administration and the second part is the interaction of the vendors with the customers.

As shown in Figure 3.83 the interaction with Governments starts with registration of vendors in the administrative portals, in our instant case it is Guwahati Municipality Corporation. It is already being practiced but when it will be done on an online portal through mobile app directly then it will be very easy for the vendors. But for making them aware of the system and procedure numerous help desks and kiosk are to be installed at multiple locations and these help desks should be advertised and publicized for broader coverage. The policy makers are emphasizing more and more on the ease of doing business and other commercial facilities for the small business sector but digital exposure of the vendors will play a major role in establishing a more transparent system. In last 5 years India as a whole has gone through a major transformation from cash economy to a digital economy and the process is still going on. The biggest achievement of the initiative is that even the micro retail outlets in India including shoe polish service provider sitting on the street is also having a QR code for online payment. If they can use QR code for payments then they can also use the mobile apps for registration and for availing other Government facilities. The policy makers have managed to register a majority of the people living below poverty line in India and they are getting their subsidies directly in their bank accounts another feather in the hat of the Policy makers of India. The registered people falling under the eligibility criteria of UJJWALA Yojna (a program for issuing free LPG cylinders to people below poverty line) are getting LPG cylinders free of cost. The distribution done in phase 1 of the scheme covered 8 Crore household and in the phase 2 it is proposed to

cover all the other left out 1 crore household. The credit of the success of the scheme goes to the efficient policy implementation by the policymakers and wide publicity through camps organized by the oil and gas companies for helping the less aware population. The Indian population is moving to a digital service/system/economy era and these changes are happening very fast hence to add in these facilities the policy makers have linked the system for paying tax online for all vendors also. The additional feature could be to have a simplified app only for street vending, where each vendor can register with the local municipality, they can pay the taxes directly online instead of paying it physically to the lease or goons. They can opt for bidding of the vending space on the online portal and the space should be provided on a rotation basis. This will prevent the daily fights of the vendors for the space. The space can ge geo-tagged and the vendor can bid online and the marking of the spaces in the market can be done with specific codes. All the vendors will bid as per their size of the space required and the system will allot the space on rotation basis, this way every vendor will get the chance to sell at prime locations also. The portal will also keep the track of the locations of all the vendors. The administration can allot specific areas for particular types of market to make it more systematic. Now the vendors sits randomly but have common consensus for some products like selling of meat and fish in some locations but that is also in patches at multiple locations. The administration can have sections for green vegetables in one sections, fruits in one section, meat and non-veg in one section, cloths and apparels in one section, street food in other section and so on. This will be very helpful for the vendors as well as for the customers also.

The proposed system will help in the following:

a. Ease of registering the vendors in the municipality.

b. Paying of the tax as per Government rule and no need to pay extra taxes to lessee, goons, etc.

c. This will prevent tax evasion; if the tax is not paid, the space won't be allotted to the vendors. No need to appoint lessee in the area, this will reduce the burden on the vendors also.

d. Transparency in the system from both the administration and vendor side.

e. No fight among the vendors for space allocation for selling of goods.

f. All the vendors will get equal opportunity. It is observed that some vendors get fixed locations in the market due to their good bonding with the lessee or the locals, where as few vendors location keep on rotating, but in case of new vendors arrive in market there are chances of quarrel for selling space in market. Hence this system will help in avoiding all these issues.

g. The same system can be used to provide them health insurance and subsidized loan also. The local goons are giving them loans without any collateral but with very high interest of more than 1% per month and in case the vendor is not able to return it on time they are stuck in a cycle of cumulative interest burden. Here Government can issue low interest loans as there are multiple schemes already run by the Government in these lines. The same can be link through our proposed app and the loan issued by the

Government may be covered by an additional insurance for double surety of the Government fund and the vendors.

h. The vendors can have their own credit scores and on the basis of their repayment frequency their loan limits can be extended by the Government and this will improve their entrepreneurial potentials.

i. Instead of distributing money directly to the people this will make the citizens more responsible and self confident. The Indian Government is already working tirelessly on these schemes but by compiling those at one place and proper publicity camps like other schemes can make this initiative very effective.

j. The unorganized retails are the largest employment sector of India, if an effective system is put into place to strengthen their capabilities, then their decline in the market share can be restricted and improvement in their market share can be expected.

In the second part of Figure 3.83 the interaction of the vendors with the customers is explained. It is explained in the service section in detail. Both the component of the figure 3.83 taken together form the digital platform proposed for the vendors. The proposed system will help in avoiding the following:

a. This will help in standardizing the rates of products in market.
b. Customers can also compare the rates of all the vendors in the market in one click.
c. The mediators and brokers consuming the margins can be checked.

d. Vendors with home produce will get more visibility with genuine rates.

e. Vendors without premium locations can also sell their products.

f. Street vendors will get a platform to compete with the organized retails and e – tails.

g. Street vendors can also have Omni format market presence.

h. The proposed technology is very cost effective and easy to use app. This will increase the profit margins of the street vendors.

3.4 Validation of Results and Interventions

To validate the proposed design interventions, we need to collect the user feedback and analyze them for understanding whether the proposed interventions are having significant improvement from over the existing scenarios or not. Hence we have used System Usability scale to analyze the user experience. We have got our proposed interventions for technology validation by getting Utility patents after extensive and multiple level examination by the field experts and level A grade scientists. Similarly the form and shape validation was done by getting grants of Design patents after extensive and multiple level examinations by the field experts and level A grade scientists.

3.4.1 System Usability Scale - *Calculation of score*

We have conducted the data analysis with the help of System Usability Scale (here after called as SUS) for all the three design interventions and accordingly the data was collected from the end users for their feedback. The data collected was recorded in a tabular format and SUS values for each individual user was calculated as discussed in chapter 2. The average of the SUS is considered as the actual value of SUS score for any given intervention. In the table No 3.11

Sample No indicates the number from whom SUS score data was collected. The names and their credential are kept confidential. The sample size is 42 .The demography of the sample is 65% of the population was male and 35% of the sample size was female. The average age of the population was 28 years, ranging from 19 to 45 years of age. The same sample was used to collect data for Space design, Product design, system and Services design:

Table 3.11 – *SUS Score for Space design of Paltan bazar*

Sample No	Qn No 1 - Q1		Q2		Q3		Q4		Q5		Q6		Q7		Q8		Q9		Q10		Total	SUS Score
	Score-S (1-5)	Final Value-FV	S	FV	S	FV	S	FV	S	FV	S	FV	S	FV	S	FV	S	FV	S	FV		
1	5	4	1	4	4	3	1	4	5	4	1	4	4	3	1	4	2	1	1	4	35	87.5
2	4	3	2	3	5	4	2	3	4	3	2	3	5	4	1	4	4	3	1	4	34	85
3	3	2	2	3	5	4	1	4	5	4	2	3	4	3	1	4	3	2	2	3	32	80
4	4	3	1	4	4	3	2	3	4	3	1	4	5	4	2	3	5	4	2	3	34	85
5	4	3	1	4	5	4	1	4	5	4	2	3	4	3	2	3	4	3	1	4	35	87.5
6	5	4	2	3	4	3	3	2	5	4	1	4	5	4	1	4	5	4	2	3	35	87.5
7	4	3	1	4	5	4	3	2	5	4	1	4	5	4	1	4	4	3	1	4	36	90
8	4	3	1	4	5	4	2	3	5	4	2	3	5	4	1	4	4	3	2	3	35	87.5
9	3	2	3	2	5	4	2	3	4	3	1	4	4	3	2	3	3	2	1	4	30	75
10	5	4	1	4	4	3	2	3	4	3	2	3	5	4	1	4	5	4	2	3	35	87.5
11	5	4	1	4	3	2	1	4	4	3	3	2	4	3	3	2	4	3	1	4	31	77.5
12	4	3	1	4	5	4	1	4	5	4	3	2	5	4	3	2	5	4	2	3	34	85
13	4	3	2	3	5	4	1	4	5	4	2	3	4	3	1	4	4	3	2	3	34	85
14	3	2	1	4	5	4	1	4	5	4	2	3	5	4	2	3	3	2	1	4	34	85
15	2	1	3	2	4	3	1	4	5	4	1	4	4	3	1	4	4	3	2	3	31	77.5
16	1	0	1	4	5	4	2	3	4	3	1	4	5	4	1	4	3	2	1	4	32	80
17	3	2	1	4	4	3	1	4	4	3	2	3	4	3	2	3	3	2	2	3	30	75
18	5	4	2	3	4	3	2	3	4	3	1	4	5	4	1	4	4	3	2	3	34	85
19	4	3	1	4	5	4	3	2	4	3	2	3	4	3	2	3	4	3	2	3	31	77.5
20	5	4	2	3	3	2	2	3	3	2	1	4	5	4	1	4	5	4	2	3	33	82.5
21	4	3	1	4	4	3	2	3	3	2	2	3	4	3	1	4	5	4	1	4	33	82.5
22	5	4	4	1	5	4	1	4	3	2	1	4	5	4	1	4	4	3	2	3	33	82.5
23	3	2	1	4	4	3	1	4	4	3	2	3	5	4	2	3	5	4	2	3	33	82.5
24	3	2	2	3	5	4	2	3	5	4	1	4	5	4	2	3	4	3	2	3	33	82.5
25	3	2	1	4	5	4	1	4	5	4	1	4	5	4	1	4	5	4	1	4	38	95
26	5	4	1	4	4	3	2	3	4	3	2	3	4	3	2	3	4	3	1	4	33	82.5
27	4	3	1	4	5	4	1	4	5	4	3	2	5	4	1	4	4	3	1	4	36	90
28	4	3	1	4	5	4	2	3	4	3	3	2	4	3	2	3	5	4	2	3	32	80
29	4	3	2	3	5	4	3	2	5	4	2	3	5	4	1	4	4	3	1	4	34	85

