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TOWARD SUSTAINABLE SMART CITIES: CONCEPTS & CHALLENGES

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TOWARD SUSTAINABLE SMART CITIES: CONCEPTS & CHALLENGES

Abstract

The world's urban population is growing enormously, increasing of energy usage, air toxicity, and traffic congestion in urban areas which need a furthestmost effective way for solutions. Smart city as a solution is expected to solve the functionality of urban systems. It needs to improve ICT infrastructure as an authoritative, adaptable, accessible, secure, and flexible one, and improve the quality of daily lifetime, refine citizen's healthiness as well to achieve economic growth and develop the physical infrastructure services to promote sustainable development. This research is a narrative review, kind of methodological approach presented as open research and structured as follows: First section presents the smart city concept by reviewing the definitions, characteristics, and its dimensions. Based on the creation of smart cities, the research aims to identify and investigate the main challenges that smart cities development will face in the coming years by analysing, estimating, and evaluating the available data. It also includes a various assortment of challenges classified under; infrastructure challenges, theoretical, urban design, interdisciplinary, hackers challenges, urban land use, disability of the elderly challenges, the Big Data, technology trap, cultural and democracy challenges, budgetary and cost constraints, and regulations challenges. Besides, it is important to be conscious of security and privacy risks when implementing new systems. One example specifically discussed, the Kingdom of Saudi Arabia smart city practices, provides a general overview of the Saudi Vision 2030. It is enlightened by a brief about "the most recent smart city project in Saudi Arabia", NEOM and illustrates the smart city practices of Makkah, in the light of the six dimensions of the smart city, also studied the city of Amsterdam as it considered one of the first smart cities at the global level. Finally, the research ends with the conclusions and recommendations.

Keywords

Smart City, Technology, Characteristics, Dimensions, Challenges, Security, Privacy

1. INTRODUCTION

At the present time, over 50% of the world’s population are living in urban regions which is around 3.3 billion as the United Nations Population Fund noted and this number was estimated to grow to 70% by 2050 (United Nations, 2019). In Europe, 75% of people already reside in cities, and in 2020 it reached 80% (The EEA European Union, 2021). Our cities are not prepared for that so globally we are in a hard situation. The moves of the people from rural to city areas, besides the rapid urban escalation, led to significant harms such as pollution, transport congestion, poverty, criminality, social services, and education entree to be equal, healthcare, communication issues, security and privacy issues, and the sustainable development of cities.

Therefore, under all the pressures cities essentially need to encourage motivation to reconsider smart cities for solving urban problems using a different variety of technologies and *intelligent solutions*. They must proceed and integrate these solutions to afford superior services, improve quality of life for their people, raise productivity, resolve traffic problems, increase economic efficiency, and settle environmental concerns to achieve proficiency and sustainable development.

2. SMART CITY CONCEPT.

The concept of a smart city is categorized as a digital city or a green city, Nam and Pardo stated (2011), “These concepts can be classified around the Smart City issue considering whether they are focused on technological factors, human factors or environmental factors”

City Concepts focused on human factor: including a creative, humane and learning city which leads to a creative life which builds a skilled economy workforce encouraging information and knowledge.

City Concepts focused on the technology factor: including a digital, intelligent, virtual and hybrid city which has infrastructure and information technologies, collecting data then delivering it to the public through web portal,

City Concept focused on the environmental factor: including a green, eco and flexible city by reducing the chemical and physical risks, diseases and consumption control and balanced with nature, absorbing the impact of danger by resistance or adaptation during crisis. (Monzon, 2015)

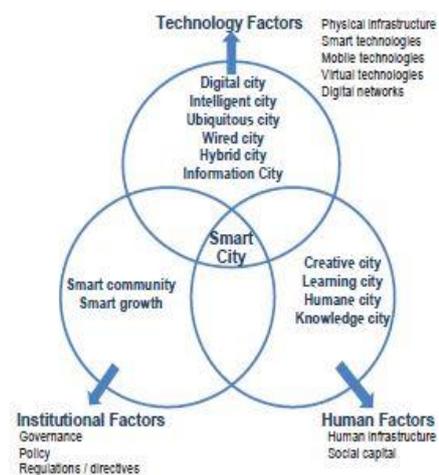


Fig.1: Component of smart city
Source: (Nam & Pardo, 2011)

2.1 Smart City Definitions

Smart cities have several definitions all over the world. The slogan has a fuzzy concept and is used in ways that are not always constant. There is a range of conceptual alternatives so there is no template of framing smart cities or one-size-fits-all definitions. Table 1 tries to show the smart cities’ different definitions

Table 1: Smart Cities Definition and identification of key dimension.
 T- Technological dimension, S - Social dimension, I– Institutional dimension Sources: Adapted from (Albino et al. 2015), (ISO-IEC, 2014), (EP, 2014) and the author

Source	Definition	Dimensions
ISO-IEC have a joint definition (ISO-IEC, 2014).	Smart Cities offer a fresh idea and a fresh approach to city planning, development, management, and smart services by integrating the latest information technologies, including the internet of things, cloud computing, big data, and space / geographical information integration, to facilitate the planning, construction, management, and smart services of cities.	* Information and Communications Technology (ICT) * Environmental Sustainability * Productivity * Quality of life * Equity and social Inclusion *Physical infrastructure
European Parliament (EP, 2014)	- A city may be called ‘Smart’ ‘when investments in human and social capital and traditional and modern communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance’. *A Smart City must be developed based on a multi stakeholder, municipally based partnership	
EU definition (EP, 2014)	A smart city is a community that uses a multi-stakeholder, municipally based cooperation to address public concerns with ICT-based solutions.	* Smart living * Smart living * Smart People * Smart mobility * Smart Governance * Smart environment
BSI. British Standards Institute (BSI) (BSI-PD, 2015)	A smart city is one where physical, digital, and human systems are successfully integrated into the built environment to provide its residents with a sustainable, prosperous, and inclusive future.	Energy, Waste, Water Telecommunication Policing and emergency Education and Training Transport Health, Social Services Housing Environment services Financial and economy
ITU International Telecommunication Union	A smart sustainable city (SSC) is an innovative city that uses information and communication technologies (ICT) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness; while ensuring that it meets the needs of present and future generations, with respect to: economic, social, environmental, and cultural aspects.	Information and Communication Technology Environmental sustainability Productivity Quality of life Equity and social inclusion Physical infrastructure
Washburn.et al. (2010)	The use of Smart Computing technologies to make the critical infrastructure components and services of city-which include city administration, education, healthcare, public safety, real estate, transportation, and utilities- more intelligent, interconnected, and efficient	T
Kourtit and Nijkamp (2012)	Smart cities are the result of knowledge-intensive and creative strategies aiming at enhancing the socio-economic, ecological, logistic, and competitive performance of cities. Such smart cities are based on a promising mix of human capital (e.g skilled labor force), infrastructural	*human capita *infrastructural capital *social capital *entrepreneurial capital
(Giffinger, 2007)	Well performing city in a forward-looking way in these six characteristics [economy, mobility, environment, people, living, governance], built on the “smart combination of grant and activities of self-decisive, independent and aware citizens.”	economy - mobility environment - people governance

