EAI Endorsed Transactions
on Smart Cities

Research Article EAI.EU

Smart Cities: Sustainable and Safety Roads Study Model

R. M. Kamal[1,*], N. A. Elsayed[2] and N. G. Gado[3]

[1] Lecturer–Department of Housing & Architecture, National Housing and Building Research Centre HBRC, Giza, Egypt
[2] Lecturer of Architecture and Planning, Modern Academy for Engineering and Technology, Giza, Egypt
[3] Lecturer of Architecture, Modern Academy for Engineering and Technology, Cairo, Egypt

Abstract

Sustainable Satisfaction in Smart Cities has been discussed extensively within the academic context, however; it is argued the fast-urban development and technology, strong trend towards facilitating of urban communities through achieving user's satisfaction. Consequently, urban planners have had to work hard to raise awareness and increase the quality of life among with future development, global goals, which are easily adopted in new cities which includes tools and mechanisms to achieve such goals.

This research aims to respond to the hypothesis by answering the following question: What are the sustainability road elements would that enable achieving a good quality of life and user's satisfaction in smart new cities???

Hence, the challenges of implementing a maximum level of satisfaction to improve smart new cities' performance to meet resident expectation and keep it ahead.

This paper pinpoints through applying various methods, concepts and practices. Using mixed methods offers a sharper insight into the research question and problems than a single methodology approach, theoretical studies includes articles that address relevant subjects. Moreover, by analyse and compare the performance of the chosen international European smart city case studies in terms of pros and cons methods and efficiency.

The researchers plan to apply their research techniques, by suggesting a check list to reach a comparative analysis for improving the current situation, raise life standards in a sustainable manner, which may help the New Egyptian cities those based on the principle of Artificial Intelligence (AI) to face any challenges and improve their opportunities, through a comprehensive and effective management system.

Keywords: Smart Cities - New Cities - Sustainability - Development Goals - Quality of Life - User's Satisfaction

Received on 10 December 2019, accepted on 19 May 2020, published on 21 May 2020

doi: 10.4108/eai.13-7-2018.164662

*Corresponding author. Email: rhmokamal@yahoo.com

1. Introduction

The main idea of the smart city can be back traced to the early 1970s, since the Community Analysis Bureau started using computer Technology for collecting databases, cluster analysis and infrared aerial photography, collect data, issuing reports and direct resources to the field that most important for fighting off potential devastations and reducing poverty.[1]

A smart city's success depends on its capability to have a strong relationship between the government (bureaucracy and regulations) and private sector. It is necessary cause most of the work done; is to create and maintain a digital, data-driven environment occurs outside of the government. Surveillance devices include sensors, cameras and server for high traffic streets could be supplied from different vendors.

As the high population density within cities continues are keeping grow, the necessaries for these urban areas to accommodate such increases are getting more essential by making and help infrastructure to become more efficient. Smart city applications can enable these improvements, advance operations and improve the quality of life for residents.

Smart city applications empower urban cities to discover and make new value from their current infrastructure. The enhancements made to encourage new

income streams and operational efficiencies, helping governments and residents save money.

However, several major characteristics are used to indicate city's smartness. These important characteristics include:

- Infrastructure Technology.
- Environmental activities.
- High functioning public transportation framework.
- Confident sense of urban arranging and planning.
- Utilize Human Resources (HR) to live and work inside the city.

However, the primary goal of this smart city is to build an urban environment that yields a high quality of life, performance for to its residents while also generating overall economic growth. As a result, smart cities major advantage is considered as their ability to facilitate and increased delivery of infrastructure services to its residents with less cost. The research aims to highlight the comparative analytical approach reviewing some European and local experiences in order to monitor the pros and cons of each of them.

In achieving the objective of the study, the remainder of this paper is organized as following, Figure1, which explains the methodology and sequence of search steps. This framework will guideline planning and urban development processes in new smart cities in Egypt towards sustainability, achieving the principles of quality of life and the user's satisfaction.