30	5	4	2	3	5	4	1	4	5	4	1	4	4	3	1	4	4	3	2	3	36	90
31	5	4	1	4	4	3	2	3	3	2	1	4	5	4	1	4	4	3	3	2	33	82.5
32	5	4	1	4	4	3	1	4	3	2	2	3	5	4	1	4	5	4	1	4	36	90
33	4	3	2	3	4	3	2	3	3	2	1	4	5	4	2	3	4	3	1	4	32	80
34	3	2	1	4	4	3	1	4	2	1	1	4	4	3	1	4	5	4	2	3	32	80
35	4	3	1	4	5	4	2	3	2	1	1	4	4	3	2	3	4	3	1	4	32	80
36	5	4	2	3	4	3	2	3	1	0	2	3	5	4	2	3	5	4	1	4	31	77.5
37	5	4	2	3	4	3	2	3	3	2	1	4	4	3	1	4	4	3	1	4	33	82.5
38	4	3	1	4	5	4	1	4	5	4	2	3	4	3	2	3	4	3	2	3	34	85
39	4	3	2	3	5	4	1	4	5	4	1	4	5	4	1	4	4	3	2	3	36	90
40	3	2	1	4	4	3	1	4	4	3	2	3	5	4	1	4	5	4	1	4	35	87.5
41	5	4	2	3	3	2	1	4	4	3	1	4	4	3	2	3	4	3	2	3	32	80
42	5	4	2	3	5	4	3	2	1	0	1	4	5	4	1	4	5	4	1	4	33	82.5
																				Average Score of SUS		**83.63**

3.4.1.1. Space Design

a. Paltan Bazar – For space Design we have developed the 3-D model of the proposed modification of the area. From the 3-d Model we have developed a walk through animation video for giving the end user visual experience of the area and on the basis of the walk through video we have collected data from the end user with the help of questionnaire of System Usability Scale. We have collected the data for both the interventions in space design i.e Paltan bazaar and Beltola Market. In Paltan bazaar we have proposed a multilevel hybrid transport system with multiple additional services. The walk through video of the hybrid transport system was shown to the sample. Along with the walk through a video Power point presentation of the facilities and effectiveness was shown to sample. On the basis of walk through and the video of detailed Power point presentation the samples were asked to fill the questionnaire of System Usability Scale. The data collected and the converted score is shown in Table No 3.11. The average score of the SUS for space design of Paltan Bazar is 83.63, which is a very good result

as per SUS scale and have shown significant improvement over the previous and existing infrastructure.

3.4.1.2. Product Design - Similar exercise was conducted for the product design category. In product design category we have developed a full scale prototype of portable vending cart and the users were asked to operate the prototype and on the basis of their experience of the prototype the SUS questionnaire was filled. The SUS score for portable vending cart was evaluated to be 81.31.

3.4.1.3. System and service Design – The system and service design intervention in our research was the mobile app developed to embed the unorganized sector of street vendors and small scale vendor in the digital movement of the Government of India. In this intervention we have developed the frameworks and working of a mobile app that can give access to the unorganized retail sector in the e tail business. The small scale vendor without knowing the technical aspects of the app can very easily operate this app and sell their products. The patent for this technology is already granted to us. For collecting the SUS score data from the end users we have taken the print out of a power point presentation of the working of the app and asked them to fill the questionnaire of SUS score on the basis of their understanding. The SUS Score evaluated for the system and service design was 80.5. It is a very good SUS score and indicate high potential of acceptance.

The response of the end users/vendors for the SUS questionnaire were collected and tabulated to get the average score of 42 samples. It was found that the SUS value for Space design was 83.63 and that for product design was 81.31 and for system & service design was

80.5. All the results validated the end user satisfaction level, since their SUS scores were above 80.3. These scores Indicates exceptional improvement over the existing scenario and improvement in level of ease in the new proposed design interventions. Hence the proposed design interventions validated in terms of user experience.

3.4.2. Technology Validation - Utility Patent Grant

Three utility patents were filed for product design, system/service design and space design respectively. A patent is an exclusive right granted for an invention, which is a product or a process that provides, in general, a new way of doing something, or offers a new technical solution to a problem. Filing a patent and getting a grant of the patent is a very critical and thorough process. There are multiple steps involved in getting a Patent grant. To start with a detailed prior art search is to be done to understand the state of the Art of a given technology or the field of innovation in which our proposed innovation/technology is to be examined for novelty. All the patent data bases of the world are checked for similar technology/product with the help of key words for checking present state of the art, this process is very similar to literature review but in the current case it is done in the data base of patents. This helps in establishing the novelty component of the invention. Then thorough examination of the functionality of the product is done by a scientist and patent attorney. These examiners are A grade officers/ scientist who are appointed by the Government. In case any resemblance with existing technologies in the world is found in the new invention then clarification is demanded from the inventor it is called First Examination Report. Then the inventor needs to submit a detailed clarification with the help of a professional attorney. After review of the reply for First

Examination report another explanation /observation may be given by the patent examiner/ attorney for better understanding working/functionality and improvement over the existing technology. In the first step the Patent examiners try to establish the state of the art of the existing technology and then they check for novelty in the new invention. This process of examination and reply may repeat for few more times depending on the level of explanation submitted in the reply of First, second or Third Examination report. If the novelty is established in the replies and the examiner is convinced that the proposed technology is enhancing the efficacy of the existing technologies then it may be considered for grant of the patent. In case the Patent examiner is not satisfied with the reply then a hearing is conducted. In the hearing the inventor with the help of their patent attorney will explain the working of the technology and it will be supported by the test data, showing the working of actual product. The prototype/working model or full scale model may be helpful to convince the Patent Examiner. The examiners will check for feasibility and efficacy of the technology, the hearing may take from few minutes to multiple hours depending upon the complexity of the technology. After all these steps in very detailed and exhaustive way finally the patent is either granted or denied. Hence the working of the innovation can be considered validated in terms of functionality since it has been audited and inspected multiple times in the process by learned scientist and the field experts appointed by the Government. The appointment of these Patent Examiners is done by Government bodies through multiple level exams to ensure the quality of the examiners and depending on their performance they are graded and promoted.

The details of the patents accepted/ published and granted from the research output of this thesis are listed in the table of publication. Generally getting a grant in a utility patent takes

3 to 5 year time. The patents which are granted for the functionality and technology part of the invention is called utility patents in India and are called 'Patents' worldwide and where as patents for form, shape, colour and texture of any product is considered as design registration in India and is called design patents in many parts of the world. Out of the three utility patents two patent for product design and system/Service design were granted for our proposed technology from this thesis. Whereas, for the third utility patent the First Examination Report reply have been submitted to patent office and the Second Examination report is awaited. The grant of utility patent validates the conceptual feasibility and technology enhancement of the product. As per the University Grant Commission of India one utility patent grant is considered equivalent to two Science Citation Indexed journal paper publications and is considered as most prestigious in terms of research and development.

