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A Study to Comprehend Role of Artificial Intelligence in Building Smart Cities

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***Abstract*— Modern day cities are rapidly turning towards adaptation of specialized technologies to address problems related to civilizations, ecosystems, morphology and similar other aspects. Smart city, which is a newly emerging concept and not too old in Indian context. This emerging trend encourages the prospects of assimilating and promoting adaptation of technologies such as artificial intelligence, robotics, sensitive sensors and big data through internet of things. Up to some extent even there exist adaptations of augmented and virtual reality for designing of smart urbanization. This chapter focuses on designing a model on such technological paradigm shift to really withstand with the terminology of smart cities. There already exists an India's smart village, Punsari in the state of Gujrat, thus depicting a model. This chapter also studies literatures related to renewable and green energy, environmental monitoring, air quality and water quality. Thus, due to research gaps, this study tends to focus on urban potentials with artificial intelligence and proposes a framework / prototype or the city of Navi Mumbai, Mumbai, Maharashtra. This is an empirical, explorative research based on both qualitative and quantitative data. These would bring upon integration between metabolism and governance for the compliance of sustainable urban development. Therefore, this informative framework would be an eye opener for researchers, academicians, corporates, government bodies, data scientist and big data analyst drawing their attention towards development of tech-based cities. Human intelligence in amalgamation with artificial intelligence would bring about social, economic and ecological sustainability. This would help to improve the living standards along with cohesively secured society.**

***Keywords*—Smart cities, Artificial intelligence, Big data analytics, Sustainability, Urbanism.**

I. INTRODUCTION

As per the reports of United Nations, the world population will increase by 9.7 billion by the year 2050. It's been estimated that around 70% of the urban population would be accommodated in cities by that time and each city would hold around 10 million population. There would be heavy population explosion leading to scarcity of resources and energy. Next big challenge would be administration and management of multiple activities related to sanitation, mitigate traffic congestions and traffic management system. The number of vehicle owners would also upsurge drastically. Thus, management of such situations are always a big challenge [1]. Our study makes an attempt to identify the role of AI for such concerns. As drastically there would be an increase in digital dependency and recent trends of technology. Thus, the use of AI would be an option to control most of the things in near future.

The study of artificial intelligence can be seen to drive from all the above disciplines which can broadly be grouped under the name cognitive science. Except that the AI community is always focused on writing programs, whether it is to investigate and validate theories of human cognition or it's to engineer system for doing a particular task [2]. The computer is a machine that allows us to present and manipulate symbols in explicitly and symbols we belief are the vehicles for idea and concept. An intelligent agent would need a multitude of faculties. The agent should be able to sense the world around it, deliberates over its options and act in the world. We called programs intelligent if they exhibit behaviour that would be regarded intelligent if they were exhibited by human beings, as said by Herbert Simon. Physicists ask what kind of place this universe is and seek to characterise its behaviour systematically, biologist ask what it means for a physical system to be living.

But many of these problems can be tamed by the use of AI-enabled Internet of Things. Using technological advancement to facilitate the new experience for inhabitants can make their day-to-day living more comfortable and secure [3]. This has

given rise to the concept of smart cities. A smart city is a city that makes use of information and technologies to enhance the quality and performance of urban services (like energy and transportation), thereby reduces the consumption of resources, prevents wastage, and overall costs. Smart cities not only possess Information and Communication Technology but also employ technology in a way that positively impacts the inhabitants.

One of the most complex entities are the cities and urban development where lot of amenities exists such as traffic control, parking place management, waste management, open spaces, buildings, roads, safety and security concerns etc.[4] when we say it as a smart city, we discuss about the use of sensors, robotics and AI which helps to collect, store and analyse data in various way. A city has to develop in many different ways to with assimilation of technologies which empowers it to smart enough in multiple ways. One must offer better performance, lower management cost, happier asset usage followed by better sustainability [5]. This work explains how AI helps to build smart cities with few specific concerns such as smart traffic management, smart parking and smart waste management.

