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Mumbai: A Vision of Smart City for Sustainable Development and Citizen Friendly

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Abstract: ***Mumbai being the largest city of India, capital of Maharashtra and one of the most populous cities in the world with current estimated population of about 12.4 million it is the world's 37th largest city by Gross Domestic Product (GDP). As of 2019, recent estimates of the economy of the Mumbai Metropolitan Region have ranged from 3.16 lakh crore (US$44 billion) (2019–20 est.) 4.04 lakh crore (US$57 billion) (2019–20 est.) ranking it either the most or second-most productive metro area of India. In the year 2015, a government led by Bharatiya Janta Party (BJP) launched a program called "Smart City Mission" in the country to develop 100 smart cities for urban renewal and redevelopment of older system by adding the flavour of new technologies. In the recent budget speech of the Finance Minister in February 2020, the move to set up 5 new smart cities has been proposed which will be developed under the public private partnership (PPP) mode. The main focus to develop smart city is to provide with high end infrastructure, excellent services and access to these services is governed based on connectivity at different levels between the administration and the end user. In context to the Smart Cities Mission, the objective is to bring up the best cities from the country by competing them with each other based on the core infrastructure, standard quality of life to its citizens, a clean sustainable environment and application of 'Smart Solutions'. The research article is the study on Mumbai as an aspiration to become a smart city by focusing on number of aspects of smart cities: smart mobility, smart living, smart healthcare, smart environment, smart citizens, smart government, and smart architecture as well as related technologies and concepts. The Internet of Things plays a major role as building block for transforming cities into smart cities by improving quality, performance and interactivity of urban services, optimize resources and reduce costs.***

Keywords: Smart City, Sustainable Development, Citizen friendly, Information and Communication Technology (ICT), Internet of Things (IoT)

I. INTRODUCTION

Mumbai on its way back till now is constantly evolving and engaged globally for over the past 150 years. With the growing population of Mumbai and the financial capital of India, people from diverse geographical areas come in for various opportunities and the city increasingly takes on the burden of that growth. It is therefore important to focus on areas like air and water pollution control, sewage disposal, maintenance and management system which includes e-governance, internet-based solutions for citizens and also using construction material that is 'eco-friendly' which should not create ecological imbalance. The smart city concept for Mumbai suits well in terms of urban planning that incorporates the advances in digital technology. So what do we mean by 'Smart City'. As the name suggests, a smart city makes use of smart devices - basically an electronic device connected to other device or network and solutions to enhance the quality of life and create a sustainable environment. A city that is connected by the internet has cameras and sensors set up and makes optimal use of gathering real time data based on demand, supply and usage of the resources. Along with the basics of water, sanitation, and electricity supply, a smart city would be required to work on mobility and powerful internet connection. Mumbai with a vision and mission to enhance the quality of living, characterized by institutional, physical, social and economic infrastructure with the use of digital technologies needs governance through the application of Information and Communication Technology (ICT). Encouraged by the success of our neighbouring state Gujarat's smart city Dholera we can gain investors from some of the major players like WIPRO, IBM and CISCO to combine their technologies for operational efficiency in governance to address cities needs under public private partnership mode.

II. LITERATURE REVIEW

A. An Overview Of The Smart Cities Mission In India

There are diverse aspects of the smart city in which various researches have been conducted. Smart Cities Mission was launched by the newly elected federal Government of India (GoI) in 2015, with the stated purpose of improving the governance and infrastructural deficiencies that plague Indian cities. The Smart Cities Mission currently stands at INR 203314.6 crore (over INR 2000 Billion) and consists of 99 cities across 28 states and 7 union territories in the country. It was said that there is no one such definition for 'smart city' therefore it implies liberty for cities to self-define their understanding of 'smartness'.

Smart Cities Mission of the Government is very bold new initiative. In order, to have a clear understanding of the mission, the researchers utilized government documentation from the 99 cities to answer one question – What constitutes a smart city in India? Among these 99 cities listed as smart city Mumbai was not on the list as Mumbai's Brihanmumbai Municipal Corporation (BMC) decided not to be part of the NDA government's flagship mission of making the city a Smart City. A city is said to be smart city when it becomes a problem solving and building solutions to its people by improving the level of living measured by providing a healthy environment to all, good educational facilities where various educational institute have a perfect network to synchronize their online learning courses, roads, highways and other metro facilities to be affordable, accessible and environmentally friendly. For healthcare special care should be taken to connect immediately with hospitals and actively manage and respond to medical ecosystem. A smart city is considered to focus on two major trends mainly on integration of networks as a collection of sensors, smart devices, and to process them on real time big data like Hadoop and Spark with ICT related to human being and the other was a new paradigm in urban planning polices related to governance and the economy. Authors have described "smart city" as planned city which will carry each activity in a supervised and controlled manner (Prof. Rahul Wantmure and Dr. Murlidhar Dhanawade (2016)). In reference to large volume of urban data with respect to its size it is been described as how the growth of large volumes of data is shifting the emphasis from strategic long-term planning to short-term thinking how cities function and can be administered (Michael Batty (2013)).