Source	Definition	Dimensions
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BSI. British Standards Institute (BSI) (BSI-PD, 2015)	A smart city is one where physical, digital, and human systems are successfully integrated into the built environment to provide its residents with a sustainable, prosperous, and inclusive future.	Energy, Waste, Water Telecommunication Policing and emergency Education and Training Transport Health, Social Services Housing Environment services Financial and economy
(Hall,2000) U.S. Department of Energy Report	A city that monitors and integrates conditions of all of its critical infrastructures, including roads, bridges, tunnels, rails, subways, airports, seaports, communications, water, power, even major buildings, can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens	T
(HARRISON, C.) IBM	The foundational concepts are instrumented, interconnected, and intelligent. “A city connecting the physical infrastructure, the IT infrastructure, the social infrastructure, and the business infrastructure to influence the collective intelligence of the city”	T S
Lombardi et al. (2012)	Run-through (ICT) Information and communications technology with effect on human and social capital and traditional, communication infrastructure, fuel, sustainable economic growth and a high quality of life, management of natural resources, through participatory governance, and environmental issues	T S
(Komninos & Kakderi, 2015)	SCRIBE is a modular for Smarter Cities, include three components: 1.a core model with classes such as events, messages, stakeholders, departments, services, city landmarks, key performance indicators (KPIs), etc.; 2.extensions by domains, such as buildings, transportation, energy, water, etc.; and 3.customizations by city.	T S I
Thuzar (2011)	Smart cities of the future will need sustainable urban development policies where all residents, including the poor, can live well and the attraction of the towns and cities is preserved. Also to have a high quality of life; those that follow sustainable economic development through investments in human and social capital, traditional and modern communications infrastructure (transport and information communication technology); and manage natural resources through participating policies, also should be sustainable, reaching the economic, social, and environmental goals.	*quality of life *sustainable economic development *management of natural resources through participatory policies *convergence of economic, social, and environmental goals

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ISO-IEC have a joint definition (ISO-IEC, 2014).	Smart Cities offer a fresh idea and a fresh approach to city planning, development, management, and smart services by integrating the latest information technologies, including the internet of things, cloud computing, big data, and space / geographical information integration, to facilitate the planning, construction, management, and smart services of cities.	* Information and Communications Technology (ICT) * Environmental Sustainability * Productivity * Quality of life * Equity and social Inclusion *Physical infrastructure
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Cretu (2012)	Two main paths of research ideas: 1) smart cities should do everything related to governance and economy using new thinking paradigms and 2) smart cities are all about networks of sensors, smart devices, real-time data, and ICT integration in every aspect of human life.	T I
Andrés Monzón	A smart city is an integrated system in which human and social capital interact using technology-based solution. It aims to efficiently achieve sustainable and resilient development and a high quality of life on the basis of a multi-stakeholder, municipality based partnership.	Smart Governance Smart Economy Smart Mobility Smart Environment Smart people Smart living
Nam and Pardo (2011)	A smart city infuses information into its physical infrastructure to improve conveniences, facilitate mobility, add efficiencies, conserve energy, improve the quality of air and water, identify problems and fix them quickly, recover rapidly from disasters, collect data to make better decisions, deploy resources effectively, and share data to enable collaboration across entities and domains.	*economic socio-political issues of the city economic-technical *social issues of the environment interconnection instrumentation *integration applications *innovations

2.2 Smart City Goals

1. Achieve and develop the sustainability.
2. Increase the citizens quality of life
3. Improve the city efficiency system (Monzon, 2015)

2.3 Characteristics and Features of Smart City

Dimensions generally organized by six pillars, They work together cooperating between each other, thus, this diversity increases the contribution of each one and creates an outcome for the city’s development as an end result of the interaction effect, impact part of the city in achieving smart city goals and reaching sustainability, efficiency and high quality of life (Monzon, 2015).

They can all be allocated within six main city dimensions used in smart city: Smart Governance, Smart Economy, Smart Mobility, Smart Environment, Smart People and Smart Living (Giffinger, 2007)

Smart Governance: Related to political participation, defined by effective and efficient public administration, quality of public services, contribute citizens in decisions making, strategies and policy perspectives obligate the transparency of governance to make technology obtainable. This creates a coordination between all the activities approved by the municipality by using ICT in e-administrations associated with stakeholders, also to achieve people needs and to develop the public services and raise confidence of community institutions. Giffinger, R. (2007).

Smart Economy: It is a Smart Economy when it brings productions, inventions, innovation and entrepreneurship to organize business procreations in market place, integration into the domestic market, and affordability enhancement to employee needs. Information and communication technologies (ICT) is used to develop e-business and e-commerce, and worldwide integration. Also it is a perfect international ideal prototype to be generally competitive. Giffinger, R. (2007).

Smart Mobility: Smart Mobility affords an efficient, clean and rightful transportation network for citizens, goods and data through technologies it collects and gives the information to customers, planners, managers and supervisors, to have available and accessible services, information and communication technology ICT (Ben Letaifa, 2015), provide intelligent transport networks (CUI & XIE, 2018), also reforming the city transport configurations mechanisms, Improving the multimodality process by coordinating and organizing between different transportation types, using sustainable transport. Electric public busses is an example, carpooling, car-bike combinations and the use of public transport leads to more efficient traffic. (Saba, D., 2020)

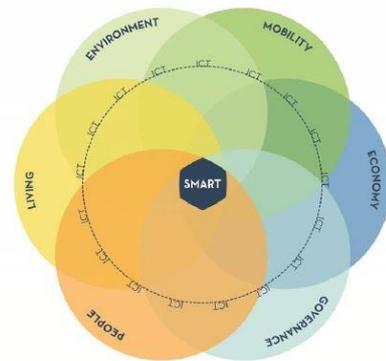


Fig.2: Smart City Dimensions, with ICT as common.
Source: (Monzon, 2015)

