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The Impact of ICTS in the Development of Smart City: Opportunities and Challenges

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Abstract*: *ICT technology has seen a widespread influence throughout the globe. It has become a crucial element in safety and security. According to the United States census bureau of 2017, it is estimated that, by 2030, the world's population will be around 8.5 billion. It is also estimated to rise up to 9.8 billion and 11.2 billion by 2050 and 2100 respectively. More than half of humanity today live in urban areas. A large number of cities are witnessing a significant growth of rural citizens moving to urban areas in search of better lifestyle and opportunities, education and a quality of life. As a consequence of this, cities' are expanding beyond their limits in their infrastructural, security and service sectors to adapt to the overwhelming surge of rural migrants. And this comes with a cost, which is the increased complexity of providing an easier way of life. This has led to cities adopting modern tools of ICT to become Smart Cities capable of adapting and allocating the incoming migrators, as well as increase the quality of life. The paper will explain the definition of smart cities, their opportunities and challenges with tools that include: Smart homes, Smart energy grid, Smart retail and Internet of Things. The study defines the essential elements that comprise smart cities. It will, therefore, aid governments in decision-making when it comes to initiating smart city projects.

Keywords*: *Database, IoE, Networking, Open Data, Smart city.

I. INTRODUCTION

According to Bakici, Almirall and Wareham Smart cities are "cities that make use of communication technologies in which their primary goal is to enhance their citizen's quality of life and allow for a more solid development structure".

A smart city can be referred as a city, which is enhanced in its governance, mobility, infrastructure and quality of life through a mixture of citizen awareness, environmental responsibility and ICT tool adoption.

A smart city can be referred to as a city which exploits ICT infrastructure in a scalable, resilient and a secure manner to [1]

- Enhance citizen's quality of life.
- Promote an economic growth by providing employment for the community.
- Ensure public safety, healthcare and education.
- Utilize clean energy to fill today's needs without harming the future.
- Streamline smart mobility, energy and water infrastructures for uninterrupted operation.
- Prepare preventive and counter measures for natural disasters and quick incidence response.
- Establish an appropriate government policy for modern legislation.

However, this comes with a new array of challenges to the development scale which may be in the form of scarce resources, traffic jams and environmental pollution.

The following is a graphical representation of a smart city.

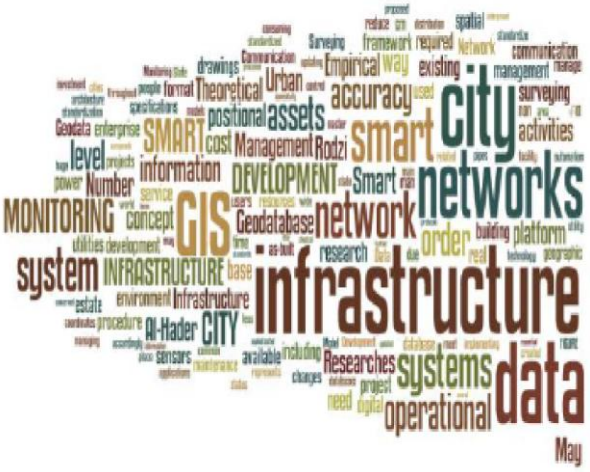

Fig. 1. A smart city [2].

ICT offer reliable solutions to issues which have arised in cities. These solutions are also cost-effective and user-friendly.

The notion of smart city refers to using pervasive communication technologies and smart devices to accomplish the urban environments and development (Kitchin 2013), thus in this scenario, the smart city can be divided into four layers according to Xu (2012) as listed below in the Figure.

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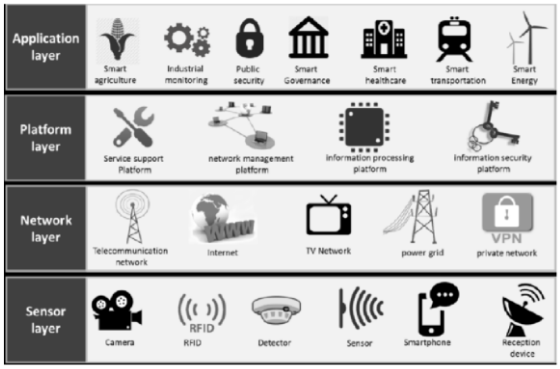

Fig. 2. Four layers of smart city (Xu, 2012)

Xu argued that these four layers interact with each other in this framework. The Sensor layer collects and gathers information and data in real-time which facilitates data management in the next layer. The Sensor layer widely uses: Cameras, RFID and Detectors to collect information.

The next layer is the Network layer, which involves the exchange and transfer of data and information. The most used channels of the network layer are: The internet, Telecommunication networks and TV networks. After this layer, comes the Platform layer which involves processing and managing information through platforms such as Business support, network and cloud computing platforms. The final layer is the Application layer which users direct interaction with smart services based on information collected within the smart city [3].