B. ICT in Smart City

A smart city becomes smarter when it gains information and knowledge from the environment by sharing the data over a network of integrating technologies, system services and capabilities for sufficiently multi-sectarian and flexible future development which has an open access. In our real world we humans at times generate wrong results or data due to miscommunication or loss of data which might have severe impact on any ongoing process. Similarly, when we talk about digital technology in use of ICT the data plays a vital role on any decision making process. Hence, we can say that ICT is the foundation for promoting new forms of technology. Also, the data generated by ICT are used in data analytics in various urban fields and the IoT through data mining techniques, analyzed and utilized by data analytics such as machine learning and deep learning which makes the devices to learn from mistakes, analyze and take decisions leading to a complete smart city. Big Data with ICT will act as a part of moving smart cities, to improve the living conditions for citizens. The process and results of ICT can be reflected throughout the entire city and used to predict urban challenges. The author quotes ICT as a real-time behaviour where human and activities can be determined through personal devices such as smart phones, wearable computing devices, intelligent home and intelligent city called as Human Dynamics Yashaswini K and Janhavi .V (2016).

C. Smart Governance, Smart City

Smart governance is one of the core components in the race of smart city because it promotes interaction between people, policies, information and technologies. Since ICT alone cannot make a transformation into smart cities, the importance of governance to manage projects plays an important role. The Brihanmumbai Municipal Corporation (BMC) has adopted e-governance to manage its ever-increasing workload and provide hassle-free civic administration. It came up with some few key attributes to define it as SMART (Simple, Mobile, Attitude, Responsive, and Transparent). In accordance to the creation of smart governance, participation and cooperation of private technologies is considered as important as different stakeholders are involved in the development of the smart city. With the BMC going on e-governance model, the citizens would be able to suggest opinions or express complaints about government policies through various communication channels such as Internet, software applications on smart phones and different levels of support systems. Different business companies are willing to acquire new policies and information in line with the government's policies and can contribute to the government policies through analysis of real-time data and technology development. The authors emphasize that smart city governance should not be a technical issue, but studied from a social, political and institutional point of view (Nicola Ianualeetal (2015)).

III. METHODOLOGY

Mumbai is witnessing a rapid pace of urbanization, which is expected to continue in the coming decades. According to recent studies of Mumbai:

1) 200 people migrate everyday to in search of livelihood.
2) By 2030, the population of Mumbai will be 27 million.
3) 70% of net new employment will be generated in cities.

Mumbai with a diverse range of population struggles with a number of significant barriers that continue to hamper the development of urban infrastructure: complex political factors, land area challenges, capability gaps, and funding shortfalls are all part of the urban challenge that is effectively holding Mumbai back from a new growth of city. Mumbai also needs to address the current problems of developing good infrastructure with separate areas of commercial and residential purposes, solid waste disposal, water logging issues, storm water and sewerage system etc. resulting in urban rot, traffic congestion and therefore worsen the quality of life for many of its citizens. Mumbai can be among the list of those top 100 smart cities of India by utilizing smart cities experience and technology accessible around the world.

Sampling method is used to conduct survey to understand area-wise demographics of Mumbai as a smart city and secondary methodology is used to understand the Smart City Maturity Model.