Table 2: Characteristics and features of the smart city

Characteristic	Description
Smart governance (participation)	Participation in decision making Strategies and political perspectives Public and social services Government transparency
Smart economy (competition)	Productivity Labor market Flexibility Economic image and brand Innovative spirit Anchorage International Ability to transform Entrepreneurship
Smart mobility (transport and ICT)	Availability of ICT infrastructure Local accessibility Accessibility (inter) national Sustainable, innovative and secure transport systems
Smart environment (natural resources)	Sustainable Resource Management

	Attractiveness of natural conditions Avoid Pollution Environmental protection
Smart people (human and social capital)	Participation in public life Cosmopolitanism Qualification level Learning throughout life Social and ethnic pluralism Flexibility Creativity
Smart Living (Quality of life)	Quality and safety housing Education equipment Cultural facilities Social cohesion Tourist attraction Health conditions

Source: Giffinger, R. (2007). (CUI & XIE, 2018)

Smart Environment: Indicates natural conditions, pollution and resource management (reuse, recycle, resource replacement). Point to collect the data from utility service network, users, city resources, water, air, etc. to create an urban planning action area, and city infrastructure planning besides reaching effective and sustainable urban environment when developing residents' quality of life, environmental protection, active waste management, use of renewable energy sources, and improve the city's ecological systems by using (ICT). (Saba, D., 2020), Giffinger, R. (2007).

Smart People: It is very important that the citizen participates in a smart urban life to add on new solutions affording innovative resolving results since diversity is essentially required to the community. Education is significantly needed to develop this dimension, online courses and distance learning, offered by the cities, provide positive results for the development (Ben Letaifa, 2015) It relays on a level of qualifications and education for the inhabitants, flexibility, creativity, social interactions, and connections. Integration with public life is openness to the world and inclusion of ICT serves increases people's creativity, education and trainings. Giffinger, R. (2007).

Smart Living: Indicates to the different aspects of quality of life. Governments must take in consideration to improve healthcare, safety, culture and living conditions of the citizens. They must also apply intelligent management of services, public spaces and facilities including ICT technologies to develop accessibility, flexibility usages, educational institution, tourism attractiveness, and to create new or improve the existing lifestyles, as well as to clarify the citizens' needs to resolve (Monzon, 2015) (Kozłowski & Suwar, 2021) (Saba & Sahli, 2020)

2.4 Layers of Architecture Smart City

The architecture of the smart city made up of four layers, application layer, the data management layer, transmission layer and the detection layer

To be a smart city, the four levels should be connected and active whenever receiving data. It is a combined multipart method by joining the information and communication technology (ICT) and IoT with city operations and activities.

Technology means nothing without the human element, therefore, people stands at the topmost level over the four levels of a connected city, playing the main part in technology at the very top

The Device Level (Application Layer): The first layer on top is the Device Level where we can find the most visible technologies including (cameras, sensors, beacons, lighting, mobiles, etc...), it mediates between urban citizens and the data management layer and interact directly with citizens. It's for various components belonging to several domains, for the security, healthcare management, industrial management, weather forecasting, grid distribution, and transportation management. (Saba & Sahli, 2020)

The Processing Level (Data Management layer): It is considered the brain of the smart city, implements various tasks of analysis, organizing, managing, intended for the decision making. (Saba & Sahli, 2020) Layer where information from the device level is to be (collected, sorting, treating, secured, and shared the Cloud, Big Data, and the Internet of Things), data analysis generation, graph generation, solution generation, recommendation generation, and control signal, alerts, messages for the user layer. (Patel & Doshi, 2019)

The Network Level (Transmission layer): The transmission layer has several communication networks (Saba & Sahli, 2020), it includes various types of wired, wireless and satellite technologies. It collects data from the base layer (High-speed internet, Wi-Fi, 3G, 4G, 5G satellite, access network: Bluetooth, ZigBee, etc.

The Infrastructure Level (Detection Layer): The Infrastructure Layer is considered the most important role because it controls the rest of the actions of a smart city and the most difficult task because of the great diversity of the data. It is used for data collection in the real world and transferring this information to the network layer. It is the base of the pyramid and works as a foundation, thus deploying sensors, actuators, mobile devices, as well as collecting environmental data such as the location, temperature, humidity, pressure, motion, pollution level, air pressure and also collecting data from the people and machines. (Saba & Sahli, 2020)



Fig.3: The pyramid of Four Levels of a Connected City.
Source: (COLLIER, 2017)

Next generation networks are built using Small Cells, Fiber Networks, Cell Towers (Macro Cells), and Power Grids but they need communication and collaboration between public and private sectors. (COLLIER, 2017)

2.5 The Four Pillars Structure of the Smart city

The four pillars/themes of a smart city are reflected through: physical infrastructure, institutional infrastructure, economic infrastructure and social infrastructure (Mohanty et al., 2016).

The institutional infrastructure; integrates public, private, civil, and national organizations when required to afford action between services. This unification assists citizens to be more reliable efficiently and effectively (Silvaa Bhagya, 2018). Governance is under the institutional infrastructure and contributes in decision making, public and social services, transparent governance, political strategies and perspectives (The World Government Summit, 2015)

Physical infrastructure; Made up of natural resources and man-made infrastructure. The physical infrastructure pillar suggests sustainability of resources to keep city processes for the present and the future (Mohanty, 2016). It is extended to green buildings, green urban planning, renovation of buildings, and smart energy (The Government Summit, 2015)

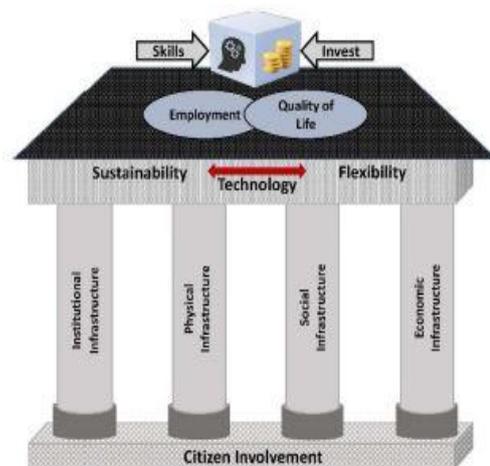


Fig.4: The Four-pillar constitution of smart city.
Source: (Silvaa Bhagya, 2018)

The social infrastructure; Includes knowledgeable assets, human assets, and inhabitant awareness and responsibilities. Using ICT to improve living standards of people is in the social infrastructure pillar. It considers people and their relationships (Nam & Pardo, 2011) and better educated citizens. Specialists in production and the academy stated that social infrastructure is a core pillar for any smart city for its great importance. (Silvaa Bhagya, 2018).