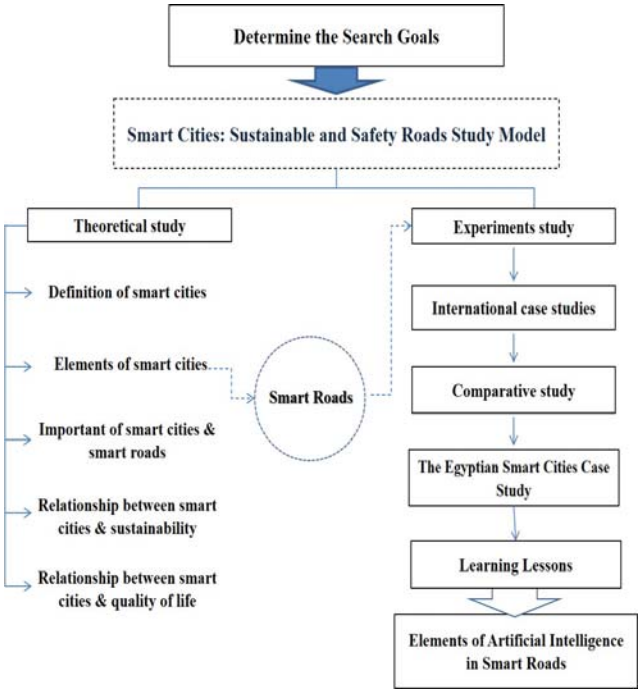

Figure 1. Research Methodology

2. Theoretical study

2.1. Smart Cities Concept

Several approaches in defining smart city are considered. In general, 'smart cities are cities that use information and communication technologies to increase operational adequacy, share information with the public and upgrade the quality of government services and resident's welfare. [2]

A Smart city is an urban area that uses different types of electronic Internet of sensors to collect information and then reuse analysis and prudence data gained from it to manage assets, resources and services effectively.[3]

A smart city is a nomination given to a city that combine information and communication technologies (ITC) to promote the quality and performance of urban services alike energy, transportation and utilities in order to reduce resource consumption, waste and overall expenses. The general aim of smart city is to improve / enhance the city quality of living for its citizens through smart technology. [4]

While the exact definition varies, they all agreed in the goal of achieving sustainability in urban communities, in addition to the overarching mission of smart city to improve the quality of life for residents by using data analysis and smart technology.

2.2. Smart City Component

There are various elements that describe the city to be considered as smart. Such cities are supported by different types of technologies, includes:

- Information / communications technology (ICT)
- Connected Internet of Things (IoT) network by using the physical devices.
- Geographical information systems (GIS)

Smart cities utilize their web of connected IoT devices and other technologies to achieve their goals of improving the quality of life and achieving economic growth. Successful smart cities follow four steps:

- **Collection:** gathering data in real time throughout Smart sensors
- **Analysis**: Information collected by the smart sensors is determined in order to draw significative insights.
- **Communication**: The analysis results phase is studied with decision makers through strong communication networks.
- **Action**: Cities use the insights drawn from the data to find solutions, optimize operations and guideline management to improve the quality of life for its residents.

These technologies may vary; however, all works together to collect and contextualize huge amounts of information that can be used to improve the components and systems running within a smart city.

2.3. The importance of smart cities/smart roads:

Urbanization is predicted to increase even more in the near coming years. The United Nations reports that about 55% of the total populace right now resides in an urban area or city; this is set to rise 68% by the coming decades. The smart technology will assist growth for city's sustainability and improve efficiency for residence welfare and government efficiency in urban areas in the coming years. Particularly population increases show that almost all future population growth will occur in urban regions.[5]

With the increases of population in Egypt, 104 million, according to the latest analysis conducted in 2017. In conjunction with the increase in life requirements and needs, the New Urban Communities Authority has launched the fourth generation of new cities, which are planned based on Artificial Intelligence (AI). The number of 4 Cities have been launched as a first stage for now, while 20 other smart new cities are being adopted to be included in the coming plans of the Authority.[6]

This paper focuses on the element of smart roads as one of the most important components of smart cities in supporting management, control, organization and connecting parts of the city as having the capability to define crises and disasters. [7] As well as energy saving, security and convenience for users. [8] This importance is also due to the problems faced by most Egyptian cities as traffic jams on all levels of road networks, especially at peak times. The figure shows the possibility of using smart networks in ways to remedy and solve the expected problems before they occur, Figure 2.