3.4.3. Form and Shape Validation of Products – Design Registration/Patent.

Similar to Utility patent, design registration or design patents also undergo same steps of evaluation. The only difference is that the time taken for design registration is less as compared to utility patents; it takes around a few months to a couple of years to get a design registration/patent.

We have filed three design registrations in Indian Patent Office for the various parts of the product design, i.e – Various forms of Vending cart with cold storage. All the three design registrations have been granted. The grant of deign registration validates that there is significant improvement in the formwork of existing vending cart. Apart from Design patent we have also conducted user study with the help of system usability scale for our products and

after analyzing the data collected from the users, it was concluded that there is significant improvement in the functionality and shape/form of the products designed.

3.5. Research Contribution

There are various stages of research already established in existing literature and these are very vast in nature. Hence to have a proper understanding each stage of research it is needed to be explored further in detail. During the course of this research a common patter was observed while conducting each stage of research. The breakup of these stages into further 4 steps and the combination of the stages of research and its 4 common steps in all stages formed a matrix. The said matrix was named as research introspection matrix and it is explained here under.

3.5.1. Research Introspection Matrix (RIM)

The different stages of research which is already well established and is also practiced in our research in the following sequence - Critical literature review, Identification of research gap, identification of objectives, selection of subject/sample/site, brainstorming, Design Intervention, user validation, expert validation, future prospectus/solutions . It is further to note that each stage of research can be further divided into four steps. First step is the current state of the art of that particular research stage which is already existing or the first step to begin with. The second stage is relevant data extraction followed by data analysis and the last step is final output of that particular research stage.

The tools and method adopted in each and every step and stages of research are marked in the research introspection matrix shown in Table 3.12. So we can use this matrix in each and every research only as per the requirement of the research the tools and method adopted will be changed in the matrix.

Table 3.12 – *Research introspection matrix*

Sl No.	Research Stages	Explore all possibilities to State of the Art	Relevant Data extraction	Analysis / research	Final output
1	**Critical Literature Review**	Keyword search in Journals, Books and Research Papers	listing of parameters of smart cities by different researchers	Literature review of individual smart city as case study	Successful Smart city is demographical and geographical requirement specific.
2	**Identification of research gap**	Demography of India	Pre user study	Card sorting technique	Research flow diagram, identification of Aim and objective
3	**Selection of subject/sample/site**	Approachable Smart cities opted by Govt	Objectives of smart city mission	Scenario planning	short listing of relevant sites in line with research gap.
4	**Identification of types design interventions**	Field survey	listing of issues	Issues identification and segregation Matrix	Product, Space, Service, System and policy design
5	**Brainstorming**	Group Discussions	listing of probable solutions	Story boarding	Primary Ideation
6	**Implementation of Design Intervention**	Prior Art Search	Drawbacks in prior art	SWOT analysis	Ideation Revision 1
7	**User validation**	Prototype	Questionnaire	System Usability scale	Ideation Revision 2
8	**Expert validation**	Submission for Utility patents and Design Patents	Constructive criticism	Multiple round of examination and cross questioning by A grade scientists followed by hearing with patent attorney	Grant of Utility patent and Design Patent validating the novelty in technology and form & shape of the final product.
9	**Future prospects/ Solutions**	All available technological Solutions	potential technology with user data mining tool	Linking with cloud for storage/ retrieval and processing of data	The product will produce solutions by its own in the form of artificial intelligence

After completion of every stage we can get the final output of that stage. This is further to state that each stage in itself is a complete set of research. That means if we did any of the stage of research mentioned in Sl. No. 1- 9 that too with all the steps from step one to the final output step then it can be said as a complete research work from state of the art to data collection to analysis of data to final output. Or any research can opt to go ahead with any number of stages of research following all the 4 steps of research as per their requirement. But each and every stage of research is a complete and exhaustive research in itself.

In this research introspection matrix the chronology of our research is recorded step by step. We started with the key word search in all the indexed journals and books. All the identified articles were analyzed for the relevant data. From the relevant Articles the list of smart city parameters were identified but these parameters were varying from city to city. So the literature review of specific smart city was analyzed. It was found that the cities which evolved along with the demography and as per the local context specific were more successful as compared to other smart cities. Hence to understand the local context first we need to understand the demography of the locality and then their location. From the literature review the demography of India was also identified and through pre user study with the help of card sorting technique the requirement of the end user was also identified. So from the end user requirement identification the research gap was narrowed down to unorganized retails and its importance in smart cities specifically in Indian context. Here the aim and objective of our research were identified.

For site selection a city from the smart city Mission of India was selected. We have studied the objective of smart city mission of India. From the earlier identified research gap,

aim and objective the after analyzing the nearest site was found to be Guwahati and in Guwahati few locations were identified which were having high relevance with respect to our aim and objective. These sites were Paltan bazar and Beltola Market. After identification of site field surveys were conducted, test walks were done site photographs were taken, satellite images were taken, personal interviews were conducted. All the issues stated by the people were listed. All the issues were segregated on the basis of type of stake holders and type of design intervention required to resolve the issue. This type of segregation has formed a matrix named Issue identification and categorization Matrix. From this matrix all the types of design intervention required were identified. Brainstorming session were conducted with a team of Design researchers and all the possible ideas were identified and recorded in the narrated stories. All the ideas identified were searched for prior art search i.e we searched for similar ideas in literature and patents filed all around the world. The existing prior arts were analyzed pro and cons with the help of various methods like SWOT analysis. After the analysis of the idea a design intervention was proposed. The proposed intervention was converted into a prototype and placed before end user for their feedback. The end user feedback was collected in a questionnaire. The questionnaire was examined with the help of statistical analysis or System Usability scale. The idea with significant improvement as per SUS scale over the previous conditions means that it is validated by the user for its usability component. The said idea was taken to next level of validation that is technical validation by the field experts and A grade scientists. A detailed scientific report is generated for the idea and is submitted to the patent attorney for examination. Multiple rounds of examinations are conducted by the A grade scientists, including cross questioning on each and every functionality component of the

intervention proposed and after a detailed hearing ad comparing with all the relevant patents the scientist team and the Patent attorney finals grants the Utility patent or Design patent. This procedure validates the technology, and form & shape of the intervention. At this stage we can say that we have a successfully tested and validated design intervention for mass implementation. The last step of research introspection matrix is the future prospects of the research. It is proposed for the future that all the identified tools and design interventions are to be linked with respective data mining tools so that we can keep a track of all the transactions of the design interventions and these data will help in prediction future problems and demands. On the basis of these demands future solutions can be proposed. The data mining and analysis part proposed will move in a cyclic process to attain a self sustaining and self resolving model of Artificial intelligence for the future.

3.5.2. Card Sorting as User Centered Town Planning Tool.

In this research one of the main out-come was the use of card sorting technique as a tool for data collection from large population /sample size, within limited time frame and at the same time it can be easily converted in to a tool for town planning. Hence it is a very useful tool for designing a user centered town plan.

3.6. Design Contribution

Since the entire research on smart city was conducted on a design intervention model hence it is important to understand what the design contribution of this research is. The design contribution of the research is framed with the help of two parameters, first one is the list of stake holders involved in the areas under study and the second one is the types of design

intervention required to cater the need of the stake holder identified. Hence the design contribution formulated is as under.