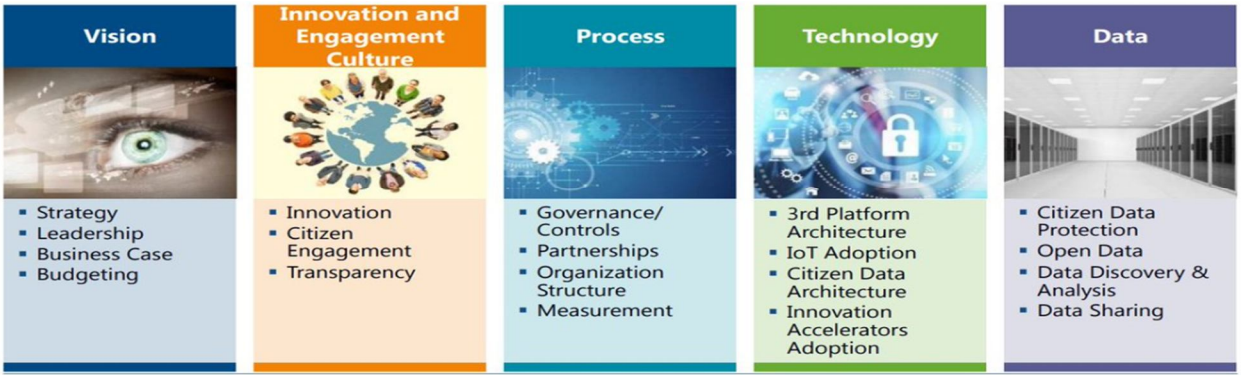

Figure 3A Smart City Maturity Model

A. Smart City Maturity Model

1) *Vision:* Mumbai being one of the densely populated, financial and largest city of India needs to have a vision towards its future growth to meet basic requirement and safety of its growing population. A strategy and roadmap needs to be planned on how to invest in data and digital technologies which enables service reform and partner collaboration. Public Private Partnership modes are important for bringing in capital to urban infrastructure and private sector efficiencies.
2) *Innovation and Engagement Culture:* Development of Mumbai as smart city can be achieved with a combination of e-government and innovative studies connected to urban governance. Use of innovative technology in city can help government to form central hub which can have high speed connection with the entire city 24x7. Today, Mumbai is community driven way where bottom-up approach needs to be followed and consider citizens as an integral part of designing and developing smart cities.
3) *Process:* Mumbai's Smart city development project will require investments and fast track progress work which can be achieved through Public-Private-Partnerships (PPP) modes by following two stage bidding process.
4) *Technology:* Implementation of technology should be open, flexible, integrated and scalable with ICT architectures which accelerate the service such as provision of automated and real-time dynamic response capabilities.
5) *Data:* Data act as heart in smart driven city which is technologically efficient to use these data assets to secure better outcomes. The data is collected form IoT devices so that further analysis can be made to recognize the patterns and needs of the city.

IV. STRATEGIC COMPONENTS

Mumbai to be developed as a smart city can be classified under three major areas based development components such as Retrofitting, Redevelopment and Greenfield development.

A. Retrofitting

The area to be developed will be a smart area which incorporates all the necessary features which can provide with more intensive infrastructure service levels and a large number of smart applications will be embedded into the retrofitted smart city. In retrofitting, a plan would be introduced for existing build up area identified by the city citizens for more than 500 acres to achieve smart city objective. The identification and selection of retrofit area based development is done based on the following approaches:

1) Profile of Mumbai city
2) Citizen engagement and opinion

B. Redevelopment

Mumbai being one of the metro city of India which is more than a century old have witnessed unparalleled inflow of migrants giving rise to large scale unplanned developments in its prime pockets. As per study, an estimation of 41.3% of people in Mumbai live in slums covering more than 500 acres with a population of 9 million people. Mumbai is growing in a haphazard manner thereby creating irreversible unplanned developments that can have detrimental effects in all fronts making future integration of infrastructure practically impossible. Redevelopment on such areas in city will create an effect on replacement of the existing built up environment and enable co-creation of a new layout with enhanced infrastructure using mixed land use and increased density. The Mumbai Redevelopment Plan for 2034 which speaks about creating 1 million affordable houses with increased in floor space index would provide potential benefits of redevelopment in the city. Redevelopment in city would cover an area of more than 50 acres to be identified by Urban Local Bodies (ULBs) in consultation with citizens. The following identification and selection of areas for redevelopment is done based on the following approaches:

1) Quality of citizens life
2) Economic well being of people

C. Greenfield Development

Greenfield Development can expand urban population to vacant land of the city's suburbs. These development needs to be planned in a way in which quality of life is determined by various parameters such as such as physical and mental health, education, safety, economic and financial opportunities, spirituality and right to personal beliefs, public services and transportation, and a well-balanced live, work, and play environment. It can provide smart solution for an area covering more than 250 acre developing by the concept of land pooling where small areas of land are owned by a group of owners who assemble for the development of infrastructure. The following identification and selection of areas for redevelopment is done based on the following approaches:

1) Return value of 60% from the developed land
2) Difficulties in acquiring land

V. RESULTS AND DISCUSSION

Any city to be developed as smart city the very first phase which comes into picture is a suitable infrastructure of that city. Mumbai which is spread along 603.4 $km^2$and area being the key element for development of any smart city a survey with random citizens of Mumbai was conducted through ICT mode using Google form by creating a questionnaire for area based proposal of Mumbai as smart city mission. The strategic components to develop smart city such as Retrofitting, Redevelopment and Greenfield development derived the following analyses.