II. LITERATURE REVIEW

It is obvious that coming up with something integrated for the smart city is a complete complex process. A need for proper traffic, waste, environment management and monitoring systems are always important. Considerable amount of literature works had been done in this area. (Ben-Akiva, Koutsopoulos, Mishalani and Yang 1997) through their study says that for traffic management, the need for constant evaluation and monitoring is a necessity. And the constant interactions between the control objectives need to be refined. The traffic management stimulator test system can address both receptive and proactive frameworks. The tiny traffic stream test system models permit the calculation of execution estimates important for a detailed framework assessment [6]. The reproduction lab gives a tool for disconnected framework assessment and evaluation of cutting-edge dynamic traffic management and explorer data frameworks at the operational level. As smartphones offer complex calculation, tremendous capacity, and long-range correspondence, Urbanet proposed by Riva for traffic management can be used as multi sensor (sound, video, and so forth) gadgets making a remote versatile sensor organization and act cooperatively to give detecting inclusion, gather and offer information empowering clients to exploit sensor-rich world. Urbanet is a middleware stage that empowers applications running on cell phones to gather continuous detected information in a decentralized way without the help of internet. It enhances resource use to the detecting movement, network conditions [7]. Urbanet proposes a portable application for drivers to recognize gridlocks in a city. It presents three middleware stages for three diverse programming models. The model proposed in Urbanet is fascinating yet doesn't utilize gathered information from various types of sensors to oversee traffic. Appending Urbanet with existing framework will likewise upgrade the generally framework execution and will allow utilizing extra ITS applications. Urbanet interest on programming applications however doesn't give details on correspondence conventions and security instruments which need more examination (Kafi, Challal, Djenouri, Doudou, Bouabdallah, Badache 2013).

Academic researches shows that more than 66% of car drivers has no trouble paying fees for the parking arrangements, which ultimately adds up to the parking business boom and act as a stimulus for the building up of car parking services for smart cities [8]. The current vehicle leaving frameworks are not extremely proficient as they don't give the 'best' administration, e.g., finding the closest accessible vehicle parking area. At the sensor layer, the majority of specialists today center around identifying the vehicle parking area spaces. A vehicle parking garage identification technique is proposed based on a threshold algorithm as the image handling calculations are costly, a hardware arrangement is recommended. Sensors and scanners can be utilized to recover the vehicle parking area position (Ji, Gnachev, O'Droma, Zhao, Zhang 2014). In light of these customer requirements, an insightful parking services ought to furnish clients with functionalities for each of the three phases of a transportation cycle, including transport planning, driving, and activities after parking. A parking

office screens the occupancy status of its parking spots utilizing vehicle recognition sensors, and updates online the occupancy status data through a data set. Likewise, the data set framework deals with the booking reservations of parking spaces for clients and shows nearby the reservation status of each parking spot (Liu, Pei, R Chen, Y Chen, L Chen 2012). (Bachani, Qureshi, Shaikh 2016) through their comparative analysis of light sensors and proximity and smart parking found out that their precision of distinguishing (various sorts) vehicles and their working vulnerability in various timings of the day under various natural conditions. The exactness of LDR sensor is exceptionally influenced by the difference in the luminous force for the duration of the day. Subsequently, extraordinary limit values have been determined based on the change in luminous intensity. This expands the code complexity and makes the vehicle recognition questionable in extraordinarily in rainy or shady climate conditions. Shadow of non-object of the interest further builds the false discovery in LDR sensor and henceforth seriously impacts the precision and its exactness [9]. In contrast with LDR sensor, IR sensor ends up being better sensor for vehicle identification as the presentation of the IR sensor isn't affected by any natural conditions like LDR sensor. IR sensor has capacity of distinguishing various kinds of vehicles dissimilar to LDR sensor. The sole drawback of IR sensor is that it burns-through more energy that makes it less cost effective in contrast with LDR sensor.

