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THE SMART CITY IMPERATIVES - ACHIEVING SMART AND SUSTAINABLE FUTURE

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Abstract

Smart city models are recognized as practical approaches to managing city operational challenges caused by growing urban populations. Its effectiveness has been proven by developed cities worldwide that have already embraced it and showcased their functional gains. Their leveraging of ICT infrastructure has created countless smart opportunities to enhance city lives. Investment challenges in smart city requirements may be a setback for developing cities but an incremental approach can gradually lead the way as can be seen in Oman. A number of smart areas are identified as crucial for such journey including smart economy, smart mobility, smart environment, smart citizen, smart living, and smart Government. Through a number of smart initiatives, Oman has been targeting these smart areas and pushing for ICT infrastructure enhancements that can support them. As a result, technologies have been incorporated across the economic sector, the social structure, and the environment, driving up the quality of living for the citizens. It can be argued that Oman has made significant progress over the recent years and eyeing a bright future on that front.

Keywords: Smart City, Sustainable Future, ICT infrastructure, Smart environment.

INTRODUCTION

The world has undergone several changes including remarkable development in the internet infrastructure since the late 20th century, due to the prevailing use of information and communication technologies (ICT) in companies, governments and communities. It was believed that ict is the basis in the development and management of the cities, which was later coined the "smart city" concept, introduced by ibm. The "smart city" concept had consequently brought countless social, economic, and environmental changes driving the need to leverage existing and develop new supporting ICT infrastructure, which is framing the current technology era. This drive is rightly justified as large number of people are noted to constantly moving from rural areas to urban areas. Currently, about 55% of the world's population is settled in the cities and this ratio is likely to increase to 70% by the year 2050 (reference). Effective strategic planning incorporating the smart city concepts is required to mitigate the foreseeable challenges and pressures resulting from the increasing population density of the cities. There is yet to be a fixed and defined definition for the smart city as its concept can be additive and changeable from time to time. John (1999) defined smart cities as cities that rely heavily on technological infrastructure to benefit from new insights, and to enhance & develop their operations, systems and services. It also can be defined as "A framework, predominantly composed of ICT to develop, deploy and promote sustainable development practices to address growing urbanization challenges" [1]. Smart cities share common characteristics, that

is, their use of new ideas & innovative methods permissible by technology, and their applications in various aspects of the city. The applications of these ideas and methods often leads to excellent management of the city, efficient use of resources, high quality services, improved quality of life, less environmental impact and many more. The Smart City concept encompasses almost every aspect of the citizen lives and the community. People interact with smart city ecosystems in different ways, be it, using their smartphones & mobile devices, as well as their connected homes and cars. It is certain that by associating all the devices and data with the physical/actual infrastructure of the city, the costs will decrease and sustainability will improve. Communities can decrease traffic congestion, improve energy distribution, improve air quality, and even streamline trash collection with help from the Internet of Things (IoT). For example, sensors send signals and data to the connected traffic lights when there are cars nearby in order to reduce road congestion. Connected cars can carry data about the places of electric vehicle charging docks and parking meters in order to guide the drivers to the nearest available spot. Smart garbage cans send data directly and automatically to waste management companies to make it easier for the employees to set up an appropriate schedule of the pick-up dates. And the smartphones can become the I.D. card and mobile driver's license of the citizens, which simplifies and speeds up the government services. In short, these smart city technologies are enhancing and developing mobility, infrastructure, utilities, and public services. Boyd Cohen is known as one of the most famous experts in the Smart City, urban areas and sustainable development. Cohen came up with the idea of the Smart City Wheel in 2012, as he defined its functions, goals and features as well as the main classifications and indicators. The Smart City Wheel involve six key components, namely Smart Environment, Smart Mobility, Smart Economy, Smart People, Smart Government, Smart Living and 18 sub-domains. See figure 1 below.

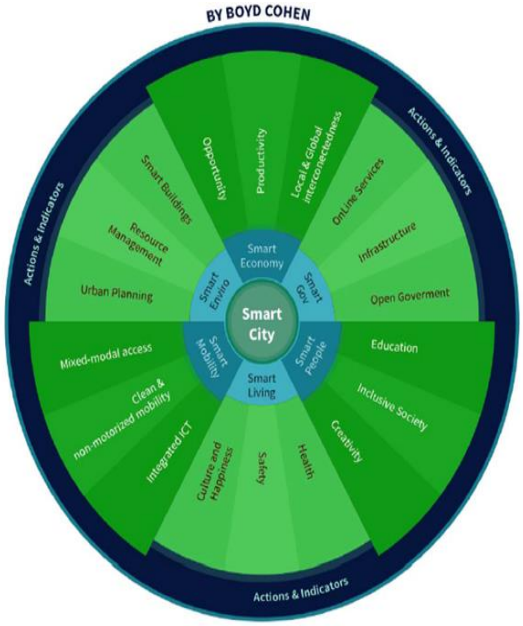

Figure 1: *Cohen Smart City Wheel*

The smart city framework proposed by Cohen which consists of six main components has been largely adopted by the academia and the related sectors. The following explains the six components.