3.6.1. Issue Identification and Categorization Matrix (IICM).

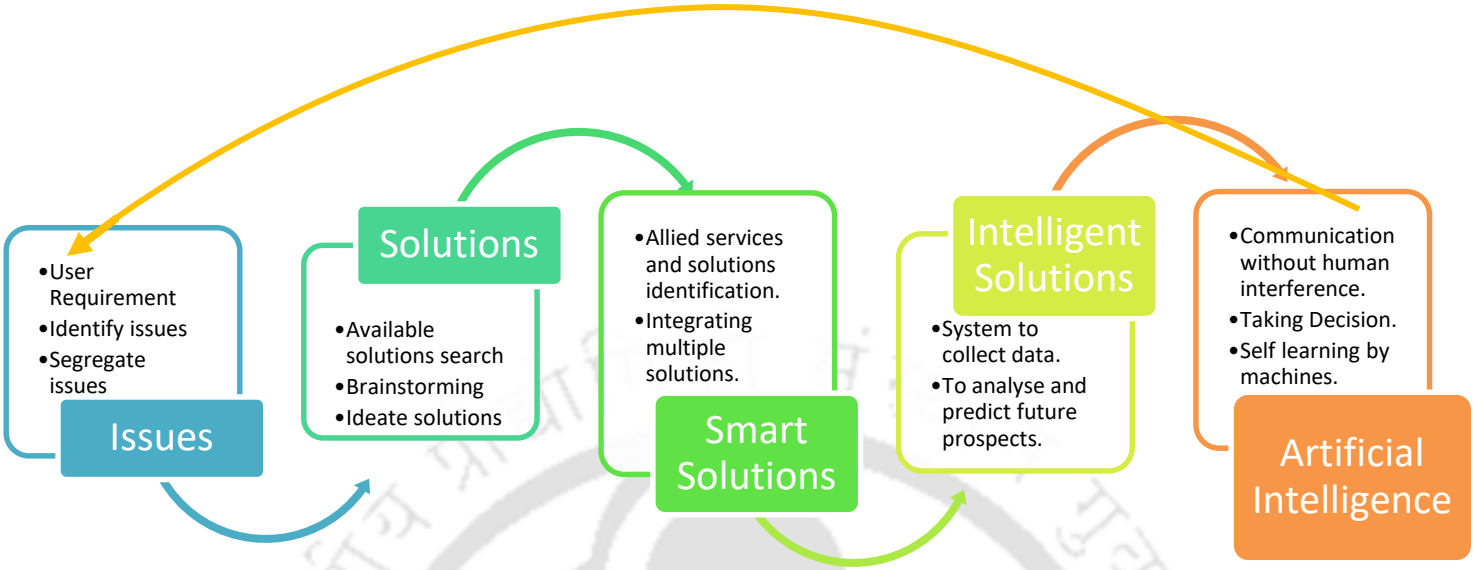
In this research we have formulated 5 types of design interventions for holistic development of any smart city.

Table 3.13 – Issue identification and categorization Matrix.

		Stake Holders			
		Vendors	**Customers**	**Commuters**	**Policy makers**
Design Intervention categories	**Product**	Lack of space for storage of unsold goods. Vegetable and fruits get damaged during transportation. No place to stay at night. Lack of portable drinking water. No covered shelter from sun or rain. No light facilities at dark hours	Poor visibility in selecting vegetables at late hours from road side vendors.	Vendors on streets expand their area as per requirement. Where as vendors with carts restrict themselves to limited space.	Tracing of registration and tax collection from vending carts are easier than from vendors without any cart and teams should be available throughout the day to check and collect taxes
	Space	Shortage of space for vending occupy footpath space for vending. Lack of toilet.	Shortage of parking space. Shortage of space for movement of vehicle. Toilets are not available No designated parking for rickshaw or mini public transport No place to sit and take rest. Unhygienic conditions – Shops are next to garbage bin The drain water is choked and smelling.	It is the main road connecting Beltola Tinali to GS road. Heavy traffic. Two wheelers are parked on the road causing hindrance for traffic. People are sitting on road edge for shopping and may get hit by vehicle. Other by pass are narrow and not suggestable for heavy traffic. Alternative routes are at long distance. Public transport like bus movement is less on this route. Only tracker or E rickshaw is available for passing.	Space and funding for basic amenities Numbers of vendors are high but space is limited. Weekly vendors population is very uncertain. No of vendors increasing day by day Heavy traffic. Parking space scarcity

		Stake Holders			
		Vendors	**Customers**	**Commuters**	**Policy makers**
Design Intervention categories	**Service**	Safety and security from youth club for chanda. leese. local goons on people staying at night. First Aid Centre is not available conducive environment for vending	Have to carry heavy baggage to long distance. Availability of products at door step. Tracing and tracking of transit vendors. Comparative rates of products in the market Online status of product availability in local market.	Traffic regulations Restrictions on unorganized parking Organized road side vending in allocated spaces	Basic amenities like toilet portable drinking water. Covered shelter. Shelter for overnight stay safety and security Conflict management Price control Citizen grievances Vendors grievances
	System	No space allotment mechanism. Disputes between daily and weekly vendors. Lack of monitoring on leesee by GMC Excessive tax collected by leese.ee Vendors grievance system	Portals with all product and vendors details online. Fresh products availability ensured on day to day basis. Customer grievance system	Market area should be isolated from traffic area.	Space allotment Mechanism Collection of taxes Registration for vendors Online portals for monitoring and services
	Policy	Relaxation in taxation Social security for the vendors Easy loan facilities Transit accommodation facility on nominal charges for overnight stays.		Identification of vending zones and heavy traffic zones	Funding and approvals from the Government for schemes formation of cooperative societies for grievance redressal of vendors, customers, commuters and communicate the issues to policy makers.

3.6.2. **Framework for Sustainable and Self Developing Smart Cities (FSSDSC) -** The process of developing smart city is a cyclic process, which need continuous improvement and hence for any city to be smart it need to keep on updating itself. A circular flow process is to be developed to have scope of continuous improvements.



Flowchart 3.2 - Framework for Sustainable and Self Developing Smart Cities

We have developed flowchart for easy understanding of the process. For making any town or city smart we can follow 5 very simple steps as shown in Flowchart 3.2, first we need to identify all the possible needs and issues of the city and its people. The identified issues/needs are segregated and categorized systematically for proposed design interventions.

The next step would be to identify all the possible solutions and with the help of brainstorming and various ideation tools of design studies the most effective solutions are identified and implemented. The next step would be to group all probable and effective solutions to make it an integrated smart solution. Making any solution a smart solution refers to solving multiple solutions with single product/idea/innovation/etc. This will help in preserving the resources and making the products more efficient.

For making the Smart solution an intelligent solution we need to embed the product/idea/innovation/etc with sensors and data collecting tools. These products will have two components one is the data collecting tool and the second one is data transfer or communicating tools. Once the product starts collecting data and transferring data then it is an integrated part ICT network. These data collections and analysis of data will help in predicting future needs/requirements of the people and the city. Hence we can say that these systems are now intelligent systems.

The transition of intelligent solutions to Artificial intelligence is the process when these systems not only collect and analyze data but also starts taking decisions for solving the issues and are itself solution finder of all the future problems. When these systems again and again move to the same steps to keep on identifying new problems/issues/need of the people and the city and keep on solving the identified issues and then again predict the future problem from the data collected. Then we can say that we have a future ready AI based Smart City. And to attain that level of Smartness in any city we need high level of innovation and design interventions.

This is not only the part of Town planners and Architects but Design studies, Computer science, IT Services, Electronics and communications, Civil Engg, Mechanical Engg, and all the possible modern fields of engineering and technologies are to be incorporated to make any city a robust Smart City.

Chapter 4

Conclusion, Limitations and Future Scope of Work

4.1 Conclusion

The steps followed in implementing all the sample design intervention have formulated a framework for future planning Smart Cities or any city with holistic approach. The said framework has also answered all the research questions identified during the research. The answers to the research questions are as under.

Research Question 1. How can we introspect the requirement of the local demography in a city, to understand their expectations from the cities they want to dwell in?

Answer RQ 1: **Card Sorting Technique -** There are multiple tools which help in collecting information from the city dwellers like, personal interviews, group discussions, questionnaire, feedback forms, etc. But all the data collection tools have their respective pros and cons. In case of data collection being done from large sample sizes it is very difficult to collect data from these tools. So we have designed a specific tool for collecting data for town planning which is both time saving and can be easily interpreted by the town planners. The tool is a modified version of card sorting techniques used in web page design. This tool is very interactive and can collect large amount of data from large sample sizes in very short time period. This tool is specifically designed for space management as per the requirement of the city dwellers. The card sorting technique can be easily converted into a simple mobile app and can collect data from any sample size in less than three minutes.