Just like traffic management, plastics have become important to our daily lives due to the numerous properties that they have. The drivers to such development are their low thickness, strength, strong, plan and manufacturing capacities and ease. Because of such properties, plastics are not just utilized as packaging materials; they are likewise utilized in car and industrial applications. Their utilization in various applications including conservation and dispersion of food just makes it sensible to track down a lot of PSW in the last stream of metropolitan strong waste (MSW). While plastics are found in practically all MSW classifications, it is necessary to recognize factors that impact the legitimate methods of managing such waste. In spite of having various positive properties, plastics contribute a list of faults from the waste management board viewpoint. Studies at local area level audits that, none of the examinations uniquely centered on post-shopper packaging plastic solid wastes [10]. Be that as it may, the consistent expansion in the utilization of plastic items has brought about a proportionate ascent in plastic waste in MSW streams in enormous urban areas and subsequently the specialists distinguished a number of drivers that can add to the improvement of practical reusing frameworks for post-customer packaging strong waste. In the part of economic improvement of waste administration frameworks, plastic solid waste reusing gives freedoms to diminish oil utilization, carbon dioxide discharges and amounts of waste requiring removal henceforth adds to sustainable manufacturing (Mwanza, Mbohwa 2016).

New ideas come to help endeavors made toward that path; a really inventive job is that of the ICT innovations. The waste collection is made today utilizing vehicles checked by GPS and containers that give data identifying with filling or weight. This information is given progressively by a framework of remote organization type, to a framework that can store it for gathering expectations, or handling and producing ideal collection courses. The GPS strategy permits the ongoing observing of the collection and transportation of waste, so the management reacts faster when status is evolving. Expectation of waste creation is of a genuine significance to nearby organizations in regard of the expense. In the computerized world wherein we live, nearly everything is conceivable. Through the collection of information communicating great utilization, data about the purchaser conduct, measurable information identified with the creation of waste in information database and information mining exploitation have been created complex examples of expectation (Ion and Gheorghe 2013).

Environmental monitoring is fundamental for recognizing changes associated with organic invasions land use change, and stressors, for example, air toxins and environmental change. Observing is also needed to assess the impacts of past or proposed environmental policies and resources the executive’s exercises. Data from continuous long term monitoring projects can be

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utilized to assess the productivity and adequacy of those projects and can inform the improvement of other comparative monitoring projects. Often, monitoring programs have numerous destinations that need to be viewed as by and large in choices to adjust the temporal or spatial degree of estimations. For instance, many screening programs track numerous factors in the examples collected. Commonly, the testing power will be steady across these variables, albeit the prerequisites for distinguishing long-term trends will be unique. The proper span for inspecting will depend on numerous elements, including cost, expected paces of change, desired certainty intervals, and the significance of the variables being monitored. Identifying potential decreases in examining force may provide opportunities to diminish expenses or divert monitoring efforts to address different issues. For instance, in the drawn out lake study portraying variety across lakes was more important than describing variety in practically no time; along these lines, an improved testing system may incorporate extra lakes while decreasing the temporal sampling inside lakes (Levine, Yanai, Lampman, Burns, Driscoll, Lawrence, Lynch, Schoch 2013).

(Zughart and Settele 2013) At the point when new ideas are presented and vulnerabilities for chances exist, ideal environmental monitoring of potential risks is required (EEA 2001). This likewise applies to genetically modified organisms (GMO). European guidelines anticipate an ecological observing for each GMO imported, prepared, utilized for food or feed, or cultivated (EC 2001). The point of post market environmental monitoring (PMEM) is to fill in as an early notice framework to encourage early and ideal relief measures (EC 2002). These days, making use of semiconductor-based innovation and other different prospects are explored. In this unique situation, manufacture of sensor exhibits that incorporate diverse sort of silicon sensors like ISFETs, metal terminals and p-n diodes as temperature sensors have been performed. Such exhibits, which comprise valuable apparatuses for multiparametric investigation by utilizing scaled down stream frameworks, are being carried out for the most part in clinical analysis. Anyway, their plausibility in environmental monitoring is as yet a test. The utilization of remote sensors is additionally a profoundly encouraging option to execute frameworks for in field applications, which is nowadays being created by many investigations and organizations around the world (Jorquera, Orozeo, Baldi 2009).