Figure 2. Smart city management and control through smart road network

2.4. Fostering sustainability with smart cities

Sustainability is another major facet of smart cities, which its achievement based on four rules includes environmental, urban, economic, social and administrative sustainability. While cities already present environmental advantages, the availability of smart road networks, including technology-based tools and devices, will help in sustaining cities. One of the most there most important methods to be described smart are:

- **Energy Saving elements:**

Where the operation of smart traffic systems that include follow-up traffic to work traffic signals in accordance with traffic congestion, in order to provide immediate traffic information to road users such as traffic sites or traffic accidents in addition to displaying messages and instructions, important traffic safety tips to increase traffic management efficiency, Figure 3. In support of environmental and economic sustainability, the sensitive LED technology is used to provide energy consumption as needed, and even to support some methods with solar cells that produce energy and thus reduce carbon emissions. As well as environmental monitoring devices and climate sensors as shown in Figure 4 as one of the smart columns' models used, including smart monitoring devices connected to the main network on the road for collecting and analyse data.

Figure 3. Example of how to display road guidance to increase traffic management efficiency.

Figure 4. Examples of smart columns used by smart methods.

- **Surveillance devices:**

Through surveillance cameras, sensors where follow-up and reporting traffic system failures also coordinating with maintenance department for further repairs, when needed. The traffic electronic panel's operation as well as the programming of traffic signals within the central signal control system, as well as following up on advertising campaigns, support the (GIS) to serve all organizations, departments and authorities. Moreover, control of the main gates, entrances and collection of fees as shown in Figure 5. It also monitors traffic violations on smart roads, and police can then use the surveillance cameras installed in cases of crimes.

Figure 5. Elements of monitoring and control through the main entrances by smart methods

2.5 Relation of smart ways with improving quality of life:

Beginning in the mid-20th century, scientists realized that the quality of life is not only material wealth, but many other factors also to be considered as: health, education, freedom, and luxury. As the term quality of life interest began to understand and interpret the relationship between the population and the built environment surrounding them, Then, it evolved in the nineties through some large research center to study the quality of life of individuals in cities and develop the theoretical approach to quality of life and methodologies used to measure and evaluate. UN, HABITAT then issued the City Prosperity Index where the quality of life was considered from the basic dimensions for measuring urban prosperity.[9] Whereas the road network is one of the components of the constructed environment that the population deals with, and most importantly because of direct friction and daily use. The more technology and smart applications the system involves, the higher the user satisfaction is.

3. International Examples of Smart Cities

While numerous urban cities over the world have begun implementing smart technologies, still a few stand outs as the uttermost ahead being developed.

About of the new smart city projects is concentrated in the Middle East and China. Reykjavik and Toronto were listed beside Tokyo and Singapore as some of the world's smartest cities. in 2018

Regularly, thought about the best quality level of the gold standard of smart urban cities, Dubai, United Arab Emirates, smart city technology is used for traffic routing, parking, infrastructure framework and transportation. The city likewise uses tele-medicine and smart medicinal healthcare, just as smart buildings, smart utilities, smart education and smart travel industry.

3.1 The United Arab Emirates, Dubai City Experience

Dubai was chosen as a model for the experience based on being an Arab country similar in general circumstances with Egypt as well as being a smart and sophisticated city throughout the Middle East.

Intelligent Traffic Solutions (ITS) [10]

- Preparing and design, electronic traffic systems using smart traffic systems, that can achieve safe, effective and smooth transport within specific schedules and budgets.
- Preparing studies and design smart traffic system, which includes suggested studying traffic systems for proposed sites, designing traffic systems' communication networks and e-linking, supervising implementation of the traffic works, in addition to the implantation of toll collection system.
- Operating the smart traffic systems, which include observing the traffic movement in the emirate of Dubai through activating surveillance cameras and sensors, effective operation of the traffic signals lights that aligns with roads, congestion levels, following-up and reporting traffic system dysfunctions and failures', to coordinate with the maintenance department to repair damages caused, operating electronic traffic display panels and programming of traffic signals within the centralized signals control system.
- Following-up, advertising and induction campaigns which presents all about intelligent traffic systems and raise awareness among citizens about these systems.
- Developing, designing and sustaining (GIS) to serve all Roads and Transport Authority's (RTA) affiliates, agencies and departments. Also, design, integrated, centralized geographic database to be implemented and managed, in addition to coordination with all other concerned departments, Government agencies and other stakeholders to gather geographical data and process it, in order to be stored in central databases as pre-approved standards.