The data collected can be easily converted in to a mind map of majority of the population of the city and how they want their city to be plotted and accordingly city planning can be done.

Findings RQ 1: Space requirement of the city dwellers can be easily interpreted from the card sorting techniques adopted in this research. It is also to add that innovative data collection models are more efficient, hence to understand other requirements of the end users similar innovative data collection tools may be designed.

Conclusion RQ 1: Innovative and interactive data collection tools is designed so that more efficient data collection can be done and the risk of biased data collection due to loss of interest of the subject during data collection can be minimized.

Research Question 2: How can the requirement of the end users of Smart Cities are categorized into well-defined parameters for systematic resolution through design intervention for the holistic development of Smart Cities?

Answer RQ 2: Issue Identification and Categorization Matrix (IICM). First we have to identify all the requirements of the end users with the help of various data collection tools and then all the requirements are to be listed down. We can prioritize the requirements based on their weightage evaluated from the numbers of end users opting for any particular requirement. Then we can categorize the requirements on the basis of type of design intervention required to resolve the issue. This will help in resolving a group of issue with a single type of design intervention. Accordingly multiple groups can be assigned to work on different types of design interventions to resolve the issues simultaneously and effectively.

Findings RQ 2: A set of parameters have been identified to cater to all the facets of intervention required in a smart city. The design intervention parameters are listed below:

- Product Design Intervention
- Service Design Intervention
- System Design Intervention
- Space Design Intervention
- Policy Design Intervention

Conclusion RQ 2: By categorizing all the requirements and issues of the end users strategically, it is very easy to solve all the issues and requirement in a step by step and systematic way. This type of approach will help in having overall holistic approach in developing a town or city.

Research Question 3: How can a user-centric innovation management tool be developed that will help in designing/redeveloping any smart city?

Answers RQ 3: The user-centric innovation management tool formulated in this research is:

Framework for Sustainable and Self Developing Smart Cities (FSSDSC).

As discussed earlier there are multiple steps in this framework:

1. In first step innovative data collection tools are to be developed to collect large amount of data (demography, geography and local context specific) from large population in limited time in this research we have used card sorting technique. Then all the requirement and issues of the end users are identified and systematically categorized on the basis of type of design intervention needed to resolve the issue of the end users. In our research we have developed Issue Identification and Categorization Matrix (IICM).
2. In the second step the required design intervention is worked out with the help of brainstorming sessions and field expert opinions. In our research we have also conducted brain storming sessions with the field experts of design and specific ideas were also discussed with the senior officials of TATA Consulting Engineers (TCE) and NBCC (India) Ltd. TATA Consulting Engineers is a reputed consultancy firm worldwide they are working in the field of High speed rails and Smart city project of India. Whereas, NBCC (India) Ltd is a Navratna company (Central Public Sector

Enterprise) under Ministry of Housing and Urban Development, Government of India. NBCC (India) Ltd is working in numerous Smart city projects in India and abroad. The field specific ideas were discussed with Design office head of Jamshedpur of TCE, Vice president of Construction Business Unit of TCE and with some senior officials of NBCC (I) Ltd.

3. After having a set of design interventions which will resolve the identified issues, the ideas are to be clubbed together to develop smart products or smart technologies which can resolve multiple issues. All the ideas are to be validated in terms of technology, form/shape and user satisfaction. We have used Utility Patents, Design Patents/registrations for validating the technology feasibility and novelty aspect of the products through examination by field experts in the process. To measure user satisfaction we have conducted system usability scale analysis.
4. The Smart solutions are to be linked with data collecting tools, in our research we have developed a mobile app framework also which will collect data from the small scale vendors and customers these data will be used to predict future requirements of the end users. Hence these type of data collection tool are to be embedded in all aspects of the smart cities for advance projections of the requirements and accordingly being prepared for the same.
5. The last stage is Artificial Intelligence – In this stage the Smart city will interact with the end users directly and from huge amount of data collected it will keep on projecting the future requirements of the city. Once any issue is projected and it is resolved with the interventions of human then the Smart City which is embedded

with sensors, technology and data collecting tool will store the data and next time will try to resolve without the interaction of the humans. This process will keep on running in cyclic loop and every time the city is stuck it will learn from the human's interventions for solving the issue. This framework can be implemented in designing of successful intelligent and Smart Cities.

A small example is – Suppose an elderly is living alone and he got a heart attack in his backyard which is under CCTV coverage. The system will automatically detect that this is not a normal position for that person and after proper analysis will raise a distress alarm for help from neighbor or nearest Hospital. This type of research is already going on in Singapore, it may have its pro and cons but will definitely will improve the quality of life, safety and security of the people.

Research Introspection Matrix (RIM) – The above mentioned frame work were the milestones from issue identification to Artificial Intelligence, where as the Research Introspection Matrix is the detailed step by step procedure for any type of research in which final output with implementation is to be ensured. Hence RIM is a very significant tool for all the researches. The most important part of this tool is that even if we do a single stage of the RIM with all the 4 steps then that itself is a complete research. Hence RIM is very systematic and exhaustive research tool.

Findings RQ 3: In our data collection exercise we have used card sorting technique for collecting space management planning of the city followed by personal interviews, Group discussions and

literature review of Guwahati city. After data collection all the end user requirements were systematically categorized and design intervention in each of the category was implemented. In this way we have done a sample intervention in every category to understand the procedure completely. These interventions were then validated with different tools like prototyping, user validation - system usability scale, articles published in peer reviewed publication houses and filing /grant of Patents. In this way a comprehensive user-centric innovation management tool was developed.

Conclusion RQ 3: For designing a successful smart city, innovation is to be implemented in each and every step of town planning starting from data collection, data interpretation, ideation, validation of the intervention and finally full scale implementation.

Hence we can state that in this research we have developed a strategic design management model for designing user – centered Smart Cities. The aim of this research is accomplished and all the objectives identified in the research are fulfilled.

4.2 Limitations

The limitations of our research are that our research was conducted in a single smart city. In this research, we have tried that the issues identified by the end users are addressed but for the users of a limited area. Since the data collection was done manually and in a single city, the sample size was limited.

4.3 Future Scope of Work

It has a huge future scope since the Government can launch data collection tools in the mobile app and collect the data from a very large number of end users for more accurate predictions for demand of the population. This will be very helpful in framing the Government policies and reducing the gap between supply and demand of agricultural goods or any other services.

Publications and Intellectual Property rights:

Table 4.1 - *Utility Patents and Design Patents/Registration from the thesis*

Sl. No	Application No/Patent No.	Title	Status	Type of Intervention
1	**201931010190**	A system to utilize a hybrid renewable source of energy obtained from roadways to generate electricity	Filed and published on 10/05/2019, FER reply submitted on12/04/2021	Space Design intervention
2	**202031007118**	Design and working of a tricycle-based vending cart consisting of a convertible refrigeration unit	**Granted**	Product Design intervention
3	**202031007121**	A vending cart with digitization to automate the working and controlling of the billing facility	**Granted**	Service and System Design Intervention
4	**330928-001**	Non-powered portable compact cold storage unit	**Granted**	Product Design intervention
5	**330933-001**	Portable vending cart	**Granted**	
6	**330952-001**	Convertible tent-mounted tricycle cart	**Granted**	

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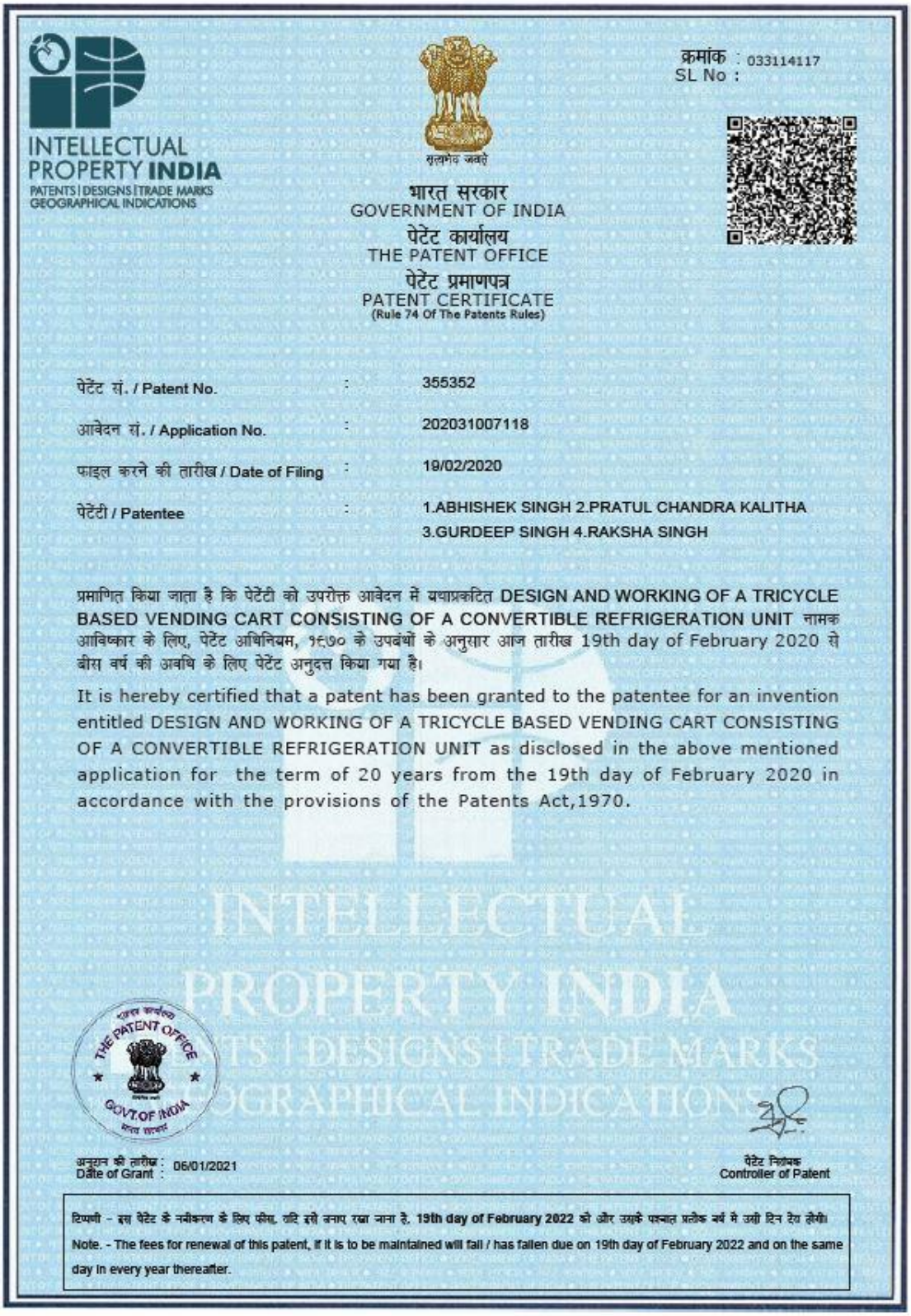
GOVERNMENT OF INDIA

Controller General of Patents,Designs and Trademarks
Department of Industrial Policy and Promotion
Ministry of Commerce and Industry

Application Details	
APPLICATION NUMBER	201931010190
APPLICATION TYPE	ORDINARY APPLICATION
DATE OF FILING	15/03/2019
APPLICANT NAME	1 . ABHISHEK SINGH 2 . GURDEEP SINGH
TITLE OF INVENTION	A SYSTEM TO UTILIZE HYBRID RENEWABLE SOURCE OF ENERGY OBTAINED FROM ROADWAYS TO GENERATE ELECTRICITY
FIELD OF INVENTION	MECHANICAL ENGINEERING
E-MAIL (As Per Record)	
ADDITIONAL-EMAIL (As Per Record)	deeabhi@gmail.com
E-MAIL (UPDATED Online)	
PRIORITY DATE	NA
REQUEST FOR EXAMINATION DATE	15/03/2019
PUBLICATION DATE (U/S 11A)	10/05/2019

Figure 4.1 – Patent for space design



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क्रमांक : 033114117
SL No :

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THE PATENT OFFICE

पेटेंट प्रमाणपत्र
PATENT CERTIFICATE
(Rule 74 Of The Patents Rules)

पेटेंट सं. / Patent No.	:	355352
आवेदन सं. / Application No.	:	202031007118
फाइल करने की तारीख / Date of Filing	:	19/02/2020
पेटेंटी / Patentee	:	1.ABHISHEK SINGH 2.PRATUL CHANDRA KALITHA 3.GURDEEP SINGH 4.RAKSHA SINGH

प्रमाणित किया जाता है कि पेटेंटी को उपरोक्त आवेदन में यथाप्रकटित DESIGN AND WORKING OF A TRICYCLE BASED VENDING CART CONSISTING OF A CONVERTIBLE REFRIGERATION UNIT नामक आविष्कार के लिए, पेटेंट अधिनिबम, १९७० के उपबंधों के अनुसार आज तारीख 19th day of February 2020 से बीस वर्ष की अवधि के लिए पेटेंट अनुदत्त किया गया है।

It is hereby certified that a patent has been granted to the patentee for an invention entitled DESIGN AND WORKING OF A TRICYCLE BASED VENDING CART CONSISTING OF A CONVERTIBLE REFRIGERATION UNIT as disclosed in the above mentioned application for the term of 20 years from the 19th day of February 2020 in accordance with the provisions of the Patents Act,1970.

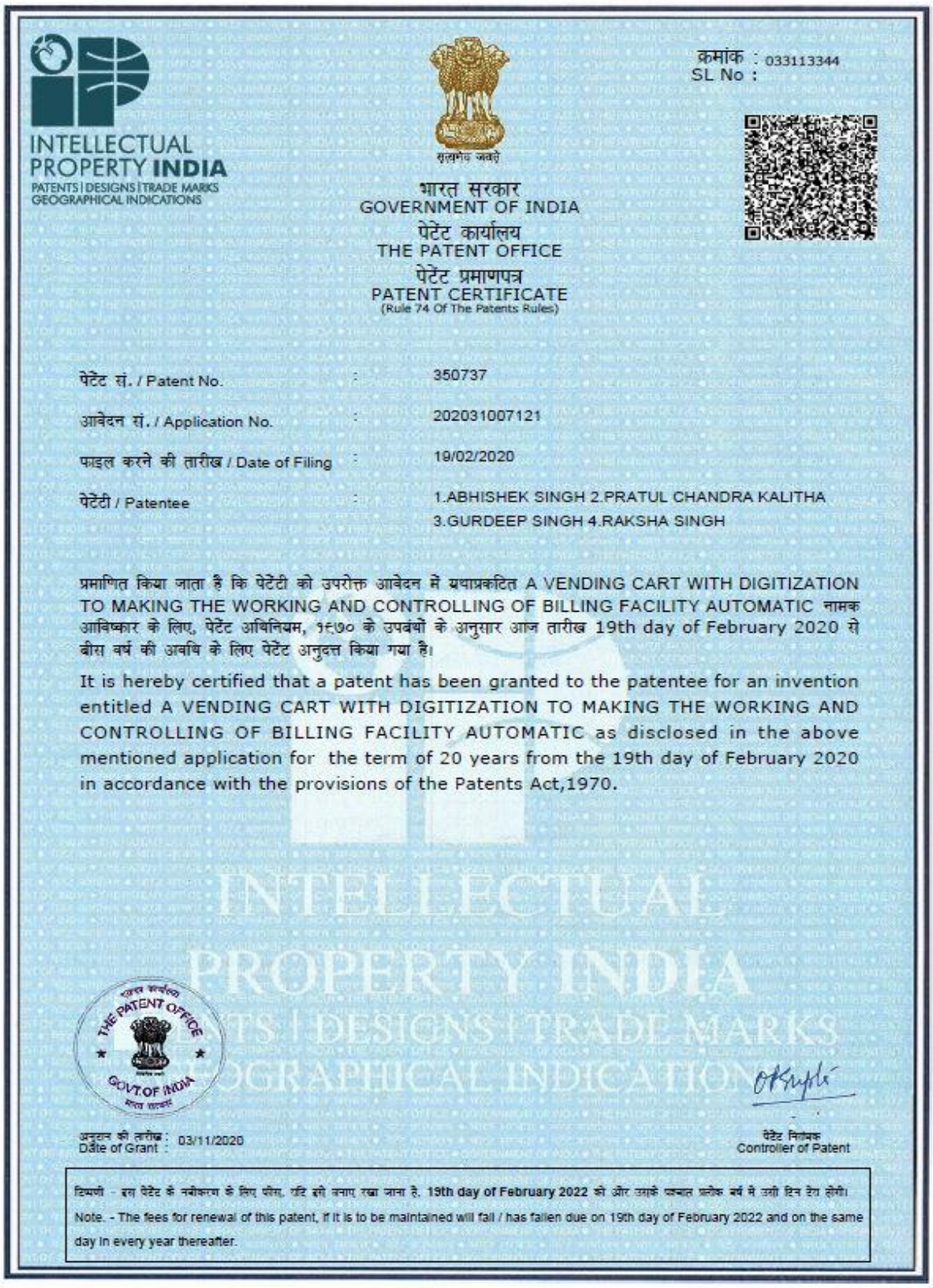
THE PATENT OFFICE GOVT.OF INDIA

अनुदान की तारीख : 06/01/2021
Date of Grant :