Economic infrastructure; Known as smart economy by stable economic and job growth (Mohanty, 2016) using the e-commerce and e-business to increase the city production, operate ICT and integrate advanced technologies to improve the performance of economic management

2.6 The (IT) Foundational Principles for Smarter City

Smarter Cities are connecting the physical infrastructure, IT infrastructure, social infrastructure, and the business infrastructure to influence the smart of the city and is extended to a virtual city infrastructure. All of them are concerned in order to allow to gather, participate, analyze, improve, and generate decisions based on data (Harrison, 2010). The foundational concepts are instrumented, interconnected, and intelligent.

IBM defined Smarter City through three IT characteristics or dimensions as follows:

Instrumented: Refers to sources of near-real-time real-world data from both physical and virtual sensors.

The combination of instrumented and interconnected systems efficiently connects the physical world to the virtual world, enables the capture and integration of live real-world data through the use of sensors and meters (measure the physical parameter such as pressure, flow, and temperature), personal devices, appliances, Video cameras, smart phones, implanted medical devices, loop detectors embedded in roads, RFID detectors for payment systems for public transportation, parking, water-level monitors, water-quality sensors, electrical distribution and traffic management systems, smart electric and water meters, telematics systems on road, GPS position-reporting systems, mobile telephone and public wireless including social networks as networks of human sensors.

Interconnected: Refers to the integration of those data into a computing platform and the communication of such information among the various city services, to connect systems physically via public and private networks. It also connects many IT software systems used by agencies to manage the operation of the city's services.

Intelligent: Means to analyzing, modeling, optimizing, and visualizing the operation of the service near real time, forward looking, or predictive.

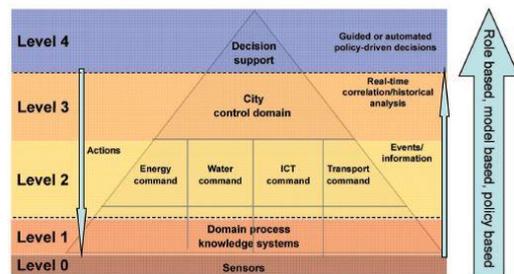


Fig.2: Shows a hierarchical model of the interconnection of systems and services within the city.

Source: (HARRISON, 2010)

To take the sources of information to help make better cities through how the physical infrastructure of the city supports the needs of the citizens for safety, employment, comfort and mobility. Creating the Smarter City by capturing and speed up these flows of information both vertically, within the operation of a given infrastructure system, and also horizontally, between the many different infrastructure systems and using this information to manage the operations (CUI & XIE, 2018).

Fig.5 shows the layered structure of the interconnection which is the Smarter Command Systems. The primary flows of information are upward and downward within individual city services within levels 1 and 2.

Level 3 provides horizontal communication capabilities and is the enablement layer the systems of level 3 provide horizontal communication capabilities and is the enablement layer the “systems of systems” view of the city. (Harrison, 2010)

3 The SMART CITY CHALLENGES

3.1 Economic Challenges

- Creating a smart city essentially needs Information and Communication Technologies (ICT).
- Using the energy wisely and carefully, reducing pollution, dropping the travel cost, increasing the GDP and economic growth, improving tourism, using the garbage compactor on solar energy, using smart meters and monitors for energy consumption, using maintainable waste, getting national and international assistance; all of those require a huge budget for implementation. (Behzadfar, 2017)

3.2 Technology Challenges

- Smart Cities need a wide range of technologies capable of working together to get a compound systems and create solutions. There are many types of technological devices used for sensing, capturing, storing, and using data from multiple types of sources (fixed and mobile). (ISO-IEC standard, smart cities, 2015)
- Technology in smart cities should appear in all aspects and sectors. It can improve quality of life and is essentially needed in the field of solar cells, routers, transparency, urban information sharing, online banking and welfare, etc.,. There exists a global realization of the importance of participation and association of international research centers and companies. (Behzadfar, 2017)

3.3 Management and Administrative Challenges

- Public participation and political decentralization policies are not taking place in some governments or are still at a simple level. Governments should take public contribution into consideration and support citizens with more facilities (Dadkhah, 2015)
- Access to information, open data, transparency, and cooperation of the government and the people are achievements of smart cities. (Rodríguez & -Bolívar, 2015)
- The participation of people in different levels for solving problems is a successful and rich factor in smart cities. (Rodríguez & -Bolívar, 2015)
- Smart technologies are important to achieve transparency, democracy and responsibility in governments, but some totalitarian governments use technology and performance to force down the people. (Greenfield, 2013)

3.4 Theoretical Challenges

- From theory levels to practical levels there isn't a particular program or movement; there are many problems in criteria, methods and standards. (Behzadfar, 2017)
- Countries have no uniform concept of a smart city or its definition or the city's architecture. This means that countries cannot be integrated nor can they shared a smart city environment. So, more theoretical studies are needed to reduce the problems of smart cities. (CUI & XIE, 2018)

3.5 Infrastructure and Operational Challenges

- Technology is improving increasingly and many progressive countries have qualifications in urban areas for making smart cities. But they have weak ICT infrastructures and lack in essential qualities needed, so it is a challenge carrying out the smart city into practice (Giffinger, 2007)
- Improvement of infrastructures and debt are the most significant challenges between inordinate governments. So many companies are trying to postpone paying for years (Mathew, 2015).
- Adam Greenfield defines a smart city as an object, unity and complete knowledge that is not available anywhere (Greenfield, 2013).

3.6 Training Challenges

- Smart city prerequisites to train citizens. (Dadkhah, 2015) Citizens must use technological skills and plan to learn all their lifetime. If residents are unqualified of living in smart cities they will face many problems. (Behzadfar, 2017)
- Some studies specified the indicator sign of education level and the inclination to learn in a lifetime. PC computers' power and control are dominant. (Giffinger, 2007)

- How can a smart city platform be combined with learning, data management and digital libraries which are available as e-government services, and how can it be available to the public on the internet? (Behzadfar, 2017)
- Integration of digital skills and improvements to training courses in all educational levels and training skilled workers to activate smart cities are needed as demand for ICT professionals is increasing, and these personals are lacking in Europe at all levels. (European Commission, 2016)

3.7 Urban Design Challenges

- Smart cities are measured by its characteristics, features, definitions, indicators as well as the methods and tools of making them smart. However, not enough studies have been done regarding the urban design and manufacturing of its environmental quality using smart systems to evaluate smart cities efficiency. (Greenfield, 2013).
- Gaming devices, cellphones, computers and etc. got advanced progressively. But local children parks and their facilities have not had any remarkable development. (Behzadfar, 2017)

3.8 Interdisciplinary Challenges (Linkage between Sciences)

- Experts and professionals from different disciplines are essential and needed in smart cities. But there are challenges in the connections and linkage between sciences, thus also to getting achievements in the sciences fields.
- Recognize and determine the needs of urban planners, designers and professionals who can provide the ideal concepts for smart city development.
- Sharing and interchanging relationships between specialists, engineering, urban planning and other science disciplines are necessary requirements in order to categorize our existing needs, to recommend better suggestions and apply suitable solutions. (Behzadfar, 2017)

3.9 Hackers Challenges

- Hackers' problem is one of the most important challenges in smart cities. If the network security is not covered and protected, they can disturb cities by having control on banking, notifications, transportation, buying issues, etc.
- One solution could be through modification of online and offline networks to prevent hackers to enter the divisions areas (Behzadfar, 2017)
- Make a private confidential access for data so that users can have a secured entry path at work sites from anywhere in the world. This could be done only to confirmed programs so the effect power of hackers will be prohibited (Hatzelhoffer, 2012)
- They can be spying, overhearing, snooping the communication channels, controlling the traffic behavior and the traffic map, threatening the data integrity and confidentiality which causes economic failures affecting urban infrastructure by stealing sensitive data, credentials, software, cryptographic keys, sensors in machines (smartphones, laptop, etc.) and technological equipment. (Mohey El-Din, 2020)
- Hackers understand how the basics of protection mechanisms are designed. They can implement targets to weaken their effects to reduce the algorithms accurateness. (Cui & Xie, 2018).

3.10 Urban Land Use Changing Challenges

- According to World Bank studies, ICT is generating new jobs and making labor markets more inventive and worldwide inclusive (World Bank study, 2013)
- There are many demolished usage sectors as a result of smart cities, even though there have been new sectors and applications.
- New produced usages which are applicable and proper could be problematic. For example, commercial sectors might proceed through online systems. Then this will have an effect on urban space activities.
- The new smart city uses should be defined in order to have a new accurate vision and assessment of the city's land use (Behzadfar, 2017)

3.11 Disability of the Elderly Challenges

- Young people would reduce ICT contribution skills to elderly even though they have limited capabilities of accepting or using technologies.
- According to a study, candidates identified that they wanted to use technology under any circumstances. But in the case of the elderly, they were anxious since it is harder for them to learn programs than for the young generation (Behzadfar, 2017)
- The Elderly did not have any training and are not able to achieve ICT. Helping only the young people is not enough and imperfect. It's difficult for them to follow
- Many gaps and deficiencies can be recognized which is required to manage and adjust to the needs of the elderly. for example (long waiting periods on public transport stops or lack of elevators getting into the platform
- The chance for elderly to move freely across the city, depends on applicable urban planning and easily using public transport (Brdulak, 2017)

3.12 Big Data Challenges

- Smart City, as a “system of systems”, can generate huge amounts of data, Big Data is complex and changing rapidly. Traditional data processing methods, tools, and techniques can't manage that big volume of information.
- The challenges include capturing, curative, storage, searching, sharing, transfer, analysis and the visual issue. (International Organization for Standardization, 2015)
- The main problems of Big Data in the context of smart cities can be shown through the five V definitions: value, velocity, variety, variability, and volume:
 - Data is created in real time, by end result, massive amount of data are difficult to deal with—volume
 - Data is collected from multiple sources (smart phones, computers, environmental sensors, cameras)—variety
 - Data is categorized and stored in several multiple platforms. In general a problem caused from the unused data—also smart city must change the technique of dealing with complex actions and huge amounts of data—velocity
 - Systems of Big Data must afford the data that contained analytical processes, as well as improving smart city applications—variability
 - Want to transform a big bulk of data into business based for big data collection, management, and analysis—value (Amovic & Govedarica, 2021)

3.13 People's Challenges

- People might not accept all positive and negative aspects of a smart city, or might not be satisfied with virtual life, waves in the atmosphere, low network security complications, etc. (Behzadfar, 2017)
- The direct and active cooperation and partnership of all citizens is a challenge. The social integration programs are required to make services accessible to all, to value the needs equally, to have representatives in government, and to improve the living standards (housing costs and services are affordable , disabled citizens support, etc.) (Voda, 2019)

3.14 Technology Trap Challenges

- The challenge was low interactions between people and the lack of care to physical-social aspects of human. Humans want face-to face social relationships and that is a problem if the interface practices are discounted and passed over due to the technology usage. (Behzadfar, 2017)
- The user is always in conflict between participative and worry for privacy.
- The use of internet, smartphones and other devices where lack of clearness, overload of commercialization and information must be observed censoriously and always. It is definite that the benefits of using social media is outweighed in terms of legality, transparency and democratization through citizen participation (Zeile & Resch, 2015)

3.15 Cultural and Democracy Challenges

- Smart city is considered as an important aspect in creation, spreading, transforming as well as destroying of culture. (Behzadfar, 2017)
- Paying attention to native original issues and general culture can be supported by using technology. But lack of awareness to inherent culture of areas possibly will generate new cultures through technology.
- Smart city is a result of technological tools. But it is also an ecological and cultural system (Kumar, 2017). It creates a specific type of relations and a specific culture of the city. A virtual space of interaction has appeared (Rodríguez & Palomino, 2017)
- The relation between democracy and smart cities is the new technological tool. (Kumar, 2017) Further information should be available for more people and should be easily accessible, as well as participation in city's political processes, the distance communication and virtual conversation with local authorities without policies criticism (Ramos, 2019)

3.16 Budgetary constraints Challenges

- Challenge in implementing, maintaining, and even improving smart city solutions needs the funding instruments and procurement scheme.
- Smart cities require new technologies, safety, security issues, and intelligent solutions to air pollution or waste management, which is too costly for the governments to implement.
- The lack of finance may cause a problem in finding and implementing smart city solutions. Must locate accurate financial tools to create smart cities to help reduce the costs (Voda, 2019)
- Cities are facing difficulties in raising taxes, so government allocations are not increasing, they are finding it a hard challenge to manage the finance issue and create a mechanism to fund infrastructure development (World Economic Forum, 2016)

3.17 One-size-fits all approach Challenges

- There is no single or common worldwide solution for smart cities.
- Urban groups challenges such as “traffic congestion, insufficient energy, lack of services, informal dwellings, poor management of natural hazards, crime, environmental degradation, climate change, poor governance, urban poverty, informal economy, and unplanned development” are common in many economies cities but are not in others (Voda, 2019).
- Work in one country might not to be suitable in another. Every country has its own strategic vision of the city development based on the related context, culture, and economy.
- Smart model should include specific requirements for each society (European Commission, 2016)

3.18 New or adapted regulations Challenges

- The speeding up technologically needs a continuous review to the regulation framework. (Voda, 2019)
- What kind of regulation is suitable to protect people and to benefit from the data?
- Two aspects that must be regulated in the digital world: the illegal surveillance and the uncontrolled data use and generation (Caron, 2016)

3.19 Sustainable and efficient mobility system Challenges

- The transportation challenge is the reduction of traffic congestion (Voda, 2019)
- The operating of a multimodal public transport system encourages mobility alternatives that obligate CO2 emission reduction and makes a reachable public transport (Monzon, 2015).
- Utilize traffic signals and smart technologies (e.g. self-sufficient vehicle technology, real-time traffic feedback, smart corridors etc.) to avoid the negative effects of traffic congestion, which is destructing the environment and the citizen's health (Voda, 2019)

4. SECURITY AND PRIVACY CHALLENGES

Security and data privacy measures are major fundamental factors of any smart city structure to ensure trust and data confidentiality.

The great challenge and essential task facing smart cities is how to secure the citizen’s data from being stolen or modified (Farahat, 2019). Whether cities are considered smart or not, technology could be a cyber-war attack targeting city government, residents, and the businesses with all services and infrastructure

- **Data protection;** must be protected from any unwanted action by unauthorized users because a security crack could lead to severe consequences and affect huge sums of people. Operation systems are exposed to risk attacks by hackers and viruses (Visvizi, 2019). So data encryption and access control are essential to ensure data security (Lafuente, 2015)
- **Big Data;** Billions of IT processes produce huge amounts of data. Much of these data must to be collected and deployed in real time, which may possibly be threats concerning confidentiality, integrity, accessibility, protection, and privacy. (Cerrudo, 2015)
- **Cyber security problems and weaknesses;** affect digital technology because of the poor software security, data encryption issues, lack of cyber-attack emergency plans and with the computer response teams, lack of ICT specialists, insecure for the old systems and poor maintenance, and human mistakes or misbehavior of actual or ex-employees.(Kitchin & Dodgeb, 2017)
- **Confidentiality and integrity compromise;** we need two things to achieve confidentiality. First: the verification, which means no one can access data only if they have the authorizations through username and password. Second: privacy means to protect data which is private (Mantelero, 2015)
- **Eavesdropping (Spying Snooping);** it means when the communication between source and end point is unsafe. Any attacker can interrupt the connection and get the data which could be compromised (Pardeshi, 2014)
- **Data loss;** if the data doesn’t have enough security as a result it would certainly be compromised and lost (Mishra, 2015)
- **Availability;** It means that all the services in the whole system obligate to be available at any time to any authentic persons (Arsalan, 2016)
- **Trust and privacy:** includes behavior and reputation which builds trust control (Sicari & Rizzardi, 2015) and makes sure that people and devices in the system accept the services and information with full privacy and confidentiality.
- **Access control and Confirmation;** only verified users and devices have access to other devices or somebody’s data and control (Patel, 2019). Successful mechanisms ensure the confidentiality, integrity and availability (Alexander, 2017)

4.1 Five types of privacy

Privacy has been recognized and well-known as a human right in Europe. Defining privacy is difficult when adapting to these days’ technology where big amounts of private data are collected, processed, and stored. Privacy violations should be clear and defined thus allowing to develop privacy protection mechanisms. Five types of privacy to classify privacy risks are introduced by smart cities can be described as follows:

Privacy of Location: It’s not the position by itself, but the time length-consumed.

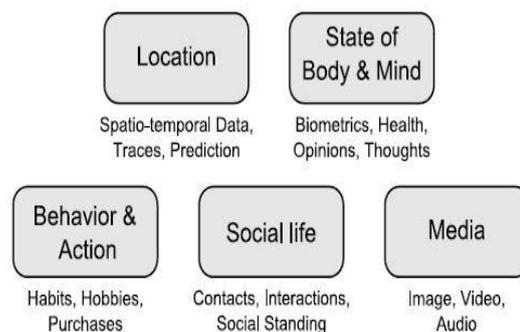


Fig.6: Five types of privacy to classify privacy risks introduced by smart city applications and technologies.

Source: (Eckhoff & Wagner, 2018)

Time and place information: It can expose and make known the person's home or workplace. Assumptions or expectations allow to indicate to other types of privacy such as lifestyle practices, buying behavior, health conditions, or person's social life.

Privacy of State of Body & Mind: Includes a person's characteristics, healthiness, mental statuses, emotions, attitudes, thoughts and beliefs. It can lead him to judged by employers and insurance companies.

Privacy of Social Life: Includes the social connections. For example what was discussed or posted on a social media platform, when and with whom he interrelates and for how long, which specific hospitals dealings with, or political group contact with.

Privacy of Behavior & Action: Includes a user's life interests, activities, hobbies, customs, traditions, habits, his online shopping or uses of credit cards, misusing the information sometimes for an advertisement purposes.

Privacy of Media: Includes images, video, audio, or any information about the user, CCTV, camera shots, or media uploaded to the internet without approval can be consider as a privacy destruction. (Eckhoff & Wagner, 2018)

4.2 Threats and Cyber Attacks on Cities

Cyber-attacks on the internet affect infrastructure and financial issues. But in the IoT, it can damage the life of peoples and cause threats in the functionaries of the overall public (Patel & Doshi, 2019). Cities using high technology are exposed insecure giving opportunity for the skilled cyber-attackers to cause harm, and damages, even they use software bugs that can create significant destruction, also they manipulating simple information which could have a large effect with negative consequence (Visvizi, 2019)

The key technologies and systems that can be attacked

Sensor: Attackers send incorrect data affecting directly the systems, also hacking the wireless sensor technology affecting people's decisions and actions

The public data: Since detailed information is available to hackers, they can control exactly the best time to attacks, depend on real data and real time,

The smart grid: Manipulating encryption problems in Power-line Communication (PLC), or producing worm concept causing damages

Public transportation: providing incorrect information on the system, it has direct effect on people causing delays, overcrowded etc.