- Receiving all traffic information and data relating to the movement and set up traffic databases.
- Assessing and evaluating systems that will be purchased by the Traffic Department and setting necessary standards to be met in the software and hardware related to (GIS) and in line with the latest international standards.
- Meeting the needs of concerned departments for pre-packaged software and in-house developed applications to provide accurate information that through which geographic data can be updated, propose and implement training programs about (GIS) 's services and software.
- Establish standard specifications for the (As built drawings) and other data, in addition to help the departments in setting terms of the projects in the parts related to traffic data and Geographical and maps sections.
- Coordinating with the Authority's Information Technology Department of the RTA and following-up requirements of the e-government in areas relating to (GIS) and the development of information security, as well as information distribution policies.

Projects:

Linking light signals with Traffic Control Center using 3G technology,2015.

The project includes interfacing all optical traffic signals in the emirate (408 intersections) with the Traffic Control Center via 3G technology. The venture is part of the Government of Dubai initiative to transform Dubai into a smart city. It includes replacing the cables/ wire line used to connect light signals to the Traffic Control Center in Dubai with a wireless network, just as associating detached signals with the Center utilizing 3G technology.[11]

The new framework has high convenience & efficiency and is effectively maintained. It wipes out the lag in the timing of light signals and is viewed as a cost-efficient compared to the past situation, which required an escalated cable infrastructure, phone lines to run the service close by each traffic light signal.

LED power saving technology in streetlights, 2014. [12]

The project is crystalised in the use of LED light technology in streetlights, aiming the aim of RTA to achieving and generate power saving of approximately 380,368 kWh/year, and thereby reduce carbon dioxide (CO2) emissions by 163.6 tons/year. As part of the authority's (RTA's) initiatives towards saving power consumption and lift the profile of the Emirate in driving the green economy and support practical sustainable improvements of projects and the business sector.

The work is ready for action in supplanting the lights of the current traffic signals progressively by LED lights empowering the saving of about 1 million kWh per year and decreasing CO2 emissions by 430 tons/year while following the full accomplishment of the project. with more than 20% of the project works under Phase I have been finished and the whole project is set for full fulfilment by 2018. It is noteworthy that, the RTA rolled out 32 power-saving initiatives in 2014, including 8 action in corroboration of the green economy as part of its commitment to upholding government efforts.

Smart parking inspection Application,2019 [13]

The new application allows parking inspectors in the Emirate to rapidly distinguish vehicles in breaking of the law governing the use of public car parks in the Emirate of Dubai. The advantages of the new application contribute in raising the efficiency of open public parking inspectors in the Emirate of Dubai, in addition, raising the productivity of work filed.

The new smart parking inspection application has a gathering of smart & technical features characterized by several smart technical specifications, including information storage of vehicles in committed of the law regulating public parking. Alerting observer to take suitable action in respect of violating vehicles. It insight fully positions, vehicles incompliant with the rules and increasing the quality of images taken of such infringing vehicles, which would reflect positively in, turn on the speed of reacting to complaints and marking them off in a timely closure.

Adoption of water flow technology to remove ground marks and dyes spilled on the streets, 2015 [14]

The project revolves around the launch of a modern technology take off the recent water jet blasters using cutting-edge technology in removing markings and paints spilled on the streets. This system is the most developed in its field regarding of speed and performance, just as being environmentally friendly.

The Authority is the region's in the van in using the water jet flow technology to remove markings and paints spilled on the streets. This ground breaking technology was previously limited use in removing rubber deposits materials left from aircraft tires due to friction with runways; especially after the successful experimental use of this new technology ITS first trial in 2010.