A. Retrofit Area to Develop Smart City Mumbai

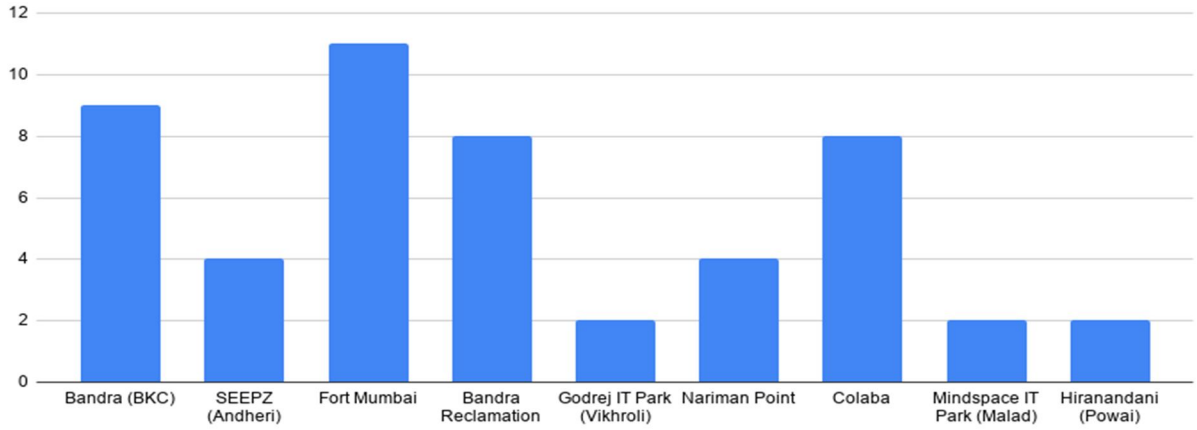

Figure 5.1.1 Feasible Retrofitting Development Area

In this first part the survey answered questions regarding the area which is feasible and ready to incorporate changes which would meet the objectives of smart city. From the figure 5.1.1 it is observed that in Mumbai citizens have preferred 'Fort Mumbai', 'Bandra (BKC)' and 'Colaba' as the most feasible area for retrofitting development in Mumbai.

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B. Redevelopment Area for Smart City Mumbai