पेटेंट नियंत्रक
Controller of Patent

टिप्पणी - इस पेटेंट के नवीकरण के लिए फीस, यदि इसे बनाए रखा जाना है, 19th day of February 2022 को और उसके पश्चात प्रत्येक वर्ष में उसी दिन देय होगी।
Note. - The fees for renewal of this patent, if it is to be maintained will fall / has fallen due on 19th day of February 2022 and on the same day in every year thereafter.

Figure 4.2 – Patent for product design



क्रमांक : 033113344
SL No :

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THE PATENT OFFICE
पेटेंट प्रमाणपत्र
PATENT CERTIFICATE
(Rule 74 Of The Patents Rules)

पेटेंट सं. / Patent No.	:	350737
आवेदन सं. / Application No.	:	202031007121
फाइल करने की तारीख / Date of Filing	:	19/02/2020
पेटेंटी / Patentee	:	1.ABHISHEK SINGH 2.PRATUL CHANDRA KALITHA 3.GURDEEP SINGH 4.RAKSHA SINGH

प्रमाणित किया जाता है कि पेटेंटी को उपरोक्त आवेदन में यथाप्रकटित A VENDING CART WITH DIGITIZATION TO MAKING THE WORKING AND CONTROLLING OF BILLING FACILITY AUTOMATIC नामक आविष्कार के लिए, पेटेंट अधिनियम, १९७० के उपबंधों के अनुसार आज तारीख 19th day of February 2020 से बीस वर्ष की अवधि के लिए पेटेंट अनुदत्त किया गया है।

It is hereby certified that a patent has been granted to the patentee for an invention entitled A VENDING CART WITH DIGITIZATION TO MAKING THE WORKING AND CONTROLLING OF BILLING FACILITY AUTOMATIC as disclosed in the above mentioned application for the term of 20 years from the 19th day of February 2020 in accordance with the provisions of the Patents Act,1970.

THE PATENT OFFICE GOVT.OF INDIA

अनुदान की तारीख : 03/11/2020
Date of Grant :

पेटेंट नियंत्रक
Controller of Patent

टिप्पणी - इस पेटेंट के नवीकरण के लिए फीस, यदि इसे बनाए रखा जाना है, 19th day of February 2022 को और उसके पश्चात प्रत्येक वर्ष में उसी दिन देय होगी।
Note. - The fees for renewal of this patent, if it is to be maintained will fall / has fallen due on 19th day of February 2022 and on the same day in every year thereafter.

Figure 4.3 – Patent for service and system design

ORIGINAL

No. 90655

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GOVERNMENT OF INDIA
पेटेंट कार्यालय
THE PATENT OFFICE

CERTIFICATE OF REGISTRATION OF DESIGN

Design No.	330928-001
Date	09/07/2020 23:22:59
Reciprocity Date*	
Country	

Certified that the design of which a copy is annexed hereto has been registered as of the number and date given above in class 12-99 in respect of the application of such design to NON-POWERED PORTABLE COMPACT COLD STORAGE UNIT in the name of 1.ABHISHEK SINGH, DEPARTMENT OF DESIGN, IIT GUWAHATI - 781039 2. DR. PRATUL CHANDRA KALITA, ASSOCIATE PROFESSOR, DEPARTMENT OF DESIGN, IIT GUWAHATI 3. GURDEEP SINGH, DEPARTMENT OF DESIGN, IIT GUWAHATI, ASSAM 4. RAKSHA SINGH, OLD MSH 28, IIT GUWAHATI CAMPUS

in pursuance of and subject to the provisions of the Designs Act, 2000 and the Designs Rules, 2001.

Controller General of Patents, Designs and Trade Marks

*The reciprocity date (if any) which has been allowed and the name of the country.
Copyright in the design will subsist for ten years from the date of Registration, and may underthe terms of the Act and Rules, be extended for a further period of five years.
This Certificate is not for use in legal proceedings or for obtaining registration abroad

MR. GURDEEP SINGH,
NEW MARRIED SCHOLAR QUARTER NO. 307, IIT
GUWAHATI CAMPUS, DISTT: KAMRUP, ASSAM,
PIN: 781039

Date of Issue 26/08/2020 16:42:46

Figure 4.4 – Design Patent/Registration for Non Powered Portable compact cold storage

ORIGINAL

No. 97197

भारत सरकार
GOVERNMENT OF INDIA
पेटेंट कार्यालय
THE PATENT OFFICE

CERTIFICATE OF REGISTRATION OF DESIGN

Design No.	330933-001
Date	10/07/2020
Reciprocity Date*	00:00:00
Country	

Certified that the design of which a copy is annexed hereto has been registered as of the number and date given above in class 12-02 in respect of the application of such design to PORTABLE VENDING CART in the name of 1.ABHISHEK SINGH, DEPARTMENT OF DESIGN, IIT GUWAHATI 2. PRATUL CHANDRA KALITA, DEPARTMENT OF DESIGN, IIT GUWAHATI 3. GURDEEP SINGH, DEPARTMENT OF DESIGN, IIT GUWAHATI 4. RAKSHA SINGH, H NO 28, OLD MARRIED SCHOLAR HOSTEL, IIT GUWAHATI

in pursuance of and subject to the provisions of the Designs Act, 2000 and the Designs Rules, 2001.

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Copyright in the design will subsist for ten years from the date of Registration, and may underthe terms of the Act and Rules, be extended for a further period of five years.
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ABHISHEK SINGH,
H. NO - 28, MARRIED SCHOLAR QUARTERS IIT
GUWAHATI.

Date of Issue 07/04/2021 16:19:01
NF

Figure 4.5 – Design Patent/Registration for Portable vending cart

ORIGINAL

No. 106402

सत्यमेव जयते

भारत सरकार

GOVERNMENT OF INDIA

पेटेंट कार्यालय

THE PATENT OFFICE

CERTIFICATE OF REGISTRATION OF DESIGN

Design No. 330952-001
Date 10/07/2020
Reciprocity Date*
Country

Certified that the design of which a copy is annexed hereto has been registered as of the number and date given above in class 12-02 in respect of the application of such design to CONVERTIBLE TENT CUM VENDING CART in the name of 1.ABHISHEK SINGH, DEPARTMENT OF DESIGN, IIT GUWAHATI, ASSAM 2. DR. PRATUL CHANDRA KALITA, DEPARTMENT OF DESIGN, IIT GUWAHATI, ASSAM 3. GURDEEP SINGH, DEPARTMENT OF DESIGN, IIT GUWAHATI, ASSAM 4. RAKSHA SINGH, HOUSE NO 28, MARRIED SCHOLAR QUARTERS, IIT GUWAHATI

in pursuance of and subject to the provisions of the Designs Act, 2000 and the Designs Rules, 2001.