Removing of road markings and spilled paint through water jet blasting technology and the re-sucking of used water is environment-friendly and does not inflict any harm to the public health compared to the old traditional method of singing the sand flow mechanism. Furthermore, the new technology is inexpensive, speedy and free from passive impacts on the flow of traffic as it does not demand traffic transformation.

This technology is also described by high speed equalling 10 times the speed of the traditional sample and it is notable that RTA is providing to utilize this service to contractors and another entity upon request at competitive prices.

Completion of 65% of Intelligent Traffic Systems expansion project

Roads and Transport Authority (RTA) announced that the completion rate of the Intelligent Traffic Systems Expansion Project had reached 65%. On completion as this project will broaden the scope of intelligent traffic systems in support of making Dubai the smartest city in the world. [15]

The project will expand the coverage of Dubai's roads by Intelligent Traffic Systems from the present 11% to 60%, cut the time of detecting accidents and congestion build-up on roads, hence ensuring a quick response.

The Authority had started the installation of new Dynamic Messaging Signs (DMS) on main roads to relay instant traffic information about road condition to motorists. The project entails the construction of 112 Dynamic Messaging Signs fitted with the latest technologies at selected locations on Dubai's road network as well as around mega-event spots, such as Expo 2020", Figure 6.

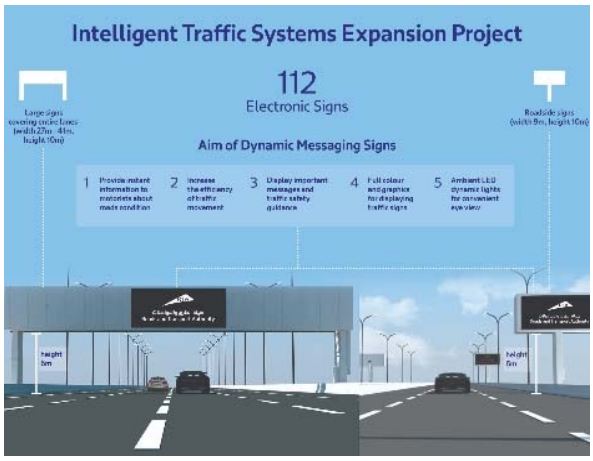

Figure 6. Intelligent Traffic Systems expansion project

These signs will provide immediate traffic information about road users such as congestions, accidents, instructions and tips related to traffic safety. For enhancing the efficiency of traffic management, there is two types of signs depending on road classification, number of lanes and traffic volumes. The first type of signals is those installed on roadsides, while the second are large signs that cover entire road lanes. RTA has completed the installation 18 panels and work is underway to complete the rest panels according to the project schedule.

3.2 Case Hamburg City in Germany Projects:

Hamburg, Germany to test first smart road in Europe

Hamburg, Germany has been chosen as the first location in Europe for testing of smart roads to begin. The Hamburg Port authority and Cisco built the section of road to make the first smart road a reality. The roadway took four months to work close to Hamburg's docks and the road lanes, three streets and the Kattwykbrucke connecting bridge.

May 2015, the road has been opened and its trimmed with cameras and sensors mounted to light posts along the road. The four segments that make the road smart enclose smart lighting, smart traffic, smart environment, and smart sensors. The smart lighting has heat sensors and only turns on when a person walks or rides by on a bike.

As the pedestrians pass by the lights, they turn off behind them to save power. The smart environment is a series of environmental sensors that transmit data via WiFi to let monitors keep an eye on the environment near the port. Smart traffic features use management features to improve and optimize traffic flow. If there is a hold up on the road, it is recorded, and information is shared with authorities immediately.

The cameras in the system don't record faces or vehicle registration information, that data is blocked on the video recorded. The bridge area is a vertical lift bridge to allow ships to pass and is 290 meters long. The bridge lifts about once every two hours and takes 20 minutes to go through its complete cycle. The smart sensors help the bridge to operate smoothly and prevent any shipping delays to the port. The smart road will be tested until April 2016 to gather data to determine the impact it has on traffic and efficiency. [16]

Cisco and Hamburg city are well on way to building first-ever smart road

About a year ago, Cisco and the Hamburg Port Authority (HPA) had got together to build the world's first ever smart road. The new method called smart ROAD project, would be used to monitor and manage city roads.

