KPIs for Maintaining Smart Clean Sustainable Cities

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Abstract
Nowadays, cities adopt new initiatives to build a prosperous future and to satisfy the society needs to optimise city functions and promote economic growth while improving the quality of life for citizens using smart technologies and data analysis, where smart cities make cities more livable ensuring efficient use and planning of urban sources and infrastructure Egypt has taken major steps in this perspective as part of 2030 vision which is one of the numerous initiatives currently being adopted by the Egyptian government aligned with the vital strategic plans.
In the Strategic Plan of the Ministry of Environment and Urbanization which is to be illustrated in this paper -the objectives of smart cities and national geographic information services are determined to make infrastructure work in order to establish smart cities, to improve the spatial management in cities with the help of technology, to share data to improve public services and to be the focus of national geographical information".
In this paper, measures used globally for Smart, Clean, sustainable cities are combined to measure the performance of the new administrative Capital in Egypt, this massive unique project that is built on a state of the art technology in all fields and aspects.

Keywords: *Smart, Sustainable, Clean City*

1. Introduction

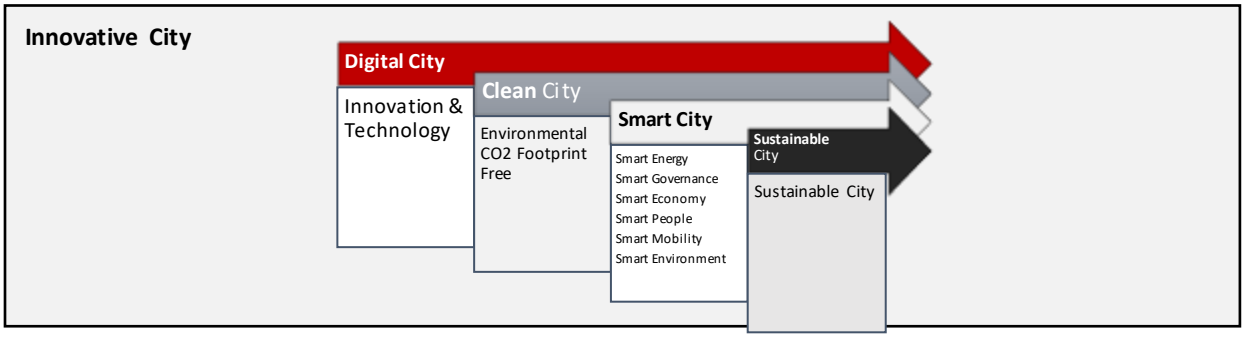

Figure 1: Innovative cities main pillars

Smart Cities are facing unprecedented challenges to become smart, sustainable, clean & digital besides challenges to take substantial measures to meet stringent targets imposed by commitments and legal obligations. Furthermore, the increased mobility of our societies has created intense competition between cities to attract skilled workforce.

Needs of cities differ strongly but the main three pillars of development remain the same and these are economic, social, and environmental sustainability.

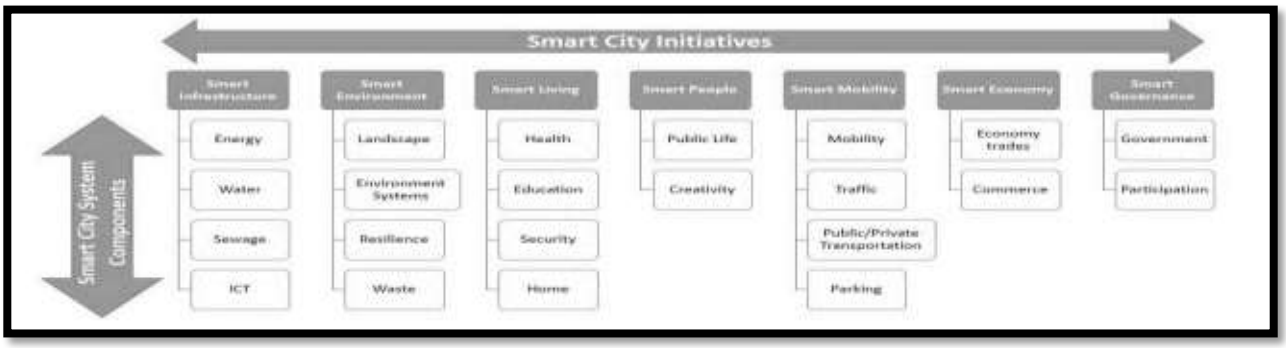

Figure 2: Smart Cities initiatives and components

A city cannot promote a thriving culture without these three pillars which is only made possible by improving a city's efficiency including the carrying capacity through the integration of infrastructure and services via smart solutions. The transformations require radical changes in the way cities are run today with the involvement of technology providers who offer technical solutions and city authorities procure them.

The development of this innovative city requires participation, input, ideas and expertise from a wide range of stakeholders. Public governance is naturally critical, but participation from the private sector and citizens of the community are equally important. It also requires a proper balance of interests to achieve the objectives of both the city and the community at large.

2. Research Aim & Methodology

This research aims to introduce new methods for smart sustainable clean cities

3.What is the innovative city and its KPIs?

In the meetings held by FG-SSC from5-6 March 2014 in Geneva, the following definition encompassing the major attributes of smart sustainable cities was agreed upon as

"A smart sustainable city (SSC) is an innovative city that uses information and communication technologies (ICTs) and other means to improve the quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects".

The U4SSC Key Performance Indicators

A consistent and standardized method for cities to collect the necessary data to measure performance and progress. The U4SSC KPIs are developed based on Recommendation ITU-T Y.4903/L.1603 "Key performance indicators for smart sustainable cities to assess the achievement of sustainable development goals".

Figure3: Goals of Smart Cities

These indicators have been formulated to provide cities and communities with a consistent and standardized method to collect and report the data needed to quantify, measure, report and monitor performance and progress towards:

• achieving the UN Sustainable Development Goals (SDGs);

• becoming a smarter city

• becoming a more sustainable city

U4SSC KPIs within the three dimensions and the corresponding 22 categories:

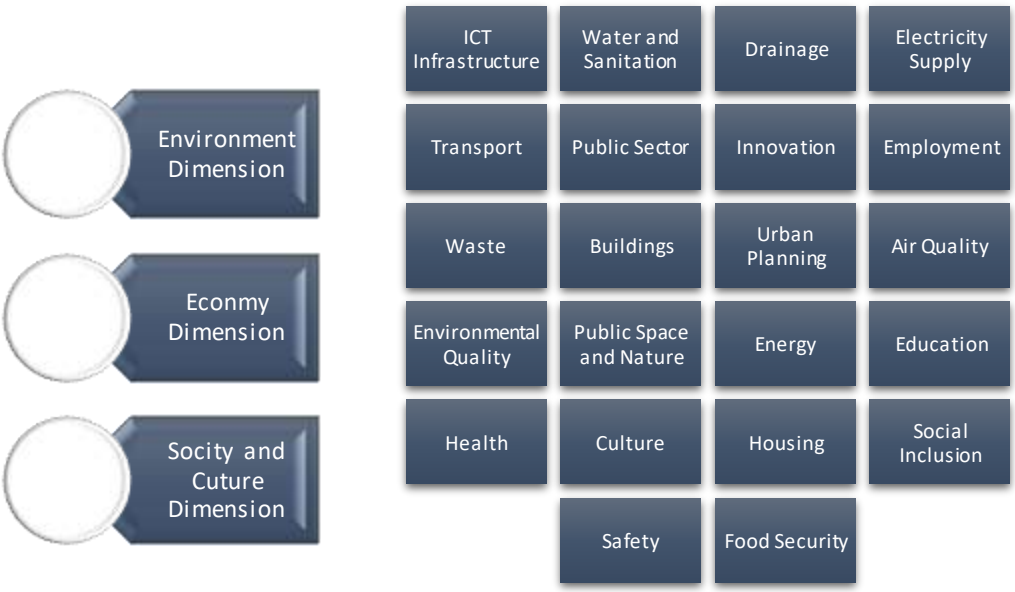

Figure 4: Dimensions and 22 categories

Table 1: Weighted KPIs discussed in Vienna

Criteria	Weight (%)	Factors	Weight (%)
Smart Economy	16.7	Innovative Spirit	2.8
		Entrepreneurship	2.8
		Economic Image & Trademarks	2.8
		Productivity	2.8
		Flexibilty of Labour Market	2.8
		International Embeddeddness	2.8
Smart People	16.7	Level of Qualification	4.2
		Learning Lifelong	4.2
		Ethnic Plurality	4.2
		Open - Mindness	4.2
Smart Governance	16.7	Participation in Publlic Life	5.6
		Public and social services	5.6
		Transparent Governance	5.6
Smart Mobility	16.7	Local Accessibility	4.2
		International Accessibility	4.2
		Infastructure - Availability of IT	4.2
		Sustainability of the transport System	4.2
Smart Environment	16.7	Environmnetal conditions	4.2
		Air Quality	4.2
		Ecological Awarness	4.2
		Suistainable Resource Management	4.2
Smart Living	16.7	Cultural Facilities	2.4
		Health conditions	2.4
		Individual Security	2.4
		Housing Quality	2.4
		Education Facilities	2.4
		Touristic Attractiveness	2.4
		Economic Welfare	2.4

4. Egypt's Vision 2030

As part of Egypt 2030 Vision, the smart clean sustainable cities initiative is a vital initiative adopted by the government.

Figure 5: Egypt's 2030 Vision &Goals

4.1Example of Egyptian Cities

The Administrative Capital is studied in this paper due to several reasons discussed below:

The administrative capital is designed to be the first smart and sustainable city in the Arab Republic of Egypt by building a digital city based on modern information and communication technology infrastructure (fiber optic cables, telecommunications equipment and sensors, data centers). To ensure the instantaneous circulation of information with world-class standards to provide many electronic services to citizens to facilitate living and promote welfare and keep pace with the technological development of the cities of the fourth generation "

5.0 KPIs Definitions for smart sustainable clean cities

5.1 Energy and Environment

Energy and environment pillars refer mainly to energy efficiency in the built environ- ment and other elements of the cities that imply energy consumption reduction such as smart lighting or renewable generation at the local and district/city levels (e.g., building- integrated RES, district heating, PV plants, wind farms, etc.).

To determine high-performance districts, the energy demand and the use and the self-consumption of the buildings are calculated. In order to accomplish this, IPMVP (International Performance Measurement and Verification Protocol) has been selected, as it is a standard for the evaluation of the energy performance.

Reporting period: It is the period after the construction or renovation of the building, where the final performance is measured. This period has the requirement of real data,

When applying at district/city level for shared generation systems (e.g., district heating), the boundary is rescaled. It does not only contain buildings and distribution elements, but also

integrates such generation systems to calculate the indicators at consumed energy levels (i.e., considering the performance of the different elements in the generation and distribution chain).
Finally, the case of lighting systems comprises the energy consumption of the bulbs and the comparative of energy when light bulbs have been replaced. In this specific case, the adjustment is not made based on climate conditions, but on hours of use.

5.2 Mobility

The mobility evaluation pursued the quantification of mobility actions impacts and performance in terms of:

- Reduction of air quality emissions due to replacement of ICE (internal combustion engine) by electricity powered vehicles (EVs)
- Amount of travel, energy consumption and journey quality of e-vehicles
- Amount of use and pattern of the charging infrastructure installed
- Degree of energy managed and supplied to EVs by renewable sources
- Willingness to use multimodality actions and investment in urban freight

Data collected from transport facilities are used for the calculation of KPIs, identified by each mobility action with the exception of the impacts in the air quality emissions that need of a specific methodology to quantify the avoided air emissions. Thus, the evaluation approach establishes two measurement periods: baseline with ICE vehicles as reference for comparison and reporting period with e-vehicles. Additionally, this considers that distances travelled during both periods are the same. Then, the emissions avoided are measured as a function of consumed fuel or distance travelled per each type of vehicle and applying different emissions factors to each energy source used by them (e.g., diesel, electricity, etc). Standard emission factors for fