



## **Smart Sustainable Cities — Vision and Reality**

### **The Egyptian Context as a Case Study**

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#### **Abstract**

Smart cities are boosting sustainability. It is an urgent and global trend. The study addressed the Smart Sustainable Cities (SSCs) considering the recent local and global constraints. It focused on the Egyptian context as a scope because of the absence of this trend in it, despite its potential opportunities.

The paper was divided into two sections; the first was a theoretical approach to the SSCs definitions and concepts. It also framed the SSCs skeleton. Then, the SSCs planning and management's guidance followed this approach. Moreover, the paper pointed out to some experiences in the developing countries and the Arabic context.

The second section was the applied study. It aimed to develop a road-map about embarking the SSCs in the Egyptian scope, as a step to transfer the vision to reality. Then, it identified the local challenges and opportunities, followed by the key pillars needed for that transformation. Finally, the paper extracted the actions required to transforming the Egyptian cities to be smart and sustainable in the reality.

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#### **Keywords**

Smart Cities; Sustainable Cities; Smart Sustainable Cities; Egypt.

## **1. Introduction**

Nowadays, smart cities are emerging in many countries to handle urban sustainability issues. It tries to solve many essential problems like traffic, pollution, crowding, energy, water, and poverty by using Information and Communication Technology (ICT).

The pressure on resources and the size of the challenges that cities face needs to evolve solutions to boost the city's livability. It needs a citywide secure, smart, and flexible transformation. Adopting ICT transformation is a key choice that states should rely on. That mitigates many of the risks and challenges they are facing. So, government leaders should build up a road-map for building smart cities. It harnesses the capabilities of the integrated ICT. It extends to not only create real social, economic, environmental opportunities, and save lives, but to achieve sustainability. So, SSCs choice is no longer just an option but essential.

In Egypt, SSCs as a notion is still new. So, this paper is not set for technical people specifically. However, it meant the governmental chiefs and policymakers at the highest level in general, and in urban development specifically. It aims to clear the Egyptian SSCs vision by giving guidelines for their leaders about the shifting. Then, it should set a strategic plan for the future of urban development to the smart cities age.

The paper comes in two sections; the first is to deduce and analyze the vision. In addition, the second is to develop a road-map of embarking the SSCs in the Egyptian scope. Then, the paper deducts the two key pillars of the transformation and the actions required, as **fig. 1** shows.

## Method

This research is a qualitative study. It assumes the traditional handling of the Egyptian urban development. There is a lack of the smartness features compared to similar cases in the regional and international context. So, the paper used the following methods:

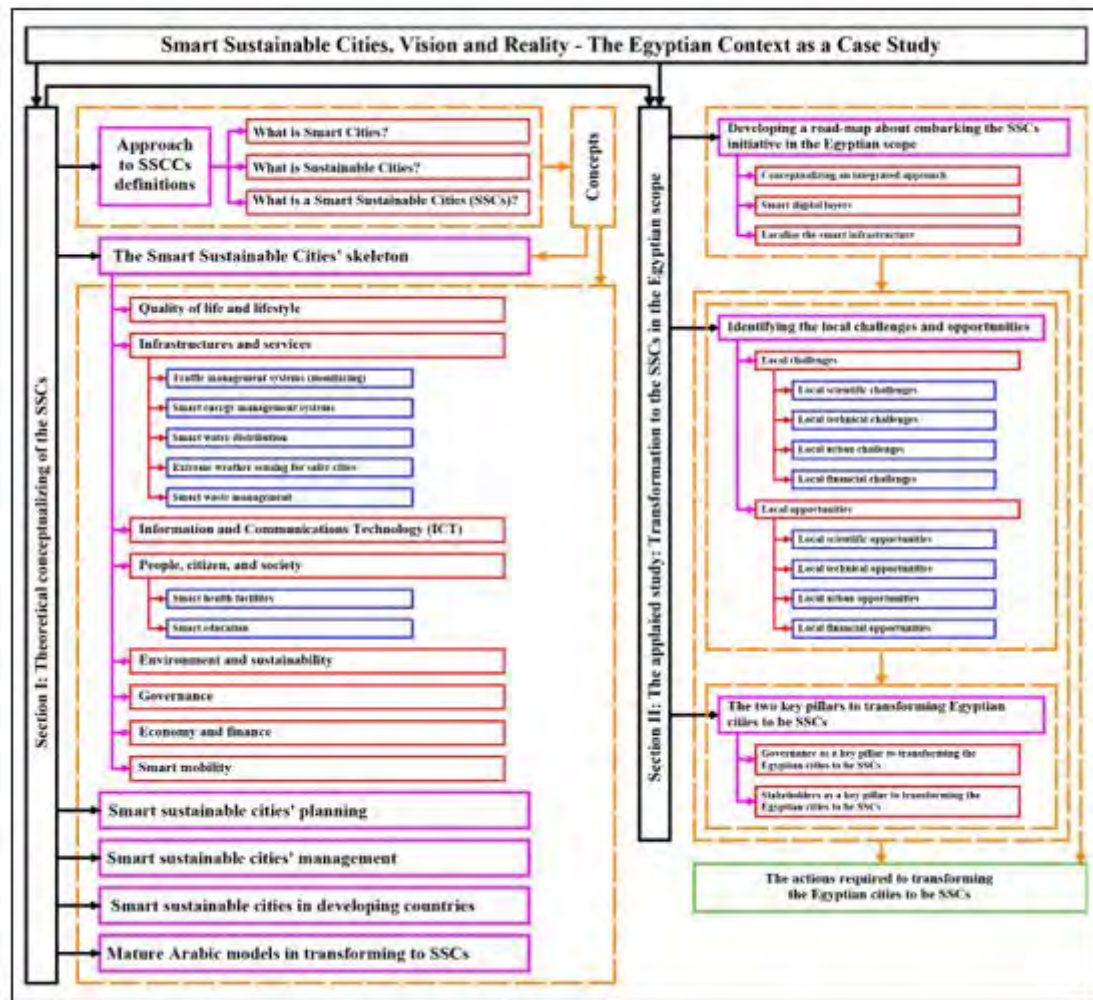


Figure 1. The research skeleton

- a . Inductive method: to address the definitions and concepts. Then, it induces the skeleton of the SSCs, planning, and management.
- b. Applied method: to develop a road-map about embarking the SSCs in the Egyptian scope and identifying the local challenges and opportunities.
- c. Deductive method: to conclude both the two key pillars needed for the transformation of the Egyptian cities to be SSCs and the actions required for achieving.

## 2. Theoretical conceptualizing of the SSC

This comes in six axes as follows:

## 2.1. Approach to SSCs definitions

This approach induces the following definitions and basics:

### 2.1.1. What is Smart Cities?

It supports the wisdom of the urban planning, construction, management, and service. It relies on the ICT, internet, cloud computing, big data, integration of spatial geography information, and other new-released of info technology. On the other hand, the smart city definition regarding governance points to the organization and administration sides.

Smart city term cannot be used for defining a city as a whole. But it discusses its various aspects like inhabitants, environment, economy, governance, communication, and transportation. So, it can define the smart city along six main axes. These are the smart economy, smart environment, smart government, smart living, smart mobility, and smart people, as shown in **fig. 2**