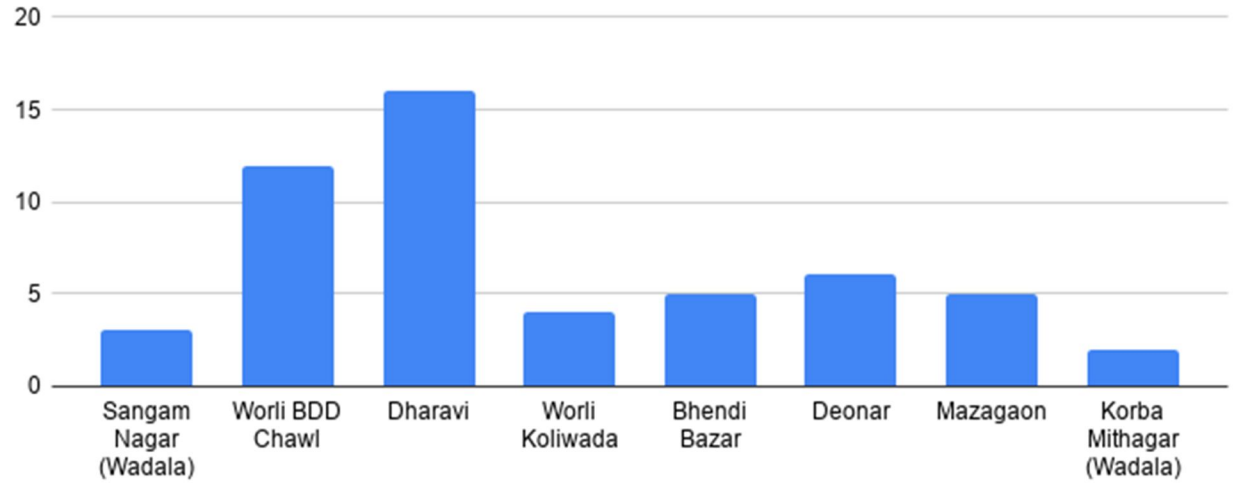

Figure 5.2.1 Feasible Redevelopment Area

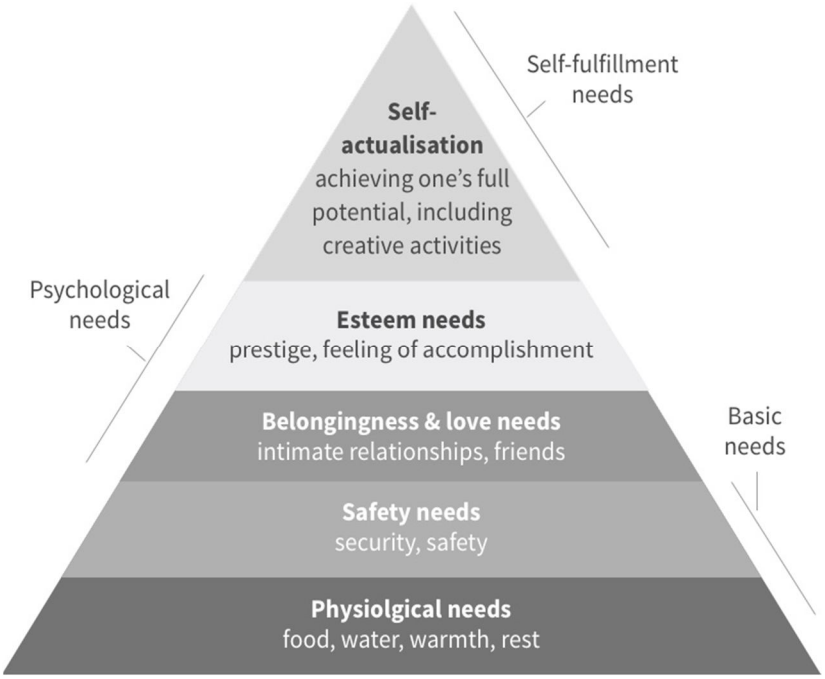

Figure 5.2.1 Maslow's Hierarchy of Needs

According to Maslow's hierarchy of needs (1954), self-actualization in Mumbai can be seen as the empowerment of local authorities and Maharashtra state as per Government Resolution (GR) for self-redevelopment suggestions by the high level committee to provide residents with opportunities to improve their local environment by suggesting various activities, actions or changes that should be carried out by the authorities or the community itself.

Almost 41.3% area of Mumbai comes under redevelopment phase. Through this research, an attempt was made to address the gap in some areas of Mumbai which are unaware of how technology can possibly improve their lives. The second part of this survey answers questions regarding the area which is feasible for redevelopment plan with mixed land use, high FSI and high ground coverage. From the figure 5.2.1 it is observed that in Mumbai Urban Local Bodies (ULBs) and citizens have preferred 'Dharavi', 'Worli BDD Chawl' as the most feasible redevelopment area in Mumbai.

C. Greenfield Development area for Smart City Mumbai

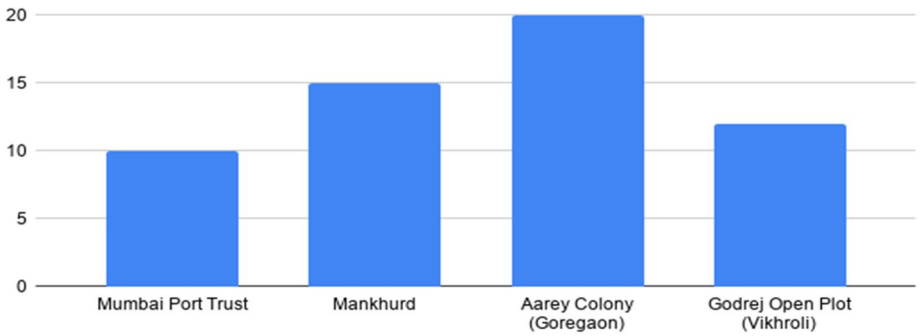

Figure 5.3.1 Feasible area for Greenfield Development

With the overgrowing continuous population of Mumbai and to address city with the needs of the expanding population, the third part of this survey gives answers to questions regarding the area which is feasible for Greenfield development. From figure 5.3.1 it is observed that Mumbai can introduce its smart solutions in vacant area like 'Aarey Colony' and 'Mankhurd'. As the total area coverage of Aarey colony is 3,166 acres of which area under roads, buildings, uncultivated and waste land under nullahs occupy 1,020 acres land can be used for Greenfield development.