Controller General of Patents, Designs and Trade Marks

*The reciprocity date (if any) which has been allowed and the name of the country.
Copyright in the design will subsist for ten years from the date of Registration, and may underthe terms of the Act and Rules, be extended for a further period of five years.
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ABHISHEK SINGH,
HOUSE NO- 28, MARRIED SCHOLAR QUARTERS IIT GUWAHATI

Date of Issue 22/12/2021 16:22:29

Figure 4.6 – Design Patent/Registration for Convertible Tent cum vending cart

Patents:

1. **Design and working of a tricycle based Vending Cart consisting of a convertible refrigeration unit. [Granted]**
   Patent Number: 355352, Granted on 06th January, 2021
   Members: Mr. Abhishek Singh, Dr. Pratul Chandra Kalita, Mrs. Raksha Singh and Mr. Gurdeep Singh

2. **A Vending Cart with digitization to make the working and controlling of billing facility automatic. [Granted]**
   Patent Number: 350737, Granted on 03rdNovember, 2020
   Members: Mr. Abhishek Singh, Dr. Pratul Chandra Kalita, Mrs. Raksha Singh and Mr. Gurdeep Singh

3. **Integrating pedestrian, rail, and road mobility for renewable energy generation :: A system approach [FER Reply Filed]**
   Application Number: 201931010190, filed on 15th March, 2019
   Members: Mr. Abhishek Singh and Mr. Gurdeep Singh

4. **Hand-held apparatus for extracting contents of sachet / pouch. [US Patent, Granted]**
   US Patent Number: 11319103, Granted on 03rd May, 2022
   Members: Mr. Gurdeep Singh, Dr. Sougata Karmakar, Mr. Abhishek Singh, Mr. Amandeep Verma, Mrs. Sangeeta Bhanja Chaudhuri

5. **Sachet / pouch cutting and squeezing apparatus. [Granted]**
   Patent Number: 415999, Granted on 29th December, 2022
   Members: Mr. Gurdeep Singh, Dr. Sougata Karmakar, Mr. Abhishek Singh

6. **Design of safety-enriched standing-position oriented mechanized apparatus for damaged pouch and sachet cutting for re-work in FMCG industries. [Granted]**
   Patent Number: 364959, Granted on 20th April, 2021
   Members: Mr. Gurdeep Singh, Dr. Sougata Karmakar, Mr. Abhishek Singh, Mr. Amandeep Verma, Mrs. Sangeeta Bhanja Chaudhuri

7. **Design of safety-enriched sitting-position oriented hand-held apparatus for damaged pouch and sachet cutting for re-work in FMCG industries. [Granted]**
   Patent Number: 355504, Granted on 08th January, 2021
   Members: Mr. Gurdeep Singh , Dr. Sougata Karmakar, Mr. Abhishek Singh, Mr. Amandeep Verma, Mrs. Sangeeta Bhanja Chaudhuri

8. **Sachet/ pouch cutting and squeezing apparatus. [Australian Standard Patent, Under Examination]**
   Application Number: 2022238038, Filed on 04th May, 2023
   Members: Mr. Gurdeep Singh, Dr. Sougata Karmakar, Mr. Abhishek Singh

9. **Sachet/ pouch cutting and squeezing apparatus. [US Patent, Under Examination]**
   Application Number: 18/020,030, Filed on 06th February, 2023
   Members: Mr. Gurdeep Singh, Dr. Sougata Karmakar, Mr. Abhishek Singh

10. **Sachet/ pouch cutting and squeezing apparatus. [PCT Application, Published]**
    Application Number: PCT/IB2022/056316, Filed on 08th July, 2022
    Publication Number: WO/2022/195572, Published on 22nd September, 2022
    Members: Mr. Gurdeep Singh, Dr. Sougata Karmakar, Mr. Abhishek Singh

Design Registration:

1. **Vending Cart cum Tent. [Granted]**
   Design Registration Number: 330952-001, Class: 12-02, Granted on 10th July, 2020
   Members: Mr. Abhishek Singh, Dr. Pratul Chandra Kalita, Mrs. Raksha Singh and Mr. Gurdeep Singh

2. **Portable Vending Cart. [Granted]**
   Design Registration Number: 330933-001, Class: 12-02, Granted on 10th July, 2020
   Members: Mr. Abhishek Singh, Dr. Pratul Chandra Kalita, Mrs. Raksha Singh and Mr. Gurdeep Singh

3. **Non-powered Portable Compact Cold Storage Unit. [Granted]**
   Design Registration Number: 330928-001, Class: 12-99, Granted on 09th July, 2020
   Members: Mr. Abhishek Singh, Dr. Pratul Chandra Kalita, Mrs. Raksha Singh and Mr. Gurdeep Singh

4. **Cutting and Squeezing Apparatus for Defective Pouch/ Sachet Rework. [Granted]**
   Design Registration Number: 360578-001, Class: 08-03, Granted on 14th March, 2022
   Members: Mr. Gurdeep Singh , Dr. Sougata Karmakar, Mr. Abhishek Singh

5. **Educational Board Game (Set) for kids. [Granted]**
   Design Registration Number: 330913-001, Class: 21-01, Granted on 09th July, 2020
   Members: Mr. Gurdeep Singh, Dr. Nandita Bhanja Chaudhuri, Mrs. Sangeeta Bhanja Chaudhuri, Mr. Abhishek Singh

6. **Ergonomic Sachet Cutting Apparatus for FMCG Re-work. [Granted]**
   Design Registration Number: 329290-001, Class: 08-03, Granted on 12th May, 2020
   Members: Mr. Gurdeep Singh, Dr. Sougata Karmakar, Mr. Amandeep Verma, Mr. Abhishek Singh

7. **Mechanized Pouch Cutter for FMCG Re-work. [Granted]**
   Design Registration Number: 329288-001, Class: 08-03, Granted on 12th May, 2020
   Members: Mr. Gurdeep Singh, Dr. Sougata Karmakar, Mr. Amandeep Verma, Mr. Abhishek Singh

Projects:

1. **Development of hand-held apparatus for pouch and sachet cutting for re-work in Fast Moving Consumer Goods (FMCG) industries. [Completed]**
   Agency: NewGen IEDC; Amount: 2.5 Lakhs
   Members: Mr. Gurdeep Singh, Dr. Sougata Karmakar, Mr. Abhishek Singh

Research Papers:

1. Singh, A., Kalita, P.C. (2021). A Tool to Design a User-Centred Town Plan. In: Chakrabarti, A., Poovaiah, R., Bokil, P., Kant, V. (eds) Design for Tomorrow—Volume 2. Smart Innovation, Systems and Technologies, vol 222. Springer, Singapore. https://doi.org/10.1007/978-981-16-0119-4_10

2. Singh, A., & Kalita, P. C. (2022). Hybrid Infrastructure for Effective Sustainable Growth: Theory, Practice and Policy (ICID-2021). In Infrastructure Development–Theory, Practice and Policy: Sustainability and Resilience, (pp. 77-87). Routledge – (Taylor and Francis)

3. Singh, A., Kalita, P.C., Singh, R. (2022). Sustainability a Tool for Employment Opportunities. In: Chakrabarti, D., Karmakar, S., Salve, U.R. (eds) Ergonomics for Design and Innovation. HWWE 2021. Lecture Notes in Networks and Systems, vol 391. Springer, Cham. https://doi.org/10.1007/978-3-030-94277-9_109

4. Singh, A., Kalita, P.C., Singh, G., Singh, R. (2022). Digitizing the Street Vending Market. In: Chakrabarti, D., Karmakar, S., Salve, U.R. (eds) Ergonomics for Design and Innovation. HWWE 2021. Lecture Notes in Networks and Systems, vol 391. Springer, Cham. https://doi.org/10.1007/978-3-030-94277-9_58

5. Singh, A., Kalita, P.C., Singh, G., Singh, R. (2022). Multipurpose, Low-Cost and Electricity-Free Cold Storage Cum Vending Cart for Vegetable and Fruit Vendors. In: Chakrabarti, D., Karmakar, S., Salve, U.R. (eds) Ergonomics for Design and Innovation. HWWE 2021. Lecture

Notes in Networks and Systems, vol 391. Springer, Cham. https://doi.org/10.1007/978-3-030-94277-9_54

6. Singh, A., Kalita, P. C., & Singh, G. (2023, September). Construction quality analysis and index. In AIP Conference Proceedings (Vol. 2888, No. 1). AIP Publishing. https://doi.org/10.1063/5.0164431

Figure 4.6 – Best paper award for Space Design.

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URL doi:10.1007/978-3-030-60922-1_11.

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