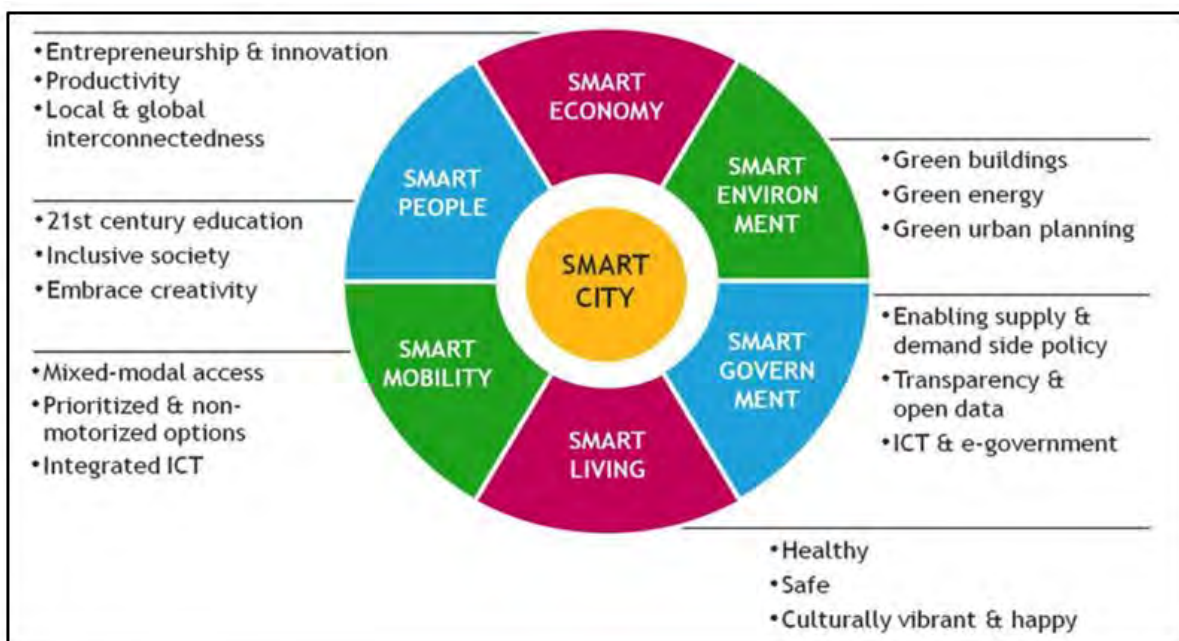


Figure 2. Identifying of the smart city

The smart city's technical definition is a physical space in which ICT is widespread and supports a new growth. In addition, it depends on the virtualization in the new dimensions of modern, sustainable, and smart planning; where it aims to drive cities towards compatibility with the resources and sustainability needs to reduce urban entropy.

Thus, a smart city offers aspiration to mend environmental, social, and economic levels. These form the main pillars of sustainability. Thus, it boosts sustainable urbanism.

### 2.1.2. What is Sustainable Cities?

In this context, urban sustainable indicators refer to four dimensions. These are the environmental, economic, social, and governmental. Other studies introduce a fifth one of the built-up environment. It intends to improve the livability of buildings and urban infrastructures, without damaging the urban context and assisting the indigenous economy.

Sustainable cities interested in renewable energy, water and electricity efficiency, compact cities, buildings' upgrading, green areas, affordable transportation, and waste and recycling systems, etc. Cities in poor countries need

resources to hold green technology transfer, capacity development. Also, it needs to improve the access to the constructed housing, water, sanitation, electricity, health, education, etc. For that, **Fig. 3** shows the four main pillars of sustainable cities and their requirements.



Figure 3. The four main pillars of sustainable cities

### 2.1.3. What is the Smart Sustainable Cities (SSCs)?

There are many definitions of SSC. The approved one is summarized by the ITU-T FG-SSC as an innovative city that uses ICTs and other means to improve life quality, the efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations about social, environmental, economic, and cultural aspects.

The SSCs concept is a new way of thinking about how we can adopt and discuss the use of ICT for everyday urban life. And it aids in dealing with increasing urbanization trends as reducing urban expenditures, managing-adopting urban complexities, improving the quality of life, and increasing energy efficiency. The technical specification defined the SSCs as by comprising five layers as shown in **fig. 4**. The SSCs focus on the integration between the natural environment and soft infrastructure of urban areas, while the services run across all these layers.

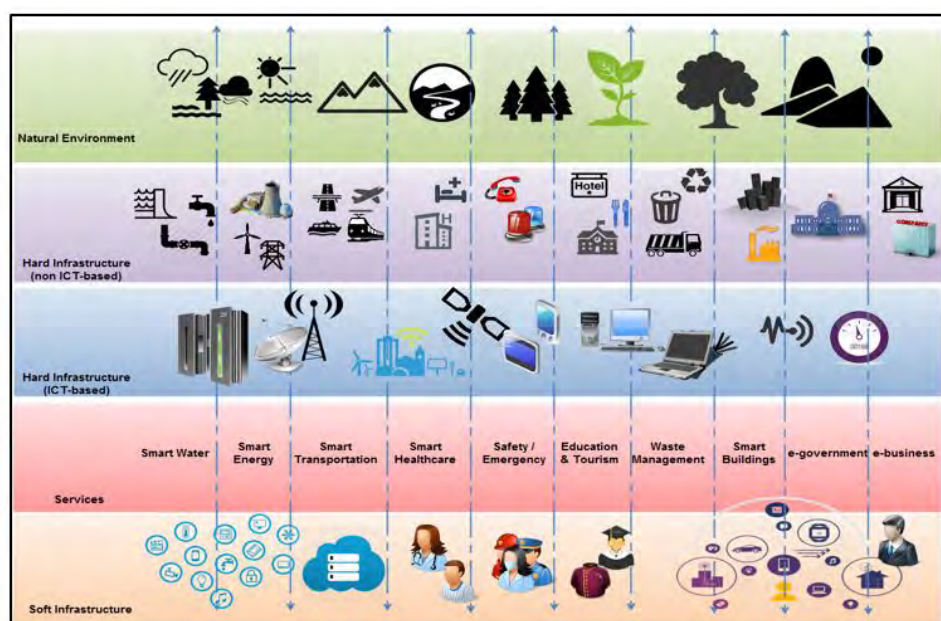


Figure 4. Multi-tier SSCs - ICT meta-architecture



## 2.2. The Smart Sustainable Cities' skeleton

Smart cities are based on the smartness concepts that rooting the sustainability. Thus, the following eight categories hold the SSCs skeleton .

### 2.2.1. Quality of life and lifestyle

The smart cities changed public services such as education, healthcare, and entertainment enhancing residents' quality of life and sustainability. Smart cities are driven by strong economic evolution, upgrading management systems, producing new income opportunities, and save cost . The adoption of the smart transformation addresses these challenges by taking advantage of the continuous flow of ICT in real-time. It enhances life in urban environments, through the proper networks' infrastructure. It will increase the efficiency and come up with better ways to give basic services for quality of life and lifestyle.

### 2.2.2. Infrastructures and services

Smart infrastructure provides the base for the key topics about the smart cities. The core characteristic is data connection and regeneration, to make sure the optimal use of resources and performance . So, the SSCs use the ICTs infrastructure in reliable, adaptable, scaleable, accessible, safe, secure, and resilient methods for various purposes. It comes through effective, well-balanced regulatory, and governance policies with the appropriate strategies . Thus, the ICTs can support the utilities at a lower cost than using tradition infrastructures. Hence, this paper details the infrastructures and services as follows:

#### 2.2.2.1. Traffic Management Systems

The increasing traffic congestion in the urban context needs an urgent rationalization of urban processes to improve life quality and energy saving. End-user services should check and plan urban routes in the city's context to be a relevant smart service. Traffic services rely on a back-end, which processes the raw data gathered by sensors. Thus, the tradition urban standards' ICT infrastructures play a basic role. These are often at the basis of the tools that allow the management application to control the urban context in the broadest domains. In particular, the sensor networks that allow the control and monitoring centers of city parts . It can work in an organized manner to track various infrastructure incidents or events. Then, the involved agencies can detect, test, analyze, and disseminate it. For management, smart-parking applications help drivers with finding locations, paying via smartphone, and helping officials through a single smart platform.

#### 2.2.2.2. Smart Energy management systems

Smart Energy provides a cheaper energy in an environmentally and sustainable manner. It relies on using new smart energy technologies such as smart grid meters, micro-grids, smart street lighting, renewable energy sources, solar energy, and advanced distribution management . These require handling in many areas that regard each other and contribute in different ways as energy generation, storage, infrastructure, facilities, and transport. Thus, these actions support sustainability in that scope, especially with the current energy crisis.

#### 2.2.2.3. Smart Water distribution

Using the ICTs save water, reduce cost, and increase both the reliability and transparency of the water distribution. It saves, improves, and secures water quality by reducing the leakage. A smart reducing for the consumption of irrigation water can do an extension of parks and forests in cities. It determines how much water the irrigation needs .

Previously, the water system was discharging water without recycling. Now, returning it for residential districts,

factories, or other sites is possible smartly. Information such as data of operational gained from plants or water in the delivery system can manage it in one location. **Fig. 5** shows the water cycle and the efficient process of handling plants and improved business efficiency that accomplished relying on treated effluent. This is a suitable approach, which the SSCs should achieve.