D. Free Wi-Fi Usage in Mumbai

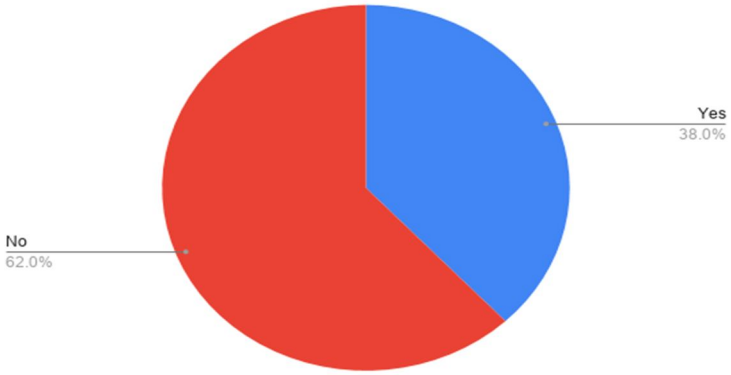

Figure 5.4.1 Percentage of citizens using free Wi-Fi services of Government

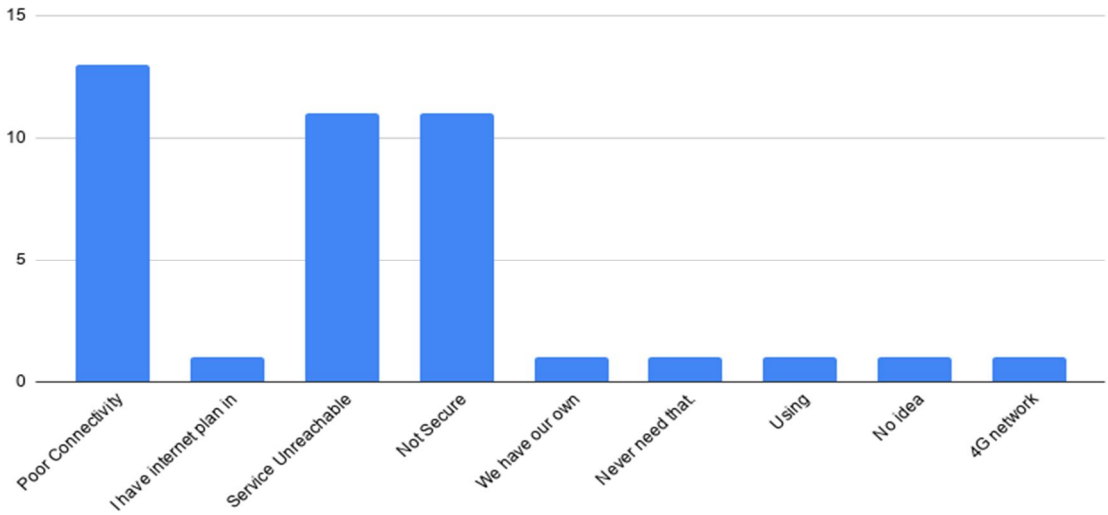

Figure 5.4.2 Reason behind not using free Wi-Fi services of Government

Mumbai has more than 500 hotspots across several locations in the city. The above survey figure 5.4.1 shows the usage of free Wi-Fi services offered by the government to its citizens. It is been observed that only 38% of overall citizens use public Wi-Fi services while the rest 62% do not prefer to use these services due to several factors as shown in figure 5.4.2. The above survey shows the factor which prevents citizens to use free public Wi-Fi service is poor connectivity. One of the major factors for Mumbai to be a smart city would be the data connectivity among various devices. In order to generate real time analysis of data and to take efficient decisions Mumbai needs to have a stronger, faster and secure connectivity. Government should come up with strong data connectivity services using latest technology enabled solutions such as LPWAN (low-power wide-area network)which can be used in different IoT devices and Machine-to-Machine(M2M) solutions by pooling data services offered by various private companies.