Smart Economy: It advocates entrepreneurship and innovation. It focuses on the development of novel high end technology in order to positively affect the services, production, and speed up work processes. By improving the different services, products, promoting research, protecting intellectual property, and opening up markets, it strengthens the links between global economies and local economies thus sustain competitiveness and vitality of cities.

Smart Mobility: It is about upgrading the quality and efficiency of the urban transportation system, which can be achieved through modern techniques such as remote tracking and video surveillance in order to monitor and manage traffic facilities and flows. The monitoring allows analysis to be conducted on the collected data to better manage pedestrian flow, traffic flow, cargo flow and prioritize emergencies in a proper manner. This also promotes the access to various transportation modes such as public transport, cycling, clean-fuel vehicles and walking.

Smart Environment: It focuses on achieving green urban planning by adopting some remote monitoring and web-based technologies. These technologies allow understanding and analyzing the grassland, public places and green belts in a comprehensive manner in order to promote and establish greener environment. The smart environment also focuses on managing and exploiting resources effectively to achieve greater environmental sustainability through energy conservation, hydropower activation, emission reduction, and channel greening.

Smart Citizen: It is important to focus on providing an environment conducive to innovation, creativity and learning to develop the human resources. Human resources play a major role in the fulfillment of the Smart City, as they are responsible for the research and development of the different technologies needed to support innovative interventions that are beneficial to the cities and countries. This point focuses on enhancing the flexibility, pluralism, openness in addition to encouraging individuals to engage and participate in public affairs through Internet platforms and other channels.

Smart Living: It is about improving the living quality and environment through social networking platforms and IoT technology. It enables individuals to manage their homes properly and communicate with each other over the Internet and thus interact with the surrounding environment very well. The goal of this point is to promote and achieve a happy and healthy lifestyle.

Smart Government: It focuses on strengthening connections between government, institutions and people by providing information, integrating networks and enhancing of public services. The smart government must have transparency and respond to the aspirations and needs of the society in an effective and timely manner.

LITERATURE REVIEW

A. The Need of Smart City

The urban population has become much more than rural population; thus, this century is known as the century of cities. According to the United Nations, in July 2007, the urban population exceeded the rural population in the world. It is expected that this ratio will dramatically rise in the future and the urban population will become more than 10 million. According to some research, there will be 221 cities by 2025 in China alone, with more than 10 million people. The cities greatly affect the social and economic development of any country, as they are considered the real platforms for people to settle. They are also considered the major centers where resources are consumed, as 75% of the world's energy and resources are consumed by cities. More so, it produces 80% of the greenhouse gases while occupying only 2% of the world's territory. For these reasons, the International Day for Urban Planning has become one of the most important days that is celebrated by different cities on four continents.

Without a doubt, changes for the better in terms of management and development of all types of infrastructure within cities are valuable goals. So public administrations should take these goals into consideration through the development of urban management models. To achieve those in an easier and more effective manner, it is essential to leverage the ICT infrastructure and align its use to the smart city concepts. This will ensure the deployment of a variety of smart services supported by IoT which is gradually being looked at as the Internet of the future.

Smart Cities, as mentioned earlier, are real digital platforms that have the potential to raise the efficiency of society, economy, quality of life, environment, and achieve sustainable behavior among stakeholders (i.e. users, management, and companies). There are a lot of smart cities advantages that are worth taking note of and they will be discussed next.

B. Marketing Needs

Healthy markets are generally viewed as free market where competitions exist, as they drive up quality of products and services, while

driving down cost. This makes quality living quite affordable. It also increases customer influence within the market ecosystem thus forcing providers to pay particular attention to customer views. The growing voices of the different international economic, social, and environment advocates have resulted in customers becoming increasingly sensitive to green initiatives to the point where they are expecting the same from their providers. So green initiatives relating to economic, social, and environment has become an integral part of modern day living and so a critical part of marketing strategies. Smart city models characteristically encapsulate all these required marketing elements within their development plans and so a justified reason for adopting such models. The leveraging of ICT potentials to improve the quality of life will facilitate the adoption and deployment of green initiatives thus the smart city concepts. It also tends to lower entry barriers into the business environment such as e-commerce, agriculture, delivery services, and training to mention a few. Ultimately, it creates innovative economic opportunities and broad-based social advancement for the citizens within a clean environmental.