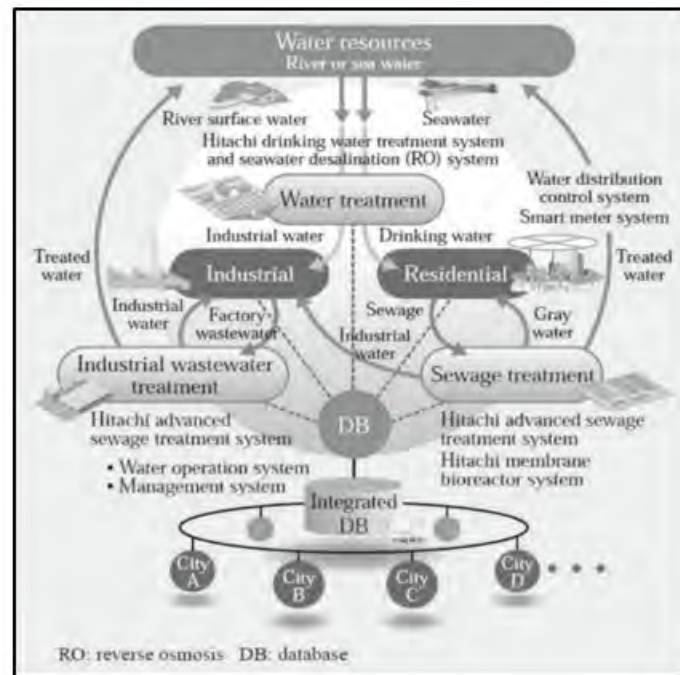


Figure 5. Water cycle in SSC

#### 2.2.2.4. Extreme weather sensing for safer cities

Cell phone traces represent widespread sources of information to understand urban mobility patterns. It is useful for risk and disaster management and prevention, spatial and temporal reliance between totals of the portable system movement, and climate information. Thus, it allows for context-aware evaluation of the link between environmental themes including weather and related social dynamics.

The IoT's and weather sensors' system through its capabilities in weather forecasting can proactively gather the information. Smart city can dedicate sensors and that requires much interoperability. Progressively, sensors incorporate tuning add-ins to pertinent postings by e-media. Consequently, data can give early alarms when events happen.

#### 2.2.2.5. Smart waste management

It helps in reducing air pollution, traffic flow, workers, time, and money. A proper technology such as software applications and Geographic Position Systems (GPS) can guide the trucks in finding the shortest path for garbage collection. In addition, this can give a new value to the cities and boosting both smartness and people-friendly, **fig. 6** shows that.

Monitoring of the fullness of bins by sensors can increase efficiency. It focuses on observing the waste managing, giving advancements to its framework, evading human mediation, and decreasing human time and exertion. It results in a healthy, waste-free environment, and saves time which leads to a cheaper service.



Figure 6. Waste management services

### 2.2.3. Information and Communications Technology (ICT)

The ICT can help urban communities to realize sustainability, where it focuses on smart infrastructure regard energy, transportation, water, etc. It updates the connections between the administration, private sector, and people to guarantee the collaborations over various policies' domains. High-speed internet and Wi-Fi wireless infrastructure citywide should be affordable, reliable, available, and accessible, thus the widespread sensors with minimal effort can build the IoT's .

Successful of the smart city needs human skills for an efficient addressing. For example, it must add a data layer to the relevant operations, technology vendors, and the integrated functioning of different departments. That includes planning and design, digital citizenship, data literacy, implementation, management, etc. The ICT infrastructure and its applications are just a prerequisite for the defined goals. However, without a real engagement among institutions, the private sector, and citizens no smart city's strategy .

### 2.2.4. People, citizen, and society

The human factors of the SSCs include concepts as a creative city, a learning city, a human city, and knowledge city. It focuses on education, learning, human infrastructure, and social capital. It considers education as a critical magnet that makes a city attractive.

Smart people comprise social and human capital features, the qualification level, affinity to lifetime learning, ethnic and social variety, flexibility, ingenuity, globalization, open-mindedness, and participation in public life . So, important to invest in people smartness not in smart technology only. Thus, to begin, cities should conduct their own analyzes of skills deficits. Consequently, the following two points are addressed:

#### 2.2.4.1. Smart health facilities

The SSCs' policy and strategy should handle health, as **fig. 7** shows. It illustrates a conceptual framework for the smart health facilities as follows

- Safe health facilities structurally, non-structurally, and functionally can endure the effect of many dangers and diminish its effects.
- Green health facilities are keen on environmental issues such as a small carbon footprint, reduced medical waste, increased recycling, water conservation, reduced use of toxic materials, and green landscaping.
- Smart health facilities reduce the damage to hospitals infrastructure and equipment. The health network's func-

tions deliver services under the emergency conditions and operating the limited resources effectively, saving cost and improves the planned strategies

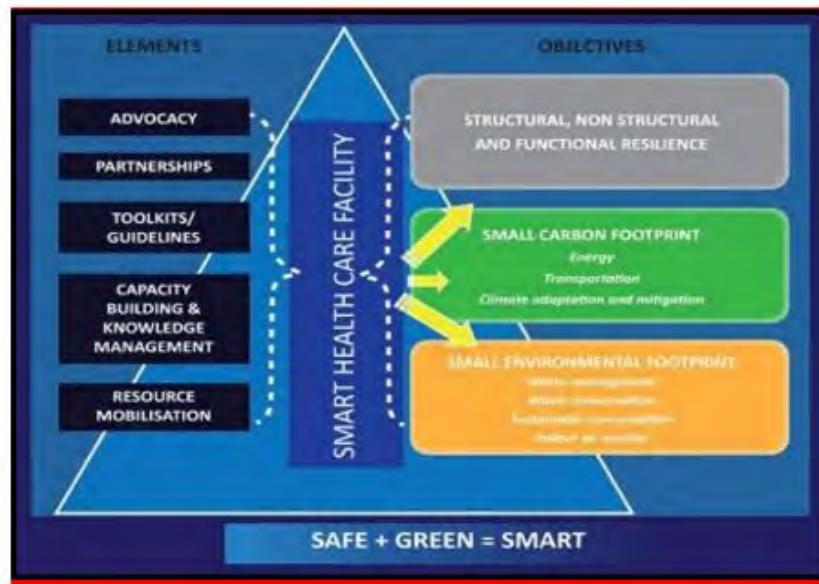


Figure 7. A conceptual framework for the smart

#### 2.2.4.2. Smart education

It comes through the learning places or virtual spaces and should propose the smart learning environment to meet learning needs. Also, it delivers the proper learning resources and supplies interaction tools, automatically record the process of learning, and test the outcomes to boost smart learning. Producing its environment have to respect the needs of the citizen, in various places like schools, homes, communities, socials, or in virtual spaces, etc .

Besides, taking aspects such as mobiles, evolving learning environments, online assessments, data-driven everything, new learning models, virtual labs, digital portals, and remote learning. When education's smart infrastructure is looked, the identity, the data, and the application layer appear. That allows crafting each layer to handle multiple devices and roles.

#### 2.2.5. Environment and sustainability

The smart cities' responsible implementation requires an integrated and interdisciplinary handling of sustainable development. It ensures matters as a low carbon, water, and ecological footprint with infrastructure designed to adapt to the environment. There are guidelines for developers in both the design and planning stages. They should consider land use planning, green buildings, energy conservation, disaster risk reduction, water reuse and recycling, waste management, sustainable transportation, biodiversity, and the community developing.

#### 2.2.6. Governance

The smart city includes the general municipal and the business services, sustainable buildings, building management, smart education, health and social care, smart energy, lighting, gas, smart grids, public safety, security and crime prevention, and actual locating facilities, etc .

Smart governance postulates citizens' involvement in decision-making, governance systems transparency, public services' readiness, and quality of political strategies. Smart mobility includes the accessibility and availability of information, communication technologies, and updated transportation systems. It comprises ICT factors of



local and global accessibility, facilitation of ICT-infrastructure, and sustainable, innovative, and secure transport systems.

Thus, the city heads are burdened with boosting both physical facilities & systems and understanding the current digital revolution. They need to preserve the uniqueness of each city wherever addressing the gap between needs and resources by developing creative solutions that leverage the digital networks. Then, it captures and shares the gathered data to increase the efficiency of urban services.

#### 2.2.7. Economy and finance

Facilities and the cost needed for the SSCs need a reliable ICT infrastructure to magnify investments, efficiency returns, and principal flow. It needs a long-term master plan to create a widespread competitive system enables the smart vision, to enrich the economic transformation. The info-media development authority should aid this master plan. So, it needs a national initiative in the economic sector with a focus on such as artificial intelligence, data analytics, cyber security, internet of things, and overwhelming media.