Cameras: Reflect the eyes of the city, they can make cities blind, attacking these devices remotely by modifying, adapting format or employing on the weaknesses.

Location-based services: Other attacks are possible at Location-based services, it depends on GPS to get real time informations, hacking by providing wrong data, and it will make the people take incorrect decisions.

Smart Street Lighting: Most are operated by wireless network, which have encryption problems causing street blackouts in a wide part of the city

Traffic control system: Provide fake data or to apply new setting form misusing traffic lights and even by creating an update worm, that will make people take wrong selections

Cloud infrastructure: It's exposed to the public, unprotected from cybercriminals or cyber terrorists, allow simply hackers to attack many cities at the same time.

Social Media: attackers can use the social media as a platform manipulating causing panic in a population or scaring other times (Cerrudo, 2015)

5. TECHNOLOGICAL SOLUTION IN DIFFERENT AREAS

Governments are anticipating to provide a new approach, methods and techniques on all community organizations to achieve an efficient services and increase the public health proficiency standard.

Data and technology are certainly improving cities and changing our lives as well, is it for better or worse? A critically logical questions should be asked, who made that data? what are the risks of collecting so much data? What types of data needed? Who is collecting and gathering it? In what way could that be used or misused? (Luger, 2020)

Smart cities has many potential outcomes, most consequences are positive others have negative impact

Oren Yiftachel (1998) stated about the way that planning can be both progressive and Regressive at the same time “The smart city can progress planning forward direction and also it can regress planning in negative direction instantly at the same time and planners are part of both of these processes” (Yiftachel, 2008)

Smart city has a potential positive issues showed in different areas for example in:

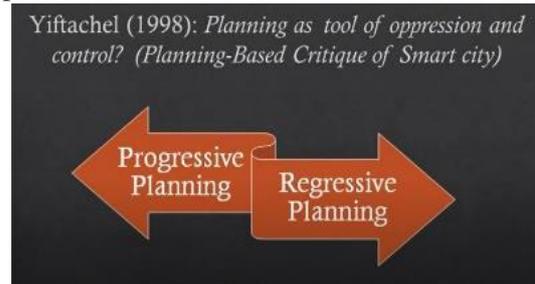


Fig.7: (Planning-Based Critique of smart city).
Source: (Yiftachel, 2008)

Smart Energy: (Using the automation in the grid with a proper distribution, to illumine up the street lights when it should be only if there is cars, and to be shut down if there’s no cars on the roads, in fact that can save a lot of money and energy)(Using Smart Grid software at the actual time) (Using Smart Metering)

Smart Transportation: (Proceeding Transportation sensors, Organizing the Traffic, Combining Transportation) by sharing facilities for example Uber with the public transportation networks supporting and improving the transit system to become available, profession and efficient)(Using Smart Grid software at the actual time)(Using Smart lighting in transit networks or vehicles)(Affording transportation data)

Smart Water: (Controlling water network)(Supervising water distribution)(Managing storm water and urban flood)(Leak detection control)

Smart Building: (Using Green Energy to be more Efficient)(Using the temperature and movement sensors for safety issues)(Joining the Smart Grid)(Controlling the temperature by a central system).

Smart communications: (Afford smart and green issues in all services)(Using an intelligent digital infrastructure for exchanging information, services and Data between all public departments in different areas)

Smart Networks :(Affording IT network services)(Implementing ICT networks and fiber telecom infrastructure)(Providing IoT- wireless sensor network) (Luger, 2020)

5.1 European Initiatives for Smart Urbanism Solutions

European cities are improving technical innovation for climate change through ‘smart urbanism’ initiatives, for example:

- **Set up the European Innovation Partnership for Smart Cities and Communities**, to participate Information and Communication Technologies (ICT) with energy and transport management to provide innovative solutions to improve environmental, social and health problems achieving Europe’s climate change and energy consumption and renewable energy goals
- **Creating a platform** where cities can present their commitments, proceed combinations and exchange knowledge

- **Public-private partnerships;** The Danish Kalundborg Smart City promotes the development of data models supporting low-carbon energy initiatives and closed-loop resource integration.
- Another example the Amsterdam Smart City project combines the work of over 80 industrial and academic partners, analyzing new technologies to allow inhabitants to create a low-carbon city, using smartphone apps to support public awareness on energy, application of heating systems, improve and test the electric vehicles and grid integration technologies
- **Use of Urban environmental sensors,** Smart initiatives owned by local authorities and residents it changes the public interacts with the resource movement, becoming an issue to micro-spatial energy monitoring and carbon reduction for urban sustainability
- **Social innovation;** new way of organizing society a shared vision of sustainability.

For example; in 2012 the University of Manchester applied the Living Lab initiative transformed its campus into an active site for teaching and inventing sustainability, creating the Corridor initiative between public and private, involving Manchester City Council in developing an innovation at the heart of the city. (European Union, United Nations Human Settlements Programme (UN-Habitat), 2016)

6. Case Study Examples of Smart Cities

6.1 Future Vision “KINGDOM OF SAUDI ARABIA”

The objective of this example is to review the smart city practices in Saudi Arabia considering the six dimensions of the smart city concept, providing a general overview of the Saudi Vision 2030 and its role in the Kingdom’s progression.

Transforming Saudi cities into smart

The Saudi Vision 2030 and the national Transformation goals, announced developing 10 new cities across the Kingdom into smart ones away from oil dependency

Operating smart city concepts aims refining urban sustainability, increasing the level of citizens’ happiness, improving the city management productive, reduce the negative environmental impact, attracting the investments, and creating job opportunities. (Al-Hindi, 2017)

The smart city practices in Saudi Arabia implemented in five cities concerning the six dimensions as pillars of the smart city concept, implemented to be smart governance, smart economy, Smart mobility, Smart environment, Smart people, Smart living .