III. OBJECTIVES

1. To explore ways to design smart city with AI leading to smart governance.
2. To incorporate AI based smart infrastructure in terms of traffic, parking and waste management for the emerging city of Navi Mumbai.

IV. AI IN BUILDING SMART CITIES

There are few ways how machine learning and artificial intelligence can help building smart cities. Initially we consider AI for Earth Observation imagery which has special geospatial characteristics used in maps and GIS software in automated ways. However, it is good to mention the other areas that come after this first stage of extraction, such as the analysis of spatial-temporal urban patterns (urban growth, infrastructure deployment, mobility and neighborhood relations, etc.). Further with patters of geospatial which helps to enrich metadata such as maximum traffic timings, parking facilities, waste collection and dispose etc. can allow to feed the data captured through AI and ML and then analysis can help to understand scenario accordingly [11]. There has been already use of smart technologies to design and operate infrastructure management of cities. This would be an indispensable tool in designing the state of art smart infrastructure in urban locations. AI has also gifted autonomous technologies which controls several specific scenarios in cities.

As the regulatory and compliance features are satisfied for safety, this will become a significant factor in how city transit routes are designed and managed. For large scale development of smart city management these tools and technologies does play great role. These are great samples of architectural footprints for large scale developments. Traffic management system and smart parking need use of such technologies which helps in better control and management. In the cosmopolitical and

metropolitan cities there have been continuous growth of automobile consumption and thus smart management to tackle with such a scenario is need of an hour. In India for the major cities such as Delhi, Mumbai, Kolkata etc. there exists a need of smart management [12]. So far, we can evidence that only at certain locations there are cameras and sensors which captures picture of any vehicle breaking traffic rules. Still there exists a great demand of such technologies which can make the governance more transparent.

V. SMART TRAFFIC MANAGEMENT

AI and IoT can implement smart traffic solutions to ensure that inhabitants of a smart city get from one point to another in the city as safely and efficiently as possible. Los Angeles is one of the most congested cities in the world to adopt smart traffic solution to control the flow of traffic. It has installed road-surface sensors and closed-circuit television cameras that send real-time updates about the traffic flow to a central traffic management system [5]. The data feed from cameras is analysed and notifies the users regarding the congestion and traffic signal malfunctions. For this purpose, we can use AI based *Picterra* which provides and intuitive and simple to use platform that geospatial imagery analysis easy and convenient. The reports generated are simple to use and read through. *It* makes getting from raw data to actionable insights fast, flexible and more intuitive than ever before. This is the leading AI-powered Software-as-a-Service platform enabling businesses to autonomously extract intelligence & analytics from satellite, aerial, and drone imagery.

It comes with a ready-to-use IT infrastructure: in a few clicks, Picterra's users build and deploy unique actionable and ready to use deep-learning models, quickly and securely without a single line of code. Similarly, *SkyWatch EarthCache* also provides developers with the tools they need to cost-effectively add Earth observation data into their applications and workflows. It is the simplest way to get satellite data for an application, whether you are working in agriculture, utilities, energy, oil & gas, natural resources management, smart cities, insurance, fintech, etc. Together, they are the first solution on the market for extracting insights with self-serve ML/AI tools and Earth observation imagery, enabling any company to cost-effectively access unprecedented geospatial intelligence & analytics capabilities. Use Picterra to automatically monitor your areas of interest for change, thanks to a combination of EarthCache's automated tasking request feature and Picterra's automated detection algorithms. It unlocks monitoring capabilities previously unseen and now made available to anyone.