This is a comprehensive view of the cities activities in the economic sector needs to be aggregated. Government data should estimate capital funding over the long-term coming years to keep up with the demands of citizens in case transformation represent a national attitude. So, a city can be smart by investment in social and human capital, conventional and up-to-date ICT infrastructure. It comes when it fuels smart sustainable economic growth and a high life quality with better participatory.

#### 2.2.8. Smart Mobility

A specific parameter that helps the local and national accessibility with safe and sustainable transportation systems. It covers the public transportation, cars, bicycles, and pedestrians, and ICT-based transportation. It gives a new way for better moves, where services allow wide varieties of limits including proximity of schools, transport links, and amenities. Relocation services present an interactive tool for attracting residents and boost the local economy. Computers, mobile devices, and applications will help citizens to get better mobility. Smart mobility offers the most efficient, clean and fair transport network for people, goods, and data. It forces technologies to collect and deliver awareness to users, planners, and transport heads permitting reforming of urban mobility shapes and enhancing the transportation modes.

### 2.3. Smart sustainable cities' planning

There is a dispute around what smartness means in cities regard its holistic evaluation level. No single comprehensive model is available for tackling the SSCs' dimensions, but there is a model can capture a city's smartness through its context features. Smart planning should place people at the heart of urban and territorial development raising "the city for all" concept.

That comes through the right of quality of life, jobs, cultural resources, regional facilities, proper and reasonable housing, suitable mobility, internet availability, and the right to involve into the urban procedures, plans, and decision-making. It should assemble the ability of each citizen as a user, manufacturer, occupant, and resident.

So, smart planning uses simulations and data analytics to enhance current planning. An example is the Complex Systems Modeling and decision-making tools. These allow planners to choose the most effective combinations of solutions to achieve the sustainability as a target.

Smart planning is a way to an interactive experience for planners, architects, and residents alike. It uses sophisticated 3D models to explore the areas, view rich media about the key issues of interests and identifying the services offered by local businesses. Its application helps both public and private sector through a 3D visualization of the city, and the tools for small and medium enterprises to interact with city planners. In addition, it gives more aware

of their local environment and provides with planning data through a user's interface .

#### **2.4. Smart sustainable cities' management**

Smart and integrated management help users to access information resources, locating events, and taking precise actions in response, which aid city stakeholders in their construction of integrated management frameworks. Municipal authorities, branches of government, and relevant policy-making entities can synthesize the information gleaned from SSCs. It develops the strategies, which aims better regular city procedures and effective reactions to disasters. Enterprises, including water, power suppliers, and other utilities, will have the ability to take part in municipalities' efforts to improve the integrated management of SSCs .

With smart management, citizens are the primary beneficiaries, where the SSCs focus on citizens and give them important notifications from municipal authorities. Then, it has a greater role in city management by announcing the challenges that citizens face

#### **2.5. Smart sustainable cities in developing countries**

Smart Cities have many potentials to improve the developing countries. But, these potentials are not fully realized in most developing countries, including Egypt. Several existing principal factors widen the gap between these potentials and reality, due to the following

- Weak research capacity hinders the contextualization required for SSCs initiatives. Because primarily the developed countries produce the smart researches where only 13% of the smart researches are in the developing countries.
- Lack of indigenous smart cities' policies means that developing countries adopt similar frameworks provided by developed countries, affecting its contexts and risks. It advances the interests of the provider countries over local interests.
- Developing countries pursue smart people and smart governance.
- Locally, driven NGOs are important to balance commercial interests and deliver sustainable benefits to citizens, but its number in developing countries is so little.
- For the developing countries, about its smart city initiatives, the ratio is a two-to-one planning to implementation. Differently, the ratio is the one-to-one in developed countries. This highlights a need for research in smart city planning within developing countries.
- Smart city initiatives in developing countries are top-down (government-led) rather than bottom-up (citizen-driven). This frame a serious issue about sustainability.

#### **2.6. Mature Arabic models in transforming to the SSCs**

There are several cases in Arab cities, especially in the large ones. Excluding the gulf's cooperation council region, which expected to move faster on this path, because of its modern infrastructure and well established to be smart cities. For instance, Masdar City in the United Arab Emirates, Lusail city in Qatar, Kuwait city in Kuwait, and King Abdullah Economic City in Saudi Arabia. On the other hand, there are serious problems in the South Tier countries, which show a wide gap for big cities such as Cairo. It may suffer a greater difficulty in adopting SSCs because of its old-established infrastructure and organizations. That requires modernization rather than just a modern construction approach.

Transformation to the SSCs is divided into two models, **fig. 8**. The first is the Greenfield, which creates the smart cities from scratch, and the second is the brownfield applied to existing cities. For example, Masdar City in the United Arab Emirates, it will build which by the year 2020, to provide innovative solutions in terms of sustainable mobility, energy efficiency, and urban re-shaping. Greenfield cities need large funds in ICT technologies for

developing new constructions; but, brownfield cities need just an evolution. Many other cities in the Arabic region are still suffering from a knowledge gap. It due to a set of constraints on many levels that ranging from the socioeconomic variance and political instability to the unsuitable ICT infrastructure and shortage of managed networks.

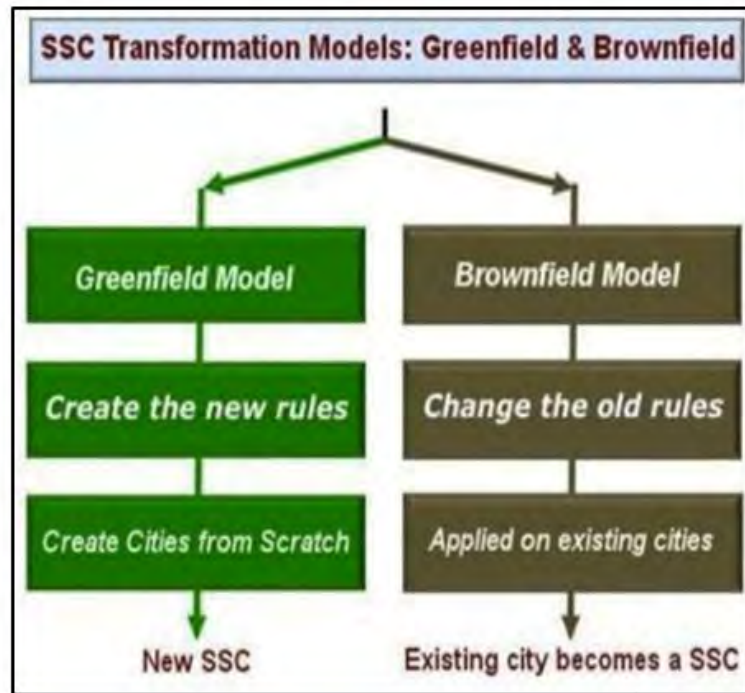


Figure 8. Smart sustainable city transformation models

### 3. The applied study: Transformation to the SSCs in the Egyptian scope

Egypt announced recently the launch of the fourth generation of the Egyptian city, based on the smart city approach. It aims to carry out that vision in its new administrative capital, New El-Alamein, and eastern Port Said.

The better performance as mentioned can come through engaging citizens, government, and each other stakeholders. It is possible through multiple channels and empowering them over direct interaction to show accountability through performance reporting. So, for Egypt, the study proposes the following road-map.

#### 3.1. Developing a road-map about embarking the SSCs initiative in the Egyptian Scope

If the Egyptian state thinks to embark the SSCs initiatives, it needs to start by developing a road-map covering the SSCs cycle. It takes steps, these are setting the vision, identifying targets, archiving political cohesion, building, measuring progress, and make sure accountability and responsibility, as **fig. 9** shows.

This study developed a framework as **fig. 10** shows. It can help the Egyptian cities in touching the current situation and determining the serious capabilities needed to enable SSCs. Then, the city leaders can use it as a guide to evolving a common language; to increase cooperation in outlining and implementing the SSCs' strategy.