Figure 3 illustrates the different schemes of a smart city's technological architecture. These schemes interact with one another via actors (Service Providers, Municipal departments and the public citizens). Underlying the infrastructure are the Sensor and Network layers. (Fig 3)

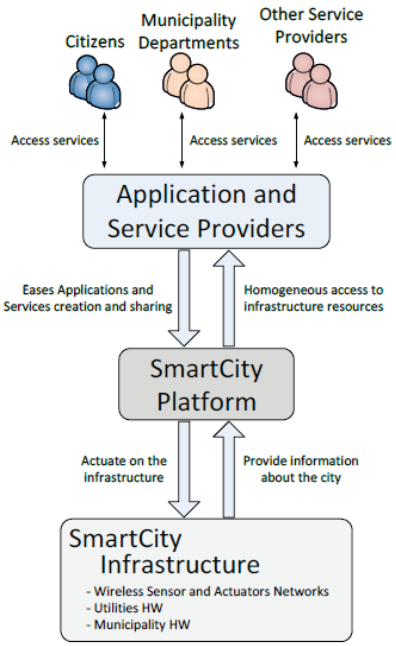

Fig. 3. Smart city actor's interactions [4]

Figure 4 divides cities into five layers of application: City resources, services it provides, social policies, infrastructural designs and the environment surrounding the city. Each layer is further classified [4] (Fig. 4).

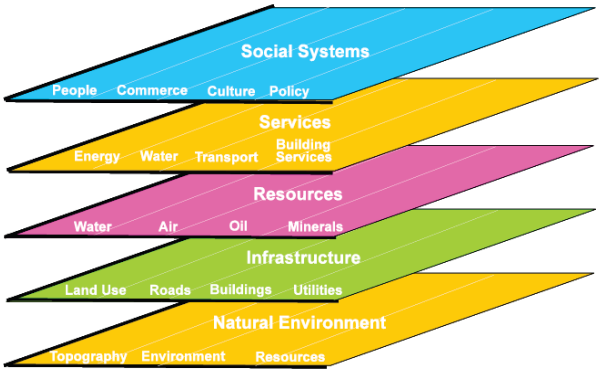

Fig. 4. Application layers in smart cities [5]

Another, simpler model of an urban system is shown in (6). The model has 3 main components the component of smart city are linked by ICT (Fig.5). [5]

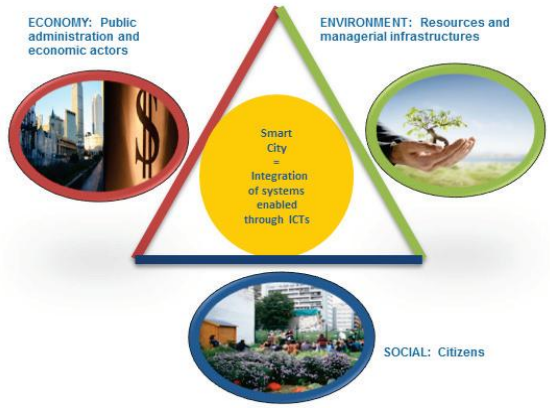

Fig. 5. Application layers in smart cities [5]

II. OBJECTIVES

Cities affect social, economic and environmental factors, and in order to manage this effect, they focuses on fulfilling three objectives.

Energy resource management which revolves around the concept of Internet of Energy (IoE).

Secondly, safety and security. This entails the use of CCTV, automated alert notifications to citizens, abnormal activities detection and real-time information updates are ready when required.

Thirdly, transportation and environment preservation. This objective focuses on reducing levels of pollution, utilizing low-energy street lights and plans to reduce congestion.

Educational facilities. Requires more investment to allow an equal opportunity. Constant learning, online and remote learning and smart tools in classes.

Tourism. Developing a city's resources which can attract more tourism. Citizen healthcare. New technologies can also improve people's health which provide accessibility to adequate, suitable health-care.

III. IMPLEMENTATION AND DEPLOYMENT

A group of experts from various fields are required for mapping out the design and deployment of smart cities. These experts can be from fields of: Economics, Sociology, Engineering, ICT, Policy and regulation.

There are a few frameworks proposed by academic and industrial sources that illustrate smart cities' architecture. Out of the many suggested models, the model proposed by the US national institute is widely adopted. A smart city is a complicated system, sometimes referred to as "A system of systems". The system houses multiple entities that may be people, infrastructure and process components. There are 6 main components of a smart city, which are : Environment, Quality of life, citizens, transport, economy and government. According to a report by the European Parliament Policy Department in 2014, 34% of European smart cities have only one of the above mentioned components.

In order to evaluate smart cities from multiple perspectives, various approaches have been proposed. Some approaches include an urban Internet of Things (IoT) system for a smart city, urban environments, competitiveness and resilience. But for a smart city to be ideally made, several fundamental components must be integrated.