The smart ROAD 'Proof of Concept' objective to enhance resource management, traffic overflow, infrastructure condition and environmental management, utilize an Internet of Everything (IoE) concept with accurate information and data analysis. Prudence gained out of this would enable Cisco, HPA and ecosystem companies to decide on a broader improvement of such solutions in the Port of Hamburg.

Today, this initiative was updated with fresh information on exactly how the streets around Hamburg's port would be transformed.

Traffic Management assists the port road administrator with monitoring road traffic. Occurrences are identified automatically, and the port road chief officer is notified to coordinate with different authorities.

Structural Sensors give accurate data on the state of dynamic infrastructures as an example, the Kattwyk Lifting Bridge, empower the technical maintenance

department to precisely and predictably the upkeep plan and repairs.

Environmental Sensor transfer data that are utilized to improve investigation of the environmental situation in the port territory.

Smart Lighting upgrades safety for people on foot and cyclists in the port and spares at the same time.

All sensors and systems involved in this experiment are associated with an exceptionally secure network infrastructure. Data is processed by examination programming, and findings are made available via a centralized, incorporated dashboard. Cisco likewise sets up a complete security structure for the entire establishment that gives visibility into safety and security and empowers the port administration to act continuously.

The smart ROAD is a consequence of the Memorandum of Understanding (MoU) marked between the City of Hamburg and Cisco in April 2014. Accomplices in the smart port ecosystem are Philips (intelligent lighting), AGT International (analytics software), T-Systems (Deutsche Telekom's IT benefits, services and consulting division), World Sensing (observing and sensors) and Kiwi (video investigation and anonymization).

"With smart ROAD, HPA is piloting an integrated concept of the Internet of Everything for the first time, with various relevant use cases for the port and the city, running on a real infrastructure".

"Smart ROAD is a key step in making the vision of the Internet of Everything a reality". [17]

3.3 Comparative Assessment Model for the International Smart Cities Case studies

Through the previous theoretical study and analysis of (Dubai City and Hamburg City), a number of elements have to be taken into account in future plans that will provide intelligent/ smart road networks that support and positively affect any new smart and sustainable city as follows, Table 1:

Table 1. Comparative assessment model for the International Examples of the smart cities

Smart Road Support Elements		Sub-elements	Dubai City	Hamburg City
Energy saving elements (Preserving the environment)	1	LED	●	●
	2	Solar Cells System		
	3	Increasing the efficiency of the road Infrastructure	●	●
	4	Climate sensations		●
Security supports	5	Surveillance cameras	●	●
	6	Smart dashboards (roads, traffic safety, visibility, etc.)	●	
	7	Emergency Services	●	●
	8	Central signal control	●	●
	9	Central control of main gates and entrances		●
	10	Central control of toll stations		
	11	Security control (crimes - ...)		●
	12	Road flow and re-pull technology	●	
	13	Monitoring traffic violations	●	
	14	GIS-GPS	●	
Luxury support Elements	15	Road Commercials screens	●	
	16	Sound System		
	17	Weather information (temperature - humidity ...)		
Intelligent Applications	18	Parking lots and alternatives	●	
	19	GPS	●	●
	20	Use of vehicles electronic traffic boards	●	

4. The Egyptian Smart Cities Case Study

As for Egypt, we find that it has recently taken its first steps towards intelligence in many different fields in parallel with global trends. Perhaps our concern is to discuss main roads, projects, developments as the Suez Road, as well as planning and design for the new smart and sustainable fourth generation cities, that will be fulfilled in the coming covenant. Mostakbal smart city, considered as one of the demonstrated models, located in East Cairo, the capital, on the Cairo-Ismailia desert road, which is considered as the connecting link between (the new administrative capital, New Cairo, Madinaty and Shorouk), Figure 7. [18]

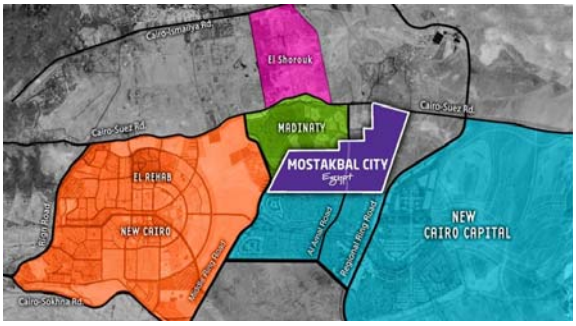

Figure 7. The Mostakbal City location

4.1 The Mostakbal City Experience

The new Mostakbal City of is one of the sustainable eco-friendly cities, as it depends on solar lighting, spacious green spaces and good natural lighting and ventilation. Its road network is also designed to support Artificial Intelligence, increasing the chances of raising the quality of life for users.