Figure 9. Smart sustainable city cycle

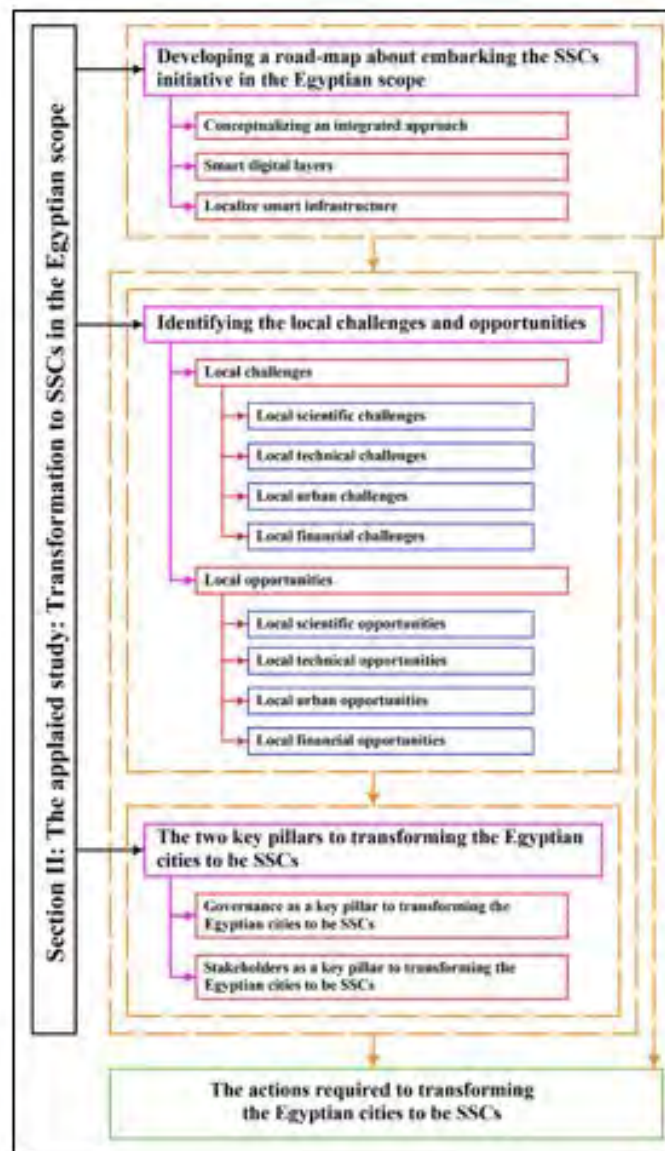


Figure 10. the proposed road-map about embarking SSCs initiative in the Egyptian

So, for the Egyptian scope, the proposed framework identifies three main requirements. It addresses the local challenges and opportunities. Thus, it conducts to the two key pillars responsible for that transforming. So, the study concludes the actions required, as follows:

### 3.1.1. Conceptualizing an integrated approach

Egyptian Minister of Communications and Information Technology stressed that plans for digital transformation are a main part of the sustainable development strategy. He conceded that it has a major impact on the social and economic development. The main elements of the Egyptian digital transformation plans include the ICT infrastructure development, upgrading the efficiency of the governmental services provision, and implementing projects of cities and smart communities, evolving human cadres. It aims to create an environment conducive to technological innovation. Thus, conceptualizing that approach comes through:

#### 3.1.1.1. Why there is a need for the SSCs initiative?

The Citizen-Government relationship expresses that the citizen demands for services are kept in balance by transferring funds (taxes) from him to the government. So, it should study the city's demographics, including the principal city stakeholders, as **fig. 11** shows. That depends on the local authorities, knowing the ages of citizens, the educational background, hobbies, city attractions, businesses, and the resources.



Figure 11. Citizen-Government relationship in

Thus, Geographic Information Systems (GIS) tools are considered in the promotion and attraction of both businesses and residents. Where people will expect and demand the government to give a broad range of services. These depend on the supply and demand relationship; where the further services the citizens demand, the more services the government must deliver, as long as the citizens will pay.



#### 3.1.1.2. Developing a policy that drives the whole initiatives

For Egypt, the SSCs policy needs to define its roles, responsibilities, strategies, and objectives. The transformation charter necessities are to give the power to the concerned fund and resources to ensure success. It provides with the trend and details on how to use technology to make it easier for citizens and business. It encourages and interacts with the government to save money and create the real required economic opportunities.

So, the policy must be relevant and addresses the existing gaps, challenges. It should meet the new demands, apply multiple views to the issues, and rely on data and evidence.

#### 3.1.1.3. Engaging citizens

Relying on the Egyptian Ministry of Communications and Information Technology (MCIT ), this engagement may come through bigger activation of e-government and effective governance, which increases of efficiency and enhancing delivery of services. It aims to build the trust and involve citizens in the solution plan, devoting mobile's applications, to let the public to connect easily to the city's infrastructure . The Egyptian Cities should strengthen this engagement to find solutions to the challenges, where citizens can detect and report problems like a broken light, water damage to the governmental authorities, which in return generates the proper solutions in life aspects and events.

#### 3.1.2. Smart digital layers

One of the key value propositions of ICT is gathering and sharing information timely. Where cities might take suitable action before the problems begin or escalate if it delivers the information at the proper time. Many digital infrastructures support digital layers as follows :

##### 3.1.2.1. Urban Context

Smart urban context layer is the layer where physical and digital infrastructures meet. These include smart buildings, smart mobility, and smart grids for utilities such as water, electricity, gas, and smart waste management systems. The Egyptian government is seeking to integrate digital services into infrastructure systems in the aforementioned areas, through the government's electronic portal, with the expansion of these smart services in the new cities.

##### 3.1.2.2. Sensors

This layer includes smart devices that measure and monitor various limits of the city and its environment. Then, the IoTs, videos, cameras, radars, and GPS, etc. come to boost the city smartness. These devices should consider the local context details under the standards.

##### 3.1.2.3. Connectivity

This layer involves the transport of data and information from the sensor level to storage and data aggregators for further analysis. Currently, the Egyptian Ministry of Information studies it to launch later in the Egyptian SSCs implementation.

##### 3.1.2.4. Data analytics

This layer concerns with the analysis of data collected by different smart infrastructure systems. It helps with predicting events such as population information, spatial geography, business, economy, and traffic overcrowding. It comprises the local authority, business, and other data centers engaged in data processing, data mining, and related activities.

### 3.1.2.5. Automation

The digital techniques which enabling the interface layer that permits automation and scalability for many devices across multiple domains and verticals. Implementing smart city technologies often need a robust, reliable, affordable broadband networks, and an efficient ecosystem for the IoTs. It gives the capacity to generate the usage of big data as a base to the SSCs. This stage has not yet emerged in the Egyptian reality.

### 3.1.3. Localize the smart infrastructure

The SSCs investment in ICT infrastructure should use the preexisting networks to decrease costs. A smart Egyptian city solution cannot transplant from a region to another where locality is needed. It should respond to local development needs, context, culture, and economics, all take a role in this process. Holistically, cities should consider urban problems before selecting the smart solutions where every city has its own aims and targets.

Consequently, for the Egyptian scope, the key policies aspects should be highlighted. Thus, this study suggests the following eight tracks as a start for the transformation initiative about smart infrastructure, as **fig. 12** illustrates.

#### 3.1.3.1. Smart transportation:

The Egyptian complex transportation's crisis, especially in major cities, needs a smart operation, particularly in public transportation management, automated planning, electronic payment services, providing people with the nearest vehicles information timely, and vacancies, etc. It improves transporting goods and people in a more sustainable manner.

This needs machine-to-machine connection as Wi-Fi, and technologies of radio frequency identification, and GPS, which supports traffic flow information in the real-time. It needs vehicle monitoring and road infrastructure surveillance, to ensure capabilities to cut travel times and reduce the number of traffic accidents.