C. Technology Needs

As discussed previously, smart city concepts are closely related to the leveraging of ICT infrastructure to enhance existing products & services, and to deploy smart initiatives that will positively impact the quality of life of city residents. The emergence of IoT are allowing for interconnection between digital devices across cities, resulting in countless digital solutions for improving operational efficiencies within cities. Connected Government agencies are also allowing for coordinated and synchronized efforts to better serve the citizens, be it, service provisions such as application for a major city project where assessments by different agencies are required, monitoring of the city to ensure safety of the citizens, or responding to emergencies within the city which again may well require multiple agencies. Furthermore, the connected digital devices are allowing for collection of all sort of city data ranging from environment, to citizens' behavior, to traffic congestions. Moreover, the advancement in big data management and cloud computing are allowing for all those collected data regardless of volume or format to be stored, analyzed, and draw conclusions to support cities in making data-driven decisions. Additionally, the interconnections are allowing citizens to connect to different services to get information or participate in city decisions. This promotes good governance, active citizen participations, and citizen ownerships of city decisions, which are crucial to create high quality of living. On the other hand, access to information such as weather forecast or traffic status enhance the planning of daily movement which can translate into more efficient road use. The wider use of machine learning and artificial intelligence technologies within key areas like traffic management, manufacturing and warehousing, airport management, and home management, are resulting in significant city operational efficiencies gain. The block chain technology is ensuring the integrity and security of personal data and online transactions boosting the confidence of citizens in embracing those initiatives. All these technologies contribute significantly towards the smart city concepts and the drive to quality living including health and safety, effective mobility, good governance, work opportunities, access to quality education, and supporting social structure.

D. Secured and Trusted Smart Cities

It is widely agreed that smart cities are more reliable and secure given their setup of connected cameras, safety control techniques, and intelligent road systems to support and protect citizens. However, what is overlooked frequently, is the need and how smart cities can protect themselves against the possibility of hacking, data theft and cyber-attacks of their citizens shared private and confidential information. It is important to have the trust in smart city participants (e.g. governments, organizations, hardware suppliers, software vendors, network service providers and power providers) while they are undertaking their assigned tasks. They are expected to commit to the four basic security objectives.

Availability: Smart City cannot flourish without real-time data access, as it must be actionable and reliable. The process of collecting, filtering, and sharing data is very imperative, and security solutions must be in place to avoid the scenario of unavailability of data.

Integrity: Smart cities rely on accurate and reliable data. Therefore, it is necessary to make sure that data is free from manipulation, and it is precise.

Confidentiality: Most obtained, stored, and analyzed data are private and sensitive (e.g., consumer details). Effective measures must be taken to prevent such data from being disclosed to unauthorized users which are likely to be misused resulting in legal implications.

Accountability: "Users of a systems must be responsible for their actions" (). Authorized users must be reliable but all their interactions with sensitive systems should be recorded in case of any problem. The forging of various records must be mitigated and ensure strong integrity protection.

OVERVIEW OF SMART CITIES ADOPTION IN MAJOR REGIONS OF THE WORLD

This part of the study will highlight briefly over the initiatives, benefits and challenges faced by smart cities over the world. Starting with,

1. Barcelona:

Initiatives:

- Pioneered smart cities initiatives such as low carbon solutions
- Among the first worldwide to introduce solar thermal
- Overall city municipality services are smart

Benefits:

- Essentially systematizing electronics and analytics to solve many issues like traffic congestion saving billions of dollars from having to build more roads in the process
- Benefits of the Smart city initiatives are long lasting (decades)
- Immediate target is embracing smart how business models
- Evident economic, environmental, & mobility benefits and so the infrastructure and services transformation through e-governance (Bakıcı, et al., 2013)

Issues/Challenges

- According to Barcelona City Council, some of the issues and challenges explain the shift from first to second generation smart city policies. Few urban challenges such as resource consumption, employment generation, wage inequality, climate change, housing, data rights etc. were in need to adequately address in the smart city strategy (March & Ribera-Fumaz, 2018).
- Barcelona "Smart City 2.0" framed to tackle social problems, more people centric to address resident needs, collaborative participation as compared to previous techno-centric approach in their first implementation (Gregory, 2019).