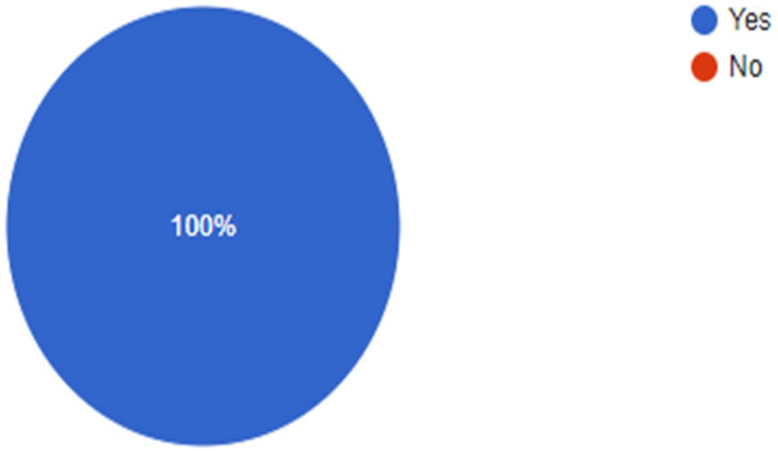

Figure 6.1.1 Percentage of citizens who prefer to see Mumbai as smart city

As per the survey conducted and shown from the above Figure 6.1.1it shows 100% result to develop Mumbai as smart city. In some figures it shows that citizens are little concern about incomplete provision of free Wi-Fi coverage and are willing to cooperate in administrative procedures when initiated by the authorities. Therefore the government should focus on the following areas to develop Mumbai as a smart city:

1) *High Quality Streets and Public Spaces:* Mumbai being a business hub of the country people have a gateway to enter through roads, railway, dockyard and airports. Considering the heavy traffic congestion and population, roads and streets should be well planned and well maintained. Minimum 41% of the total land area in Mumbai must be reserved for open public spaces and shape the urban structure to help and support local economy, connectivity, culture, creativity and future developments. Transport system with standard functions for vehicles, pedestrians and cyclists. City streets need to be connected over a network which is capable of acquiring data and delivering information and services to and from millions of devices which includes information about traffic, road blockages, road works, etc. Implementation of this will help in efficient management of resources and people to have better public transportation and urban landscape.
2) *Land Usage:* Mumbai covers approximately 1.07 lakh acres of land. In order to build a well planned smart city there should be smart planning of land usage. It is been observed from the study that there is a mixed land usage for both residential and commercial purpose; at least half of the land should be used for public space. Zoning which is one of the terms used for land usage planning which can be taken as an initiative by the local government and urban planners. One way to adjust zoning policies can be to combine suitable, compatible and feasible land use into one block and neighbourhood.
3) *Device Connectivity:* Mumbai being the city which has India's biggest public Wi-Fi network with more than 500 hotspots connectivity can easily be implemented. The connectivity should be faster, secure and stronger. The entire concept to make a city smart is based on IoT devices. These IoT devices contain sensors embedded into them which collect, reads live data that can be useful to analyze and gain relevant insights. Mumbai being one of the complex city, use of IoT devices can help to exchange and manage the information quickly in real-time manner. Minimization of accidents and unintended consequences can be managed by integration of data analytics in the system. With strong connectivity, data can be seamlessly moved among several administrative and municipal systems.

4) *Waste Management:* Mumbai generates about 11,000 tons of waste per day. To tackle this waste we need to incorporate some smart waste management techniques wherein the city starts to segregate the organic waste such as food and it is transported to a waste-to-fertilizer plant. One of the solutions to reduce operational costing of city is by installing sensors inside the bins. The sensors will monitor the level of trash in each bin and can be emptied only when the bins are full. The respective department will receive a notification through sensors from central hub station and accordingly the truck would be: collect the trash and empty the bin. This research opens a few possible directions for further investigation. If consider our findings valid for the entire city, then we need to investigate people's use of technology, how they participate and what they would consider worth doing and when. There should be a perspective of we-government along with e-government. This research has shown that Mumbai can become a smart city despite of its dense population, democracy, mixed land use and technology provided that smart city project does not enjoy any political intervention.

VI. CONCLUSION

Smart city can be an ideal city for solving the challenges that arise in various fields, with the use of technological tools for e-government, which develop energy and mobility sustainable projects empower citizens to ICT. With the implementation of Mumbai as smart city, the transparency, flexibility and automation of administration process between the government and citizens is possible and response to different issues can be faster on real time basis. The survey of Mumbai as a smart city was carried out by ICT means to analyze the vision and feasibility study of Mumbai to make a smart city. However since the research fields of the smart city concept are wide and diverse it somewhere requires governance based on communication and cooperation of citizens, governments, stakeholders and private companies. Mumbai can become a smart city if every citizen of it would think together smartly to promote high urban services; apply smart concepts which would provide in return smart solutions for betterment of the city.