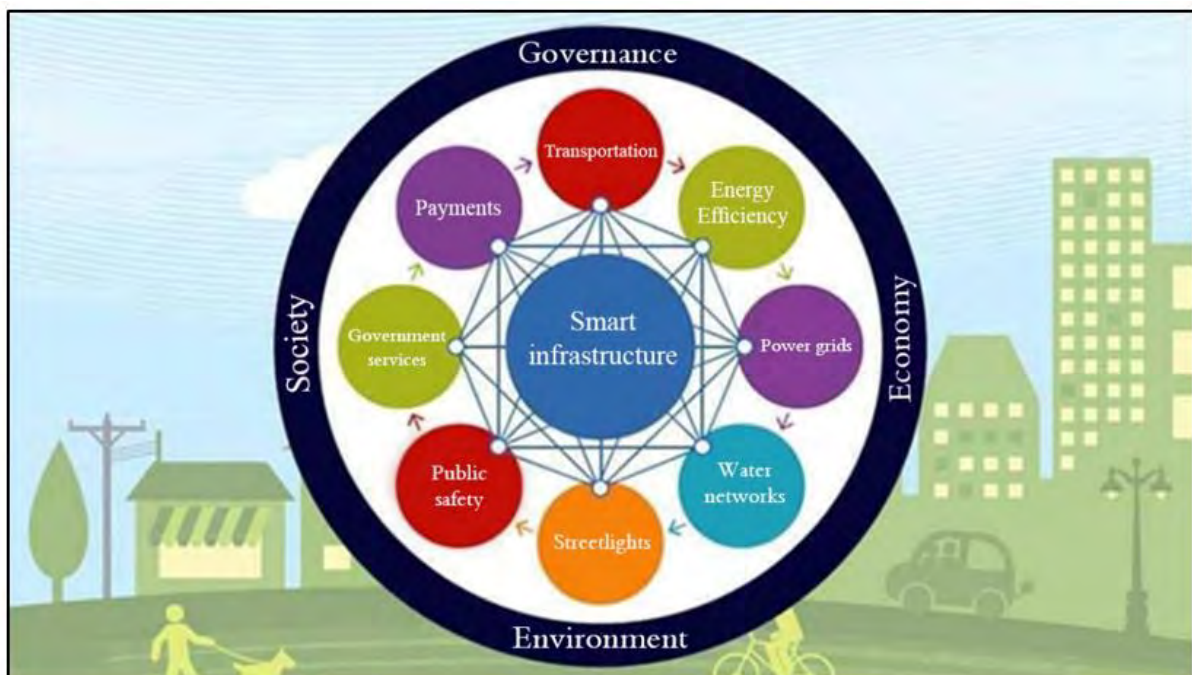


Figure 12. The eight tracks suggested regarding smart infrastructure in the Egyptian scope

### 3.1.3.2. Smart energy efficiency

Regarding the global energy crisis, especially in Egypt, the need to improve energy efficiency appears. It needs modernization of networks infrastructure. Thus, it can be divided into:

- a. Smart energy in buildings in both old and new buildings, providing better specifications, a well using of renewable energy sources, and smart energy systems.
- b. Smart power systems integration to provide solutions for different types and sources of energy. Especially, with the decreased traditional capacity of the Nile-based energy resources.
- c. Clean power generation relying on renewable sources such as wind and solar energy, underground geothermal energy, hydropower, biogas produced from waste.

### 3.1.3.3. Smart power grids

The Egyptian modernization of grids is a priority for utilities. The government should develop strategies and practices handling it to its upgrading, which has specific goals as follows

- a. Making the production and delivery of electricity more cost-effective.
- b. Providing consumers with information about energy consumption to control the costs.
- c. Reducing greenhouse gas emissions in a generation by using of the renewable resources.
- d. Improving the reliability of service.
- e. Preparing the grid to support the electric vehicles to reduce its dependence on oil.
- f. Facilitating the distributed resources into the public grid.
- g. Boosting investment for increasing capacity of generation, transmission, and distribution.

### 3.1.3.4. Smart water networks

This is an Egyptian significant issue, considering the current water crisis. As the smart water technologies become ubiquitous, automation will reduce the interventions of manual operators. Its data has a large range of solutions, to meet the complexity of the IT and other business fields. It includes such flow and pressure meters, acoustic sensors, sensors of quality, data tools, service dashboards, GIS and graphics tools, management, staff apparatuses, alert systems, pressure management, infrastructure monitoring tools, stability, and leakage recognition applications, hydraulic modeling, and pump optimization.

Thus, cheap, easy-to-use data technologies, and external pressures on the water's industry mean that water networks need much greater sensors and controllers, and more central data systems, leading to a significant contribution towards sustainability.

### 3.1.3.5. Smart streetlights

It is a quick step for the Egyptian situation and has a great impact on energy saving. It does not need a sophisticated technology. Adding ICT and LED upgrades within streetlights are cost-effective. IoT's solutions can provide a cheaper service, depending on abundant sensors in cities. It allows both remote monitoring and control to set smarter services. Then, smart lamps, robots for maintenance, aircraft robots, etc. are considered.

### 3.1.3.6. Smart public safety

The Egyptian cities safety is a significant aspect of a Public-Private Partnership (PPP) expansion through the public safety areas. It is in relevance to all approaches to disaster management. The PPP's notion means the sharing of information and resources between public and private sector agencies and non-profit organizations as a power multiplier for disaster preparedness, prevention, response, and recovery at both local and regional levels.

Therefore, the PPP's task recognizes the challenges and necessities, using an updated, developed, and prototype

technologies, also fielded by the technology firm's partnership. It comprises research centers such as universities, business, and official governmental affiliations. Moreover, it includes governmental agencies, first responder groups, and public service end-users. It has many standards as traditional and smart surveillance cameras, alarm systems, security's remote control systems, motion detection sensors.

### 3.1.3.7. Smart government services

It enables serving the public by the internet aid, where the government can capture, process, and make reports of data for re-shaping the new role of the decision-makers. Recently, the Egyptian government adopts the e-government, where it boosts the integrated and easy service practices. It aims for compatibility with the public, evolving policies, and giving solutions for a better lifestyle. It started with selected services as issuing licenses, official papers, automating the courts, the commercial register, and other entities which dealing with the public.

Whereas the up growth of social media, mobile applications, massive data analytics, and mixing techniques allows citizens to more connect with the government, So, Egyptian governmental services need various areas and levels of response, as **fig. 13** illustrates.



Figure 13. Smart government services and levels of response

### 3.1.3.8. Smart payments

It benefits the government in various ways, such as better business management, responsibility, and economic planning. It merges purchases through traceable electronic payments. In addition, it ensures compliance with expenditure strategies and offers full records for pricing negotiations, etc. It ensures the quick paying of dues to the governmental employees, savings, accuracy, and responsibility as a significant aspect. Salaries, bonuses, and stipends become easier, even in disruptions or political unrest. Besides, it offers unbanked employees a consistent way to receive money. It improves the economic interest taking in consideration, the administrative corruption, the official tax collection, etc., where mobile payments are basic in such as retail, personalized tourism, enhanced mobility, and peer-to-peer interactions. Then, the government should have solutions for digitalizing the entire customer experience

## 3.2. Identifying the local challenges and opportunities

It reflects the previous concepts of the proposed road-map into the Egyptian context. This comes through the survey at multiple levels. Therefore, the study concludes the following challenges and opportunities to pave the way for the required transformation, as follows:

### 3.2.1. Local challenges

There are various levels of challenges, but the present study divides it into four axes, as follows:

#### 3.2.1.1. Local scientific challenges

The major Egyptian scientific challenges of planning and development related SSCs encompass typologies, infrastructures, ecosystem services, human services, and governance models to its operational functioning, planning, and development. It has emerged through monitoring, analysis, evaluation, modeling, simulation, prediction, and smart decision support. These are founded on the analysis of big data and context-aware by computer aid. Anyway, it considered as a bundle of advanced technologies and new applications for control, automation, optimization, management, policy progress, and strategy design in sustainability manner.

Therefore, this entails developing smart functions as new notions of planning, operational functioning, and management, which base on various scientific pillars. However, it is so far from the smartness required in Egypt.

#### 3.2.1.2. Local technical challenges

The Egyptian technology context, networks, and hubs among different sectors despite its importance, not properly developed for taking its way to the transformation into the SSCs structure. This challenge extends because each city has unique characteristics, and it needs certain innovations. So, many large and small companies reluctant engaging in these projects.

Noteworthy, the big challenge lay on the national capacity to provide with the technical solution for these needs to start the transformation. It is due to the national real status in the industry and applications. It is one manifestation of developing countries with its limited technology, of which Egypt is one.

#### 3.2.1.3. Local urban challenges

Over 50% of the world's population lives in cities . That lays huge heaviness on its infrastructures as housing, power, water, transportation, and facilities. Many of which need an enormous redesign and capital expenditure. According to the results of Egypt 2017 census, where the total population of Egypt that was 94.8 million people inside, 57.8% is in the countryside of the Republic, compared to 42.2% live in urban areas. It showed the comparison that the results of the earlier census in 2006 are the decline in urban zones. That shows urbanization decline differently of global proportions.