Looking at the increasing number of vehicles on the roads of Navi Mumbai, one can design a prototype monitoring system that that uses AI through traffic cameras. Traffic cameras automatically detect vehicles and this information is sent back to a central control centre where algorithms estimate the density of traffic on the road [13]. The system then can alter the traffic lights based on real-time road congestions. To respond in this way, however, requires data. Lots of information from traffic monitoring systems, road infrastructure, cars and drivers themselves via their mobile phones. Millions of cameras can line our roads while the passing vehicles induce tiny electrical currents in loops of metal hidden beneath the tarmac, providing further information about the traffic conditions. Motorists can send instant updates about hold ups thanks to the navigation software they use on their mobile phones and in their cars.

The system can use video feeds to automatically detect the number of road users, including pedestrians, and types of vehicles that are at an intersection. The AI software then processes this information second by second to come up with the best way to move traffic through the intersection, changing traffic lights depending on the most optimal way of keeping traffic moving. Decisions can be made autonomously, and shared with neighbouring intersections to help them understand what is coming their way. As vehicles become more connected with the help of mobile phone and other wireless technology, they too will help to feed even more information into systems like this. In the future, connected vehicles will be able to communicate information about their speed, driver behaviour and even potential faults to the surrounding infrastructure.

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VI. SMART PARKING

Finding a parking slot especially during holiday time is a real struggle. With road surface sensors embedded in the ground on parking spots, smart parking solutions can determine whether the parking spots are free or occupied and create a real-time parking map. This will also reduce the time drivers had to wait to find an empty space which would also help reducing congestion and pollution. The growing number of cars combined with more and more restrictions related to car traffic making finding a parking spot a challenge, not only in big cities but especially there. No wonder there is a growing need for optimizing the way both public and private parking lots work. Picterra can help to make a difference by detecting cars and parking spaces to give insights about the current situation. Thus, managing parking places can be an easy task with the help of such smart AI powered technology. Once the vehicles are mapped then they can be placed properly. We can also have sensors deployed at different locations to guide the vehicles to get placed. Any which ways these implementations need lots of developments in terms of smart infrastructures [14].

Searching for a parking place for vehicles in the cities is a big challenge at pick hours. Drivers need to keep the vehicles move from one place to another in search of a place [1]. Thus, the solution can be vehicles having decision systems which permit to locate the optimal parking in lesser timing. In the real time this could help to have a proper parking system, avoiding concerns related to no parking, standing at wrong place and violation of traffic rules [2]. Thus, we propose an optimal method which could support, manage, reduce and control the parking activities in the city of Navi Mumbai.

VII. SYSTEM ARCHITECTURE

We look forward to propose a system that locates parking for the vehicles circulated in the road networks of vehicles looking for parking place. Also, the proposed system would support into smart parking according to traffic and road conditions. Thus, we consider here important parameters such as vehicle count, parking places, environmental data, waiting and parking time. The results retrieved from the analysis could be system driven/ automatic as a part of control system or intimated to the driver and left for their discretion. Figure 1, demonstrates prototype of the proposed system. This system holds three major actors such as vehicle agent, parking agent and agent profile. The parking agent could locate the optimal parking place based on driver's profile like distance between proposed parking and vehicle along with parking and waiting time. An agent is a software system that is situated in some environment and that is capable of autonomous action in order to meet its design objectives. The proprieties of multi-agent systems offer autonomy to find the optimal parking, in real time. Thus, it provides a suitable framework for these systems. Also, they provide a number of important characteristics as the cooperation, negotiation, adaptation, and the mobility.