NEOM “the most recent smart city project in Saudi Arabia, “will be discussed in the next paragraphs as an example (Doheim, 2019)

6.1.1 NEOM city

The Crown Prince Mohammed bin Salman announced the launch of NEOM in Riyadh, October 2017 to be the first futuristic smart megacity in the Saudi Kingdom, to achieve new future way of life, fully generated by net zero carbon. It will be built from scratch, its unique location bridging across three countries -Egypt, Jordan, and Saudi Arabia, with the mineral resources, oil, gas, and natural resources such as solar, wind speed, silicon that can be taken out from the sand existed from the desert and used in manufacturing the solar panels which used in energy generating, applying the latest



Fig.8: Saudi Arabia Futuristic City Neom

Source: <https://expressreport.net/>

technology in transportation, digital air, health care, growing and processing food, net-zero carbon houses, renewable energy, online education, and robots industry (Frag, 2019)

6.1.2 Makkah smart city practices

Makkah is spiritually considered a capital of the Islamic faith, it was a small town built with a unique Islamic style, replaced with modern technology towers

Prince Khalid Al Faisal, the governor of Makkah, had an important announcement: “We will employ all kinds of modern technology to make Mecca smarter than any other smart city (Peer, 2012)

Makkah authority has implemented transformations considering the dimensions of the smart city concept.

“*Smart living*” dimension, such as redevelopment of informal areas to modern smart areas,

Also to establishment “Sumuw” a new area in the suburb of Makkah that will be built to the smart specifications and will provide accommodation for about 690,000 people. Design and operate a smart system to monitor and control the lighting network for more than 200,000 traffic lights in Makkah, by integrating electronic system linked to “Supervisory Control and Data Acquisition” (SCADA) satellites.



“*Smart mobility*” dimension, more than 3000 smart cameras all over Makkah, all places are installed to control Makkah streets and adjust the process of crowd management, also creating a smart parking project, rearranging the parking lots in the neighborhoods, operating an electronic payment system, as well smart transportation of pilgrims, and setting up smart systems to follow up and control Hajj works and electronic identification bracelets, as well provide multiple choices of transportation such as airport, sea port, train, metro, trams, and buses



Fig.9: Makkah-smart-city-megaproject.
Source: wordpress.com

“*Smart environment*” dimension, The design and operation of a smart system will help to monitor the cleanliness of Makkah city, using smart containers, smart cleaning equipment, and Automatic Vehicle Location (AVL) follow up system that linked to the geographic information system (GIS) (Al-Hindi, 2017) also reduce dependence on oil and gas and replace them with the renewable energy and sustainable agriculture (Muhammad, F, 2017).

“*Smart economy*” dimension, Advance strategies of diverse economic investments will establish, the new Al-Faisaliah city project, which is located in the western part of Makkah to be an extension to the old city, 2450 km², it will accommodate 6.5 million people by 2050, provide one million jobs in different sectors in health, education, technology, and services. (Doheim, 2019)

6.2 Case Study: The City of Amsterdam

Amsterdam considered one of the first smart cities at the global level, not only at the European level. The first work regarding the Amsterdam Digital City (ADC) that the establishment of an exchange platform for citizens, interconnected and can communicate with each other, exchange opinions and ask questions, became a trading company using e-commerce to finance the social aspect. (Alberts, 2017),

It concerned about environmental issues and, more specifically, about its environmental footprint. Pollution and energy consumption, in 2009, the Amsterdam Smart City Program (ASC) was set up which has strategy aims at better energy management between public and private infrastructure and citizen participation.

Smart Mobility: Aim to create a more efficient, more comfortable transport network with more security. Example of a project under development: Vehicle 2 Grid (Amsterdam Smart City, 2019) use of the solar power grid:

It allows citizens to use the battery of their electric car as a means of storing excess fuel. The energy in a smart grid. In this way, citizens will decide how and when this energy from the solar is used, it may transfer to grid, used directly or also stored in the battery of an electric car for later use for driving the car or for home appliances.

Smart Living Aim to make the city a pleasant place to live and pleasant to work,

Example of project: Energy Management Haarlem (Amsterdam Smart City, 2019) customers had the opportunity to test an energy management system, to inform customers about the energy consumption of each house and the appliance plugged into their home. It allows them to control their consumption online, to turn the devices on or off to save money on their energy bills

Smart Society To improve its human and social capital, the municipality of Amsterdam implemented many projects, for example Beautiful, Smart, Sustainable Wildeman (Amsterdam Smart City, 2019) it involves local residents to improve the Wildeman estate by making it more beautiful, enhance the social and environmental quality of the neighborhood and sustainable

Smart Economy The city have projects for investment attractiveness, in relation to entrepreneurship, productivity, innovation and openness to the international. For example of a project: Budget Monitoring: This project makes it easier for citizens to participate in public policy and spending decisions to be more effective

Infrastructure Infrastructures related to Information and communications technology

(ICT), energy, roads or even water for example of a project Amsterdam Free access to WIFI (Amsterdam Smart City, 2019)

Amsterdam Smart City (ASC) The city of Amsterdam is focusing on the environmental quality, energy consumption, and pollution, made many smart city initiative projects, working on the smart goals. Projects aim to create a four-propeller model (four important institutions): public agencies, social agencies, universities, and research centers and private companies to build a knowledge network at the city level to develop intelligently (Amsterdam Smart City, 2019), the involvement of citizens is important to build smart strategies.

7. CONCLUSIONS

It is remarkable to compare the Smarter City definitions with its main goals, working aligned the architects, urban planners, and city governments.

Smart city is an essential recommended issue to spread on for solving the cities different problems in the last few years, In spite of the effectiveness making a city smart that will produced several challenges.

Identifying the global challenges and their different aspects could be an important step for creating smart cities, therefore challenges were determined, evaluated, and assessed therefore classification were provided. These challenges discussed within various proposed areas; technology, theoretically, infrastructure, people, society, public services, urban design, environmental, cultural and democracy. Providing solutions as a respond to challenges which driven from many schemes proceeded or studies investigated in the approach for making the city smart, which could be helpful, Although new challenges may appear throughout the following years, but future researches can take them into consideration.

So this research has tried to take attention inspecting the challenges facing smart city, suggest practical guidelines phases for solutions by;

- Estimate evaluations of cities that aimed to be smart
- Creating directions, instructions, and recommendation solutions for each challenge,
- Using analysis to determine the connection between the data
- Settle the challenges with technological solution in different areas smart “energy, transportation, water, buildings, communications, networks” to achieve smart city.

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Abbreviation

ICT	Information and communications technology
IEEE	Institute of Electrical and Electronics Engineers
IEC	International Electro technical Commission
ISO	International Organization for Standardization
ITU	International telecommunication union
SCRIBE	Smart Cities Reference Information and Behavior Exchange ontologies
IT	Information Technology
ASC	Amsterdam Smart City Program