Egyptian big cities have environmental and population challenges with limited urban fabric. It needs to develop smart strategies for sustainability to manage issues such as water, energy, urban planning, and green buildings. In many indicators, Egyptian cities go far from both smartness and sustainability, because of current weak initiatives, legislation, and standards.

#### 3.2.1.4. Financial challenges

The Egyptian economy situations place huge budgetary constraints on the cities, it is limited in its ability respond to difficult pressure gradients. That returns to high development cost and lack of financial resources required to support the implementation, with the absence of a proper e-legislative system. So, the city government should consider sustainability as a necessary condition for any financial resources. Its stability is as important as its availability because it suffers from external pressures, vulnerability, and volatilization.

The outside effects on the local market are also an indirect economic challenge because the market is a consumer and non-productive. In addition, no balance between exports and imports, leading to imbalances in the state payments balance. Thus, the difficulty of sustaining participation and interest of the parties involved and cooperation of multi-stakeholders is an impediment to the required transformation



### 3.2.2. Local opportunities

Migration to advanced e-services has become more workable. Nowadays, the government can carry out it at a relatively lower cost. It can start even if it did not complete the e-government national program. The proposed road-map needs the adoption of all regulating authorities and stakeholders to the SSCs initiative. Political leadership should instill the aspiration to the smartness through the following four divisions:

#### 3.2.2.1. Local scientific opportunities

The Egyptian MCIT tries to push the scientific and technological infrastructure of ICT and digital services. As it seeks to include them in the governmental agencies as one of the main priorities of the ministry. It aims to increase the demand of the ICT in the areas of education, health, governance, electronic content, legislative facilities, and green info technology .

Leadership represented in senior leaders of local governments, including mayors and CEOs have to establish a special entity with its scientific and technical cadres that embrace the SSCs concept. It should have the financial resources and the legal powers to coordinate and establish the necessary scientific, technical, and financial controls as an initial step.

#### 3.2.2.2. Local technical opportunities

The Egyptian MCIT struggles to improve the Egyptian international competitiveness by evolving the outsourcing sector. It gives efforts for increasing exports of ICT services, attracting foreign investment, and developing the sector's growth and job creation .

It announced the start of promoting development opportunities by incorporating smart infrastructure, as a prelude to adopting the regulations governing investment in real estate and substructure, to provide for the later incorporation with smartness features in the base of investment projects. That requires as a step of incorporating a smart city's standards into local authorities' procurement of services.

#### 3.2.2.3. Local urban opportunities

Although Egyptian cities have not planned as a smart city, various implemented cities development initiatives could fit into the smart city framework. The new administrative capital, the new El-Alamein city, and the new East Port Said city are of the principal Egyptian cities planned to be smart. After five years, the new administrative capital becomes the first smart Egyptian city. The city governance adopts smartness as a trend in these cities as it announced. That appeared by providing flats or homes with new types of internet lines equipment, telephone networks, television networks, water meters, and electricity where services are controlled and connected to the internet. For urban, cameras and surveillance cameras which linked to the relevant security authorities monitor the streets. Its association with control rooms helps with fighting the negative phenomena, thefts, and crimes.

The Egyptian authorities present a strong and scalable possibility for modern concepts. That comes through policies, strategies, and cadres in different disciplines, where it can set up and develop detailed work guides for SSCs planning. Therefore, it should consider both the General Organization for Physical Planning and the New Urban Communities Authority.

#### 3.2.2.4. Local financial opportunities

The Investment and Finance Section of the Egyptian MCIT works with venture capitalists and financing institutions to complete agreements and increase funding to provide the best global applied practices. It also works with startups that need infrastructure and models. It aims to strengthen the relationships with current and future financiers, including government agencies, and develop successful and diversified financing strategies. This helps with increasing the investment to narrow the finance gap. The gap that hinders the smart development and analyzes the visions and the financial reporting, and it decreases the capital attraction.

The Center for Technological Innovation and Entrepreneurship at the Ministry manages these relationships with decision-makers in venture capital companies and governments to show best practices in smart industrial investment models. It activates the role of universities, the Egyptians abroad, and multinational corporations .

Regionally, it can achieve consistency by reconciling regional actors to plan a coherent and clear local vision to support transformation. Since only the local authority can define this vision, which provides a context to decide by combining individual interests and common objectives. Thus, it can frame the convincing bids for financing and investment in a larger context than the state borders, making it easier to finance and investing in applying the SSCs road-map.

### 3.3. The two key pillars to transforming the Egyptian cities to be SSCs

After developing the proposed road-map and extrapolating both challenges and opportunities, this study focus on the following key pillars needed for the start:

#### 3.3.1. Governance as a key pillar to transforming the Egyptian cities to be SSCs

The current urban planning situation treats the smartness as a normative claim and ideological direction. So, being smarter necessitates a strategic dimension where governments and public authorities should embrace to distinguish their new policies, strategies, and programs for targeting the sustainability.

The government should take a serious path towards digitization through e-government to improve services. E-government can boost economic growth stimulation, promote effective management, and raise social engagement. Government starts technological programs to tackle local challenges. Cities' leadership represented in mayors, the board of supervisors, and IT managers should be visionary and have the wish, the talent, and the ability to build a SSC.

Speeding up education programs in science and technology is necessary for addressing the skills gap mentioned at the challenges and opportunities within the proposed road-map about data governance in sustainability-driven smart cities. So, it should strengthen partners by reforming the curriculum and promoting multidisciplinary learning with the technologies to train the SSCs workforces, **fig. 14**.

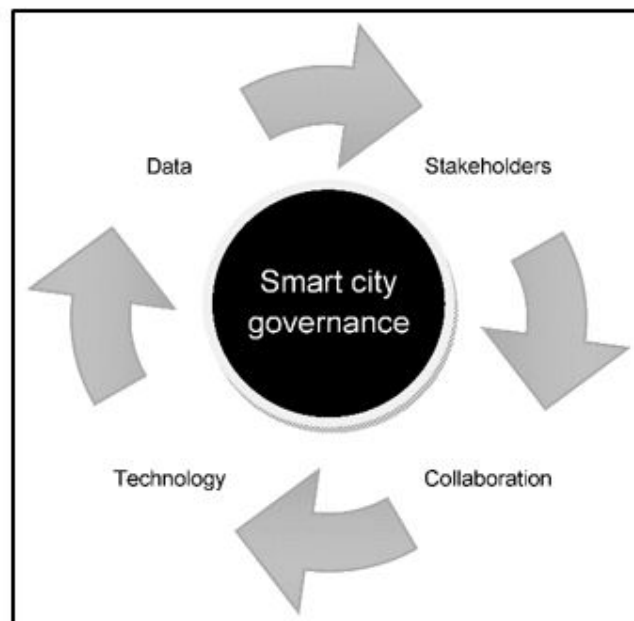


Figure 14. Smart city governance

Thus, the government should capture, collect, store, and integrate urban big data into a better later chance for processing, analyzing, visualizing, deploying, and sharing. Then, it will support decision-making about urban operations, functions, designs, services, practices, and the SSCs policies. It can view these big data as the most scalable and synergic asset of SSCs to drive the transformation.

In Egypt, big data in urban planning still needs collection, understanding, and exploiting. It should improve technologies and increase its applications. It should benefit of the potential of big data and data-driven decision-making in transforming urban planning by formalizing and systemizing its approaches to boost the SSCs implementation later.

This transformation involves not only smart management and planning but also monitoring, understanding, and analyzing all domains of the cities. This instills an opportunity for cities to use their momentum to promote the proposed road-map that based on:

- a. Exploit the local innovation as an overarching solution.
- b. Boosting open data, open scientific models, and transformation details, etc.
- c. Establishing a specific innovative authority with all required potentials in cooperation with the existing authorities.
- d. Exploiting the regional and global collaborations with its settled standards.
- e. Convincing the political will at the highest level of the proposed road-map, through related scientific studies and detailed reports, to get the provision required for activation.

This necessitates constructing and aggregating several urban simulation models of different situations of urban life with the integration of the urban systems. In addition, to explore and diversify the approach to the construction and evolution of simulation models. This is becoming achievable in the existing cities. Finally, the collaboration required between government, the private sector, and citizens will give the best chance of the transformation in real.