2. Berlin

Initiatives:

- Highly innovative in use of green technology initiatives
- Strong collaborations and support from BMW for the implementation

Benefits:

- Technology and digitalization helped in providing both short-term and long-term solutions to building more resilient ecosystem - Berlin Innovation Agency (BIA)
- Benefited with balanced utilization of public mass transportation
- Characteristics of resilient city of Berlin - socially inclusive, eco-friendly and digitized services

- Their mobility model is smart, shared and intermodal (Zyolska, et al., 2019)

Issues/Challenges

- Research reveals that participatory practices, collaboration of several types of stakeholders and digital strategy to tackle smart city challenges in the near future, was main focus in Berlin (Spil, Robin, & Jaron, 2017).

- Issues and challenges were mapped against social, political and economics ricks and threats.

3. Tokyo

Initiatives:

- Created small towns in the suburbs in partnership with Panasonic, Accenture, and Tokyo-Gas.

- Eco-burb homes integrate solar panels, storage batteries and energy efficient appliances with all connected to smart grid

Benefits:

- Most successful metropolis city referred to as Earth's model Smart City due to its Virtual vertical farming and energy efficient appliances key initiatives

- These initiatives are providing opportunities for having environmentally and economical spaces

- Collecting and recycling drain water for better utilization and agriculture

- Analog devices, Intel Microchip Technology and Molex are helping share the future of smart city of Tokyo (Kim, et al., 2017)

Issues/Challenges:

- Recent research on Smart City as a case of Tokyo depicts that application of IoT creates engineering, scientific and other such issues to be resolved. More ingenious research needs to be done (Tai-hoon, Carlos, & Ramosb, 2017).

- Water resilient plan with three major issues needs to be resolved.

4. Stockholm

Initiatives:

- Pioneer in having Networked Society

- Ranked high on the innovation city index for maintaining long track record to drive the progress of ICT infrastructure.

Benefits:

- Achieving vision of how cities will operate and be developed for sustainability over the next 20 years (the new urban agenda)

- Benefits includes enhanced city governance & planning, and improved basic services & greener city

- Utilization of ICT for solving social, economic and environmental problems leading to improving standard of living and conditions of citizens (Evertzen, et al., 2019)

Challenges/Issues:

- KTH Royal institute highlight the shortage in houses due to overwhelming public transport infrastructure.

- The developed from rural to urbanization has significantly increased the population size and lead to increase traffic.

- Increased traffic also damages city's infrastructure such as potholes develop [faster, cracks, and every repair leads to more congestion in the city.

5. New York

Initiatives:

- Partnered with IBM to launch Business Analytics Solution Center for addressing the growing demand for the complex capabilities needed to build smarter cities and help optimize all manner of business processes and decisions-making

Benefits:

- New York city's midtown in motion initiative has been introduced and is taking advantage of Innovations, advanced smart

signaling, traffic control by sensors and EZ-passes

- The NYCx initiative connects local start-ups and global tech companies thus solving issues of traffic, pollution and income inequality

- Link NYC is first of its kind communication network that has replaced 7500 payphone with link Wi-Fi. Superfast Wi-Fi, public link to charge devices and tablet access to city services and maps

- Cyber NYC plan aims to catalyse investment and grow the cybersecurity infrastructure

- My NYCHA mobile app allows public to manage housing services

- City Bike programs helping public with ease mobility services

Issues/Challenges:

- New York is a famous tourist destination. The current population of New York is ever increasing along with increased tourism each year. This leads to issues such as more traffic.

- Water consumption has significantly increased. Automated meter reading (AMR). Waste management issues at the road infrastructure.

- Air quality – With the increasing population as traffic, the air quality of the city is significantly damaged. This is in direct contact with NYC Department of Health and mental hygiene.

II. MUSCAT-OMAN AS A SMART CITY

Smart technologies for a smart city have become progressively popular. In the recent decade, several diversification strategies are being pursued to encourage the boosting of economic growth across Oman. Such efforts are to reduce its dependence on Oil, as stated by the National Programme for bracing the economic diversity in the Sultanate [1]. Oman vision 2040 and eOman 2030 strategies are few initiatives that are embracing the smart city concepts and eyeing towards a smart Oman [2]. In this regards, massive infrastructure investment plans in the fields of Information Technology & Communication, transportation & logistics, tourism & fisheries are being deployed to build a smart, sustainable, dynamic and globally competitive nation. Smart city Programme like Knowledge Oasis Muscat is a huge success following Al Mouj Marina Smart Community, Duqm (DSEZ) Smart City. These initiatives are looking to facilitate and improve the quality of life, enable residents to enjoy wellbeing, social welfare, and transform Oman into a dynamic & globally attractive place [3].