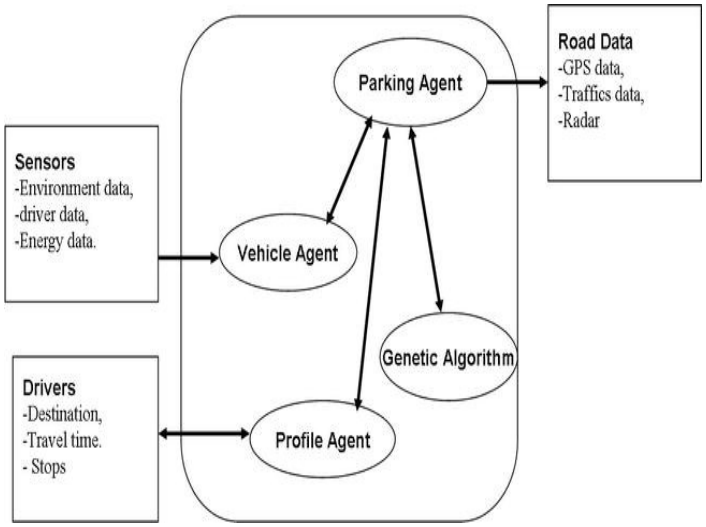

Fig. 1. Prototype on proposed system

Simulator is present with each parking agent to identify the driver's comfort level and locate the optimal parking in the prevailing conditions. Thus, this would help to find out proper balance between discovery time and system performance. Analysis and calculations could help the driver to make a proper desired decision based on the results retrieved. The drivers' comfort model permits to control the drivers' preferences via computer techniques to find the optimal parking which satisfies drivers' comfort and increases the efficiency and productivity of the system [15]. There must be a proper evaluation between

system's efficiency and driver's comfort. The parking agent would evaluate the number of vehicles in the parking place along with driver's comfort level which has a demand for specific parking place. Thus, the major objective of a parking agent is to resolve the conflicts which would arise between maximizing the gain and increasing the drivers' control and comfort level. This also includes the availability of parking places, traffic road conditions and drivers' preferences. Generally, the distance between the vehicle and proposed parking and the waiting and parking time are used as parameters to evaluate the drivers' comfort level.

VIII. SMART WASTE MANAGEMENT

Waste collection and its proper management and disposal are an essential city service. This increase in the urban population necessitates the adoption of smart methods for waste management. Adopting AI for smart recycling and waste management can provide a sustainable waste management system. One such example could be of Barcelona's waste management system which has sensors and devices fitted on waste bins that send notifications to the authorities to dispatch the waste collection trucks as soon as they are about to be filled. They also maintain separate bins for paper, plastic, glass, and waste food items in every locality.

Sewage systems in cities are becoming more efficient with the use of artificial intelligence to predict the quantity of chemicals that should be used to clean up the water runoff after your dirty business, given different potential scenarios such as temporary population increases due to events, planning for normal population growth, precipitation levels etc. With IoT, AI will become the standard way we design most things.

The current waste management systems are unable to efficiently deal with the tons of garbage that's generated every day. The city of Navi Mumbai is densely populated and releases tons of garbage. The city generates around 700 MT of garbage per day. Navi Mumbai had jumped four positions from the previous year's ranking and bagged the third position in the annual survey of cleanliness, Swachh Survekshan 2020 [MIDC]. Automating the processes of garbage sorting and disposal, by switching to AI for smart recycling and waste management, is expected to bring in better disposal methods to recycle sustainably.