The Mostakbal City Phases

Are divided into five phases, the first one is the best area to attract the population, while the second phase, extends on an area of 1715 acres, contains a lot of services and facilities such as health, administrative, commercial, and Entertainment services. As for the third, fourth and fifth stage is residential compounds, Figure 8. [19]

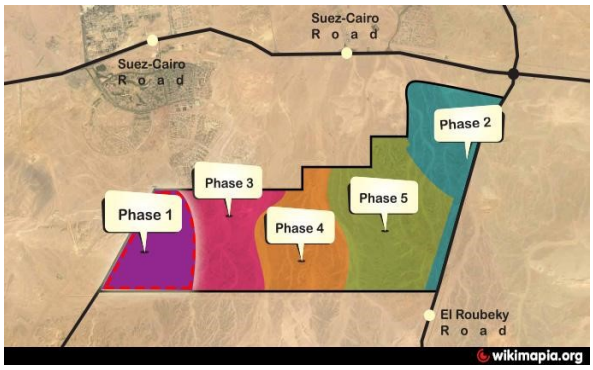

Figure 8. The Mostakbal City phases

A package of smart systems has been identified for the city's implementation, such as:

- Use smart systems to control the road lighting network.
- Installation of internal surveillance cameras throughout the city.
- Use of control systems for the entry of individuals and cars to the city.
- Use control systems to manage parking lots.
- Use ITS smart traffic light control systems.
- Use internal radio broadcast control systems to make advertisements/ calls/ announcements throughout the city, or to play music in public places and park area.

From the above, the elements that were extracted from the aforementioned experiments and from the theoretical study can be applied to the Egyptian experience represented in the Mostakbal smart city and extent its achievements to various divisions through the following check list, Table 2:

Table 2. Mostakbal City Assessment Model Check List

Smart Road Support Elements	Sub-elements		Mostakbal City
Energy saving elements (Preserving the environment)	1	LED	√
	2	Solar Cells System	√
	3	Increasing the efficiency of the road Infrastructure	√
	4	Climate sensations	
Security supports	5	Surveillance cameras	√
	6	Smart dashboards (roads, traffic safety, visibility, etc.)	
	7	Emergency Services	√
	8	Central signal control	√
	9	Central control of main gates and entrances	√
	10	Central control of toll stations	
	11	Security control (crimes - ...)	√
	12	Road flow and re-pull technology	
	13	Monitoring traffic violations	√
	14	GIS-GPS	√
Luxury support Elements	15	Road Commercials screens	√
	16	Sound System	√
	17	Weather information (temperature - humidity ...)	√
Intelligent Applications	18	Parking lots and alternatives	√
	19	GPS	√
	20	Use of vehicles electronic traffic boards	

5. Conclusion

Smart City mainly depends on modern technology and how it can be applied at all levels of the city, especially the roads and traffic through:

(i) Preparing & implementing intelligent traffic studies and designs concerning intelligent traffic system, which comprise studying suggested traffic systems' sites, designing traffic systems' communication networks and e-linking, overseeing implementation of the traffic works, in addition to the implantation of toll collection system.

(ii) The design smart applications, technology appropriate to the size and density of the city, which contributes to reduce the traffic congestion daily rates such as the application of new by parking lots.

(iii) Connecting Light signal networks to a wireless system based on 3G technology to follow up its work, to avoid breakdowns.

(iv) Applying GIS system on all geographical databases for roads with a maximum use for traffic, as if to know the congestion rates, as in google maps app.

(v) The primary goal of a smart city is to preserve the environment keep it sustainable for future generations

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