Humans and machines interaction is certainly a common characteristic in our daily life. Global Information Technology report is showing that Oman's level of ICT development is progressing positively and the country is moving forward to leverage the smart sustainable infrastructure goals as per their strategies [4]. Smart City Framework with suitable indicators were set and public authorities are there to monitor the progress and performance over time. Productive evaluation is identifying challenges, as well as recommendations to improve and support future goals. Targeted smart city initiative of Knowledge Oasis Muscat (KOM) criteria's are Reliability, alignment, comparability, relevance, measurability, data availability, non-redundancy and familiarity [5].

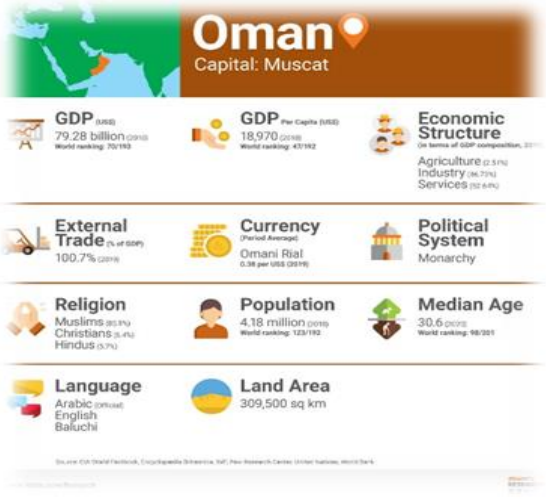

Figure 2: *Illustrating Oman Economic and Political Status*

The urbanization in Oman has witnessed a significant growth rate during the last decades. Indeed, it went from 31.3 % in 1971 to 86.3 % in 2020. The population has also increased rapidly from 723,851 in 1970 to 5,106,626 in 2020[6]. These demographic and social changes were accompanied with other challenges such as energy use, climate change, security and others which led together to an increasing demand to bring a new approach for digitalization and modernizing the social services[7]. To tackle these challenges, Infrastructure operators have worked on developing intelligent solutions and smart city projects. ICT and smart solutions were expected to help the urban infrastructure gain its full potential. Information Technology Authority (ITA) has started the Smart City Platform with three other founders which are The Research Council, Muscat Municipality and the Supreme Council of Planning. The platform is a knowledge-sharing consortium that leads the smart city initiatives in the country. It aims to share the knowledge, facilitate the collaboration between the smart city stakeholders, encourage for innovative projects through funding the research and carrying out competitions for innovation. [8]. In March 2020, The Ministry of Technology and Communications has launched a pilot project for the smart cities in Oman at the Knowledge Oasis Muscat (KOM). Both Cisco and Bahwan Information Technology are responsible for the implementation of this project. The project targets to provide an infrastructure for smart city projects in the country and to serve as an experimental model for similar projects. [9]. Muscat Municipality has also smart city plans in order to implement its strategy that aims to make Muscat a sustainable city that incorporates clean technology, green and safe urban planning with protection of inhabitant's privacy. To this end, it signed a memorandum of understanding (MoU) with Oman Telecommunications Company (Omantel) in order to provide to it ICT solutions and services needed for transforming Muscat and Suhar into smart cities. Omantel will make its expertise and capabilities as well as partnership with important companies such as Blockchain Solutions and Services (BSS) at the disposal of the Municipality in order to provide the smart solutions that will enhance the quality of services. To conclude, Smart city initiatives in Oman are still in their planning and research stage. The government has set the foundation stones for ambitious Smart City projects that will help to optimize the existing infrastructure and achieve the e.Oman vision in transforming the Sultanate of Oman into a sustainable Knowledge Society, enhancing the government services, empowering the individuals and enriching the business.[10]

CONCLUSION

The smart city concepts and models are widely recognized as effective approaches to managing city operational challenges and pressures being exerted on city limited resources due to growing urban populations. Developed cities around the world are already embracing such concepts and are reaping the benefits. It may be slightly more challenging to developing cities due to the kind of investments required but an incremental approach to the investments can gradually lead to the realization of smart city status. Oman is doing just that and it is apparent in its cities like Muscat, Sohar, and Duqm to mention a few. The smart initiatives being deployed are targeting all the smart areas discussed earlier, be it, smart economy, smart mobility, smart environment, smart citizen, smart living, and smart Government. The rapid ICT infrastructure enhancements over the recent years have seen the recommended technologies being incorporated across the different aspects of life, be it, communication in between citizens and the Government, access to Government services through its eservices portal, immigration management, access to financial services, and recreational activities. This is also setting up the market to allow for competition thus availability of affordable quality product and services. The resulting quality of living is clearly on the rise. The progress made is very encouraging and the journey to realizing smart city status looks bright.

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