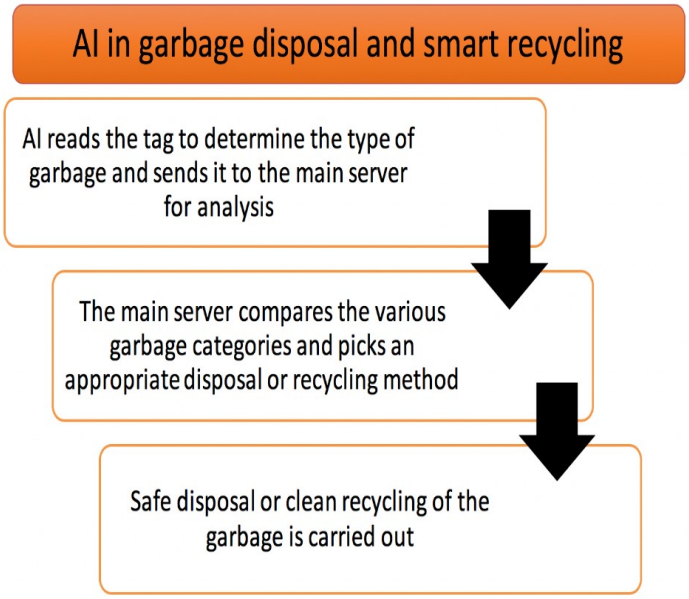

Fig. 2. Proposed architecture for smart waste management

Radio Frequency Identifications [RFID] tag is a recent technology which can be adopted for waste management. Such transformations are heavily used by many western nations for garbage management process. Accordingly, the primary server, which stores all this data, determines an appropriate method to dispose the total waste generated. AI programs and IoT sensors, is another revolutionary concept in the waste management sector. The sensors on these trashcans measure the waste levels of the garbage thrown inside them and send this data, via intermediate servers, to the main disposal system for processing. The system categorizes the data into the type of garbage, the quantity of each type of garbage, and the respective waste disposal method. This entire system can also refine itself over time by studying historical records to improve its efficiency. The automated intelligent machines are gradually replacing the traditional waste sorting methods. The designed smart bins could think for themselves while sorting and sending garbage [16]. All a person has to do is to put the garbage in the bin. The bin then uses its sensors to study and compare the trash recovered with the previous trash records and then makes a decision on what needs to be done with garbage. Depending on the decision,

the bin itself sends the trash to an appropriate disposal system, be it a dumping ground or a recycling factory. This will go a long way in maintaining the environmental balance for a better and sustainable future.

XI. SMART GOVERNANCE

The main motive of smart cities is to make a comfortable and convenient life for its inhabitants. Therefore, smart city infrastructure is not complete without smart governance. Smart governance implies the use of ICT intelligently in order to improve decision making through better collaboration among different stakeholders, including government and citizens. Smart governance would be able to use data, evidence, and other resources to improve decision making and compliance towards the needs of the citizens. A city with all the smart technologies can be considered as with smart governance. The emerging city of Navi Mumbai would become a smart city in real sense in near future. With the increase on digital dependencies, we see a better future with smart devices for our city.

X. FUTURE SCOPE

These proposed models could be further worked upon and accordingly brought to real life in our cities. There would be lot of assimilation of technology and management in the similar mentioned processes. AI and sensor networks along with recent trends in technology would be a boon to these rapid emerging cities. There are few limitations in the following study such as pilot run, compliance with government and costing for such a mega project. There would be lot of challenges when these smart systems come to live but sill their adoption would be always a boon to mankind. All the aspects considered on the mentioned study such as smart traffic management system, smart parking management and smart waste management based on AI tolls would be a great support to build smart governance.

XI. CONCLUSION

AI implementation would change the ways cities operate, delivers and manages public amenities such as traffic system management, parking management and waste management to demonstrate smart governance. However, the correct selection of the technologies indeed matters a lot for smooth functioning. Still even we believe that this would be taking a long time for the cities to become fully AI operated as there exist challenges too. Increasing population and digital divide along with existing gap in digital literacy are few of the major concerns. Thus, retrofitted solutions could be fruit for thought. Another important thing to take care of while adopting AI is collaboration. For cities to truly benefit from the potential that smart cities offer, a change in mindset is required. The authorities should plan and across multiple departments. Though the budget can be another issue to consider, the results of the successful implementation of smart city components across the world prove that if implemented properly, smart cities are comparatively economical. Smart city transition not only creates jobs, but also helps save the environment, reduce energy expenditure, and generate more revenue. This study is an attempt to explore ways to design smart city with AI leading to smart governance. We have propounded few ways which demonstrates the adoption of smart AI based technologies. Also, we have tried projecting our thought process on incorporating AI based smart infrastructure in terms of traffic, parking and waste management for the emerging city of Navi Mumbai.

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