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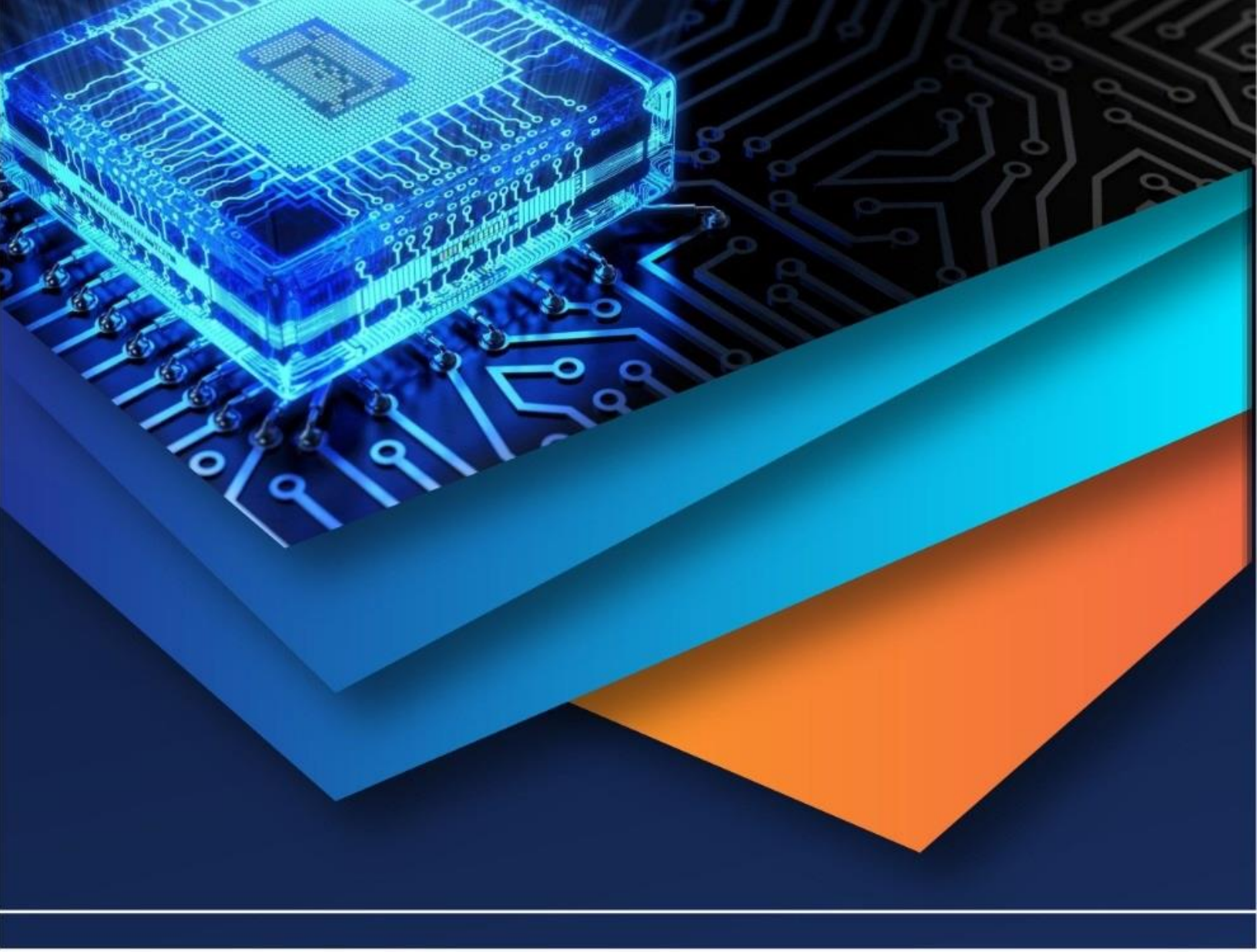
ANNEXURE

The following questions were asked to the respondents of the survey-
Q1 Select an area based development of Smart City Mumbai for Retrofitting development
Q2 Select an area based development of Smart City Mumbai for Redevelopment
Q3 Select an area based development of Smart City Mumbai for Greenfield Development
Q4 Do you used free Wi-Fi services provided by the government?
Q5 If No, please select the reason for the same
Q6 Being a citizen of Mumbai would you prefer Mumbai to become a smart city?



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