IV. FUNDAMENTAL TECHNOLOGIES.

Smart cities are designed in such a way that involve a number of technologies that can be summarized in table1:

Table- I: shows Examples of Different ICT Technologies for Smart City

Technology	Description and Functionality
Big data	Large amounts of data could not be processed by early developed data management and processing tools. Big data stores data in volume, variety and velocity classifications that allows processes such as capturing, storage, searching, processing, analyzing, and visualization. Functions include reaching an adequate level of sustainability and improve the living standards for all entities of a smart city.
Networking	Network technology allow multiple devices to be connected. Traditional networks such as Bluetooth, ZigBee and RFID. Modern networks such as Wireless network taken place lately Smart buildings Smart water networks Intelligent transportation ,etc.
Internet of Things	Wireless sensors, Street lights, Parking, Infrastructure and maintenance, Air quality, Public safety, Traffic flow,etc. Governments must use IoT to accomplish efficiency, improve their performance, and enhance the lifestyle of its citizens
	Cloud computing technologies enables easy network access to data resources shared. The cloud may be defined as a resource pool that is configured to group
Cloud computing	services, applets and testbeds. People's social interactions will inhibit such resources; A smart city, therefore, must have an IT infrastructure which is a prerequisite in a smart city, from a technical, as well as, an organizational viewpoint. Functionality includes Automatic backup and rigorous authority management, computing resources, data storage resources and network communication resources distributed storage management
Ubiquitous computing	Enables multiple complex computations throughout the physical environment, but hides them from the user. According to 'Lee' There are several roles a smart network functions as, they are: Awareness in content and context, automatic network management, programmability, efficient resource management and ubiquity [9].
Cyber security	Privacy of citizens and government are a considerable challenge in smart cities. Such issues involve people's personal safety. Current smart cities already have to cope with data tampering, malicious code and eavesdropping. Some incidents such as Hacking attack caused 'massive damage' at German steel works. Estonia also faced a full-scale cyberwar. Sabotage of traffic signals in Los Angeles Distributed Denial of Service (DDoS) attacks delayed trains in Sweden.

Integrated sensor systems for smart cities. These sensors are invaluable in any smart control system. Improving a process is done based on the environment it is under, a group of sensors make the control system aware of the surroundings. The sensors collect data and trigger a response process which adjusts according to the system programmed.[10].

Sensors in the table2 are classified as Technical in situ, remote and human sensors. Technical in situ involves environmental sensors which monitor the environment that is used in meteorology and weather forecast. Technical remote involves remote sensors that use satellites for thermal and atmospheric measurements. Human sensors uses people as sensors for flood mapping, noise measuring and disaster management.

Environmental Sensors	Environmental sensors : Monitoring air pollution, Heat detection, flood levels monitoring and other matters related to the environment,etc.
Mobile sensors	Portable applications for disaster management, on-the-go measurements for low-response time scenarios, etc.
Remote sensors	Thermal sensors, Aerosols, airborne optics.
Collective sensing	Managing incidents and disasters, transportation patterns, disease outbreak detection ,etc
People as sensors	Flood monitoring Disaster and incident management Examples (Social media posts on any personal, environmental or any other external abnormalities

Table- II: Integrated sensor systems for smart cities [11].

V. CHALLENGES AND RESEARCH OPPORTUNITIES

In this segment, the challenges smart cities must go through will be revealed. Also any future research possibilities will be put into light.

Table- III: CHALLENGES AND RESEARCH OPPORTUNITIES

Smart City Component	OPPORTUNITIES	CHALLENGES
Government	This includes Smart government, smart buildings, Public safety, smart grid, smart transport, and smart utilities such as CCTV, GPS tracking and incidence-response systems for reducing crime.	Major financial obstacles such as Fluctuation of energy prices, the amount of investment required is generally substantially high, the risk for investing in modern solutions is also unfeasible in certain circumstances.
Economy	Gives rise to more business opportunities and investment of innovative solutions.	Lack of investment due to perceived high risk of cyber-attacks in modern technological models.
Smart citizens	Higher awareness of technologies and power saving features. Hence, increasing the quality of life through virtuous citizens.	The tendency to do bad actions such as Cyberattacks, Violating privacy and confidentiality. Also lack of technological awareness in minorities.
IoT management	Promotes data availability and in synch with the various other components of a smart city.	Keeping hardware updated due to data coming from multiple sources. Overcoming connectivity issues. Waiting for government regulations and policies to permit the use of certain services.
Smart Mobility	Reduced traffic jams, reduced environmental and noise pollution energy consumption.	Electricity consumption in electric cars. Increased population growth increases the complexity of smart mobility requirements.
Sensor networks and human sensors	Flood monitoring Disaster and incident management	Lack of communication infrastructure to link events and monitoring tools. An aggregate method of processing the data.

VI. CONCLUSION

Merits of a smart city improve the citizen's quality of life, as well as, provide the government with more resources to further build its city. All while not neglecting the environmental and personal safety of the public. In this paper, we have defined the concept of smart cities, their components and entities that are inter-related in the system. We have also named the challenges, as well as, the opportunities available that will make establishing smart cities in a large scale more appealing. However, the benefits of a smart city outweigh the challenges, and in order to establish a smart city, developers, engineers and architects must emphasize on certain core fields which are: Data Management, Internet of Things and Renewable energy resources. We also must keep in mind that security and privacy are hurdles that require an innovative solution. All in all, smart cities are the way to go, in their complexity lies the flexibility in satisfying numerous qualitative factors for a modern society. The challenges do exist and cannot be ignored, but they can be tackled through innovative ICT tools.

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