### 3.3.2. Stakeholders as a key pillar to transforming the Egyptian cities to be SSCs

California Institute for smart communities detailed the concept where it clarifies it as a community that relies on using technology in governance, business, and where inhabitants understand the ability of ITs to create an aware decision. With a holistic view, it composes a smarter community of not only more integrated, collaborative, and inclusive but also of multiple neighborhoods and communities of interest and of a kind . So, it highlights governance among stakeholders and institutional factors for governance.

Therefore, the Egyptian city should seek to address public issues via ICT- based solutions founded on a multi-stakeholder, municipally based partnership. The official visions should be clear to the stakeholders and fit with them. It should consistent with key industries such as ICT, transportation, energy, water, management, and public security and safety.

The proper techniques are important for the SSCs, but it alone is not enough. So, it requires empowering the public by engaging them in the decision-making process and the problems solving. Stakeholders in all domains should recognize the community challenges and engage them in shaping the budget allocations and drawing the local taxes, etc. .

One of the Egyptian key challenges that face the smart city concept is promoting the inclusiveness and application provision. For example, it should consider in strategies the necessities of the vulnerable groups as the elderly, women, and people with debilities. They will lack the skills to use applications, and their livelihoods may be the most affected by it. Thus, promoting participatory governance is a prerequisite for developing inclusive smart cities, especially in Egypt with its current politics .

So, the Egyptian transformation should relate to at least two of the four p's :

- a. People: e.g. citizens, governments, NGOs.

b.Problems: e.g. reducing commuting times, upgrading infrastructure in all domains.

c.Programs: e.g. urban regeneration, education, technology.

d.Phenomena: e.g. social polarization, class social inequality, change of identity and behavior.

Thus, the transformation initiative should examine whether a problem affects a group of people. For example, how a program solves a problem, or analyzing, how a phenomenon produced by a program affects a group of citizens. As an application, studies could test the efficiency of automatic surveillance in outdoors (program) for enhancing the safety (problem) of citizens (people). Therefore, all studies have to be integrated to conduct the proper solutions about SSCs.

#### 4. The actions required to transforming the Egyptian cities to be SSCs

What makes the Egyptian cities smart and sustainable is not just a bunch of independent initiatives, but there is a need for a holistic approach. It can be implemented across the government, business, and the industrial agencies. Internationally, few cities have started this step, but several years passed until applying in real.

Big cities as Cairo face a higher difficulty in adopting SSCs (especially Greenfield model), because of its old-established infrastructure and organizations. So, it requires an upgrading approach instead of just a modern construction. Many cities in the Arabic region including Egypt are still suffering from many challenges regarding the transformation to be SSCs as mentioned earlier. These challenges are ranging from the socioeconomic disparity and political instability to unsuitable ICT infrastructure and a shortage of proper networks .

So, implementation of the proposed road-map; needs governmental providing of a deployment guide through the concerned authorities. It should expose its concept, process, and implementation. In addition, it should embed and provide municipalities and concerned stakeholders with a general outline of the phases and practical requirements needed to use the notion of SSCs. Besides, it provides with a detailed guide for the implementation based on the intensive use of ICTs. This refers readers to a series of thematic reports, which the government prepares. These reports adopt the exact technical sides engaged in both the design and implementation of the SSCs policies, strategies, solutions, and applications.

This study as shown in **fig. 15** extracts ten phases for implementing the proposed road-map to transform the SSCs from vision to reality in the Egyptian context, as follows

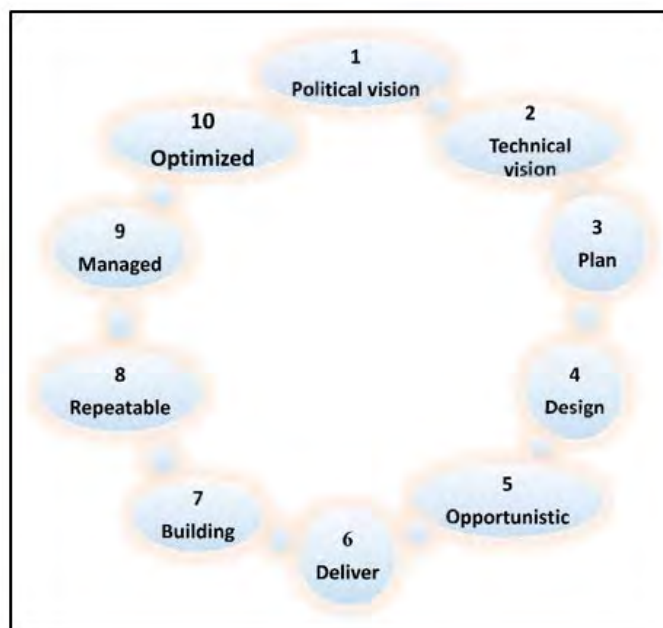


Figure 15. Ten phases for implementing the proposed road-map to transform the SSCs from vision to reality

- Political vision phase: where the transformation concept is an inevitable step for the state. However, with the complex challenges in the Egyptian context, it can concentrate the pivotal role in the political will at the highest levels. It is the only can announce this new trend across all the domains of the cities.
- Technical vision phase: for developing the SSCs strategy and business cases. It guides the traditional government about the way of the targeted projects, department-based planning, and separated smart projects. This phase proves the value of the SSCs concept and evolves the business cases.
- Plan phase: for developing smart projects plans and overall preparedness goals. In this phase, it can consider both the extracted SSCs skeleton and the proposed road-map.
- Design phase: for gathering in details the business requirements and design SSCs services.
- Opportunistic phase: for engaging key stakeholders and get their buy-in as the developed and accredited road-map for the SSCs initiatives.
- Deliver phase: for preparing the transition of the project into the SSCs services. Where the first wave of smart services and applications appears to meet the more significant investments that directly come on into stream
- Building phase: for the actual carry out, operation, support, and test the SSCs services.
- Repeating phase: to characterize frequent tasks, arrangements, proceedings, actions, and processes for integration. The focus of this phase is to monitor, check, improve outcomes, and deliver services for enhancing the repeated projects in the SSCs.
- Managed phase: for preparing the city to predict the needs of its population, visitors, and businesses to provide with preventative services before problems arising.
- Optimized phase: at this final phase, the sustainable citywide platform is in place. The goal of this phase is to recognize the competitive differentiation driving the SSCs. Then, smart sustainable cities come true in reality.

## 5. Discussion

In terms of the Egyptian context, planning and implementing the SSCs from scratch without utilizing of the existing urban momentum can be considered as a complication for the required transformation. Thus, adding attributes of smartness to the Egyptian cities gradually whether existing or new is logical regarding the Egyptian scientific, technical, urban, and economic challenges. Conversely, developing the SSCs without the preparation on the same levels and supporting pillars is a killing for the transformation idea from the beginning. Where that transformation cannot rely on the imported techniques only (the core of smart city) without local roots (the concept of sustainability).

Hence, this study concludes that Egypt needs to establish an independent entity to carry out this national task. It should have many disciplines to cover the inputs mentioned in the theoretical part of this study. It should have the power, the official control, monitor, and evaluation under the direct support of the political administration. As this is a great transformation in Egypt's urban history, considering that each city transformation has its determinants and objectives as shown in the similar cities on the Arab level, where it carried out by defining the most important objectives needed. Thus, it adapts the multiple features and manifestations of smartness to achieve these goals as a step in the path of the transformation needed.

## 6. Conclusion

Smart cities support sustainability through its various potential. In terms of Egypt, the trend to adopt smart cities is a vital need, considering the current determinants. The Egyptian urban problems that this paper identified represent an essential entry point to promote the transition to smart sustainable cities. Unconventionally, it can deal with many major national problems such as energy, water, traffic, communications, governance, management, education, economy, safety, security.

So, the paper was divided into two sections. The first section comprised six divisions; theoretical definitions, the extracted general skeleton for the SSCs, the planning, management of the SSCs, the SSCs on developing countries



and the causes of the gap's widening, and examples of the Arabic context through green and brown transformation models.

Then, the study in the second section focused on the Egyptian cities transformation by reflecting on the theoretical part. This section was divided into three parts; the first was developing a road-map about embarking the SSCs initiative in the Egyptian Scope. Then, the second part was a reviewing of the Egyptian challenges and opportunities, which divided into scientific, technical, urban, and financial considerations. The third part was a defining of the two key pillars required for starting the transformation; these are governance and stakeholders, with detailing the needed precautions to activate their roles.

Finally, the third part proposed the actions required; through extracting the ten phases for implementing the proposed road-map to transfer the Egyptian cities to be smart and sustainable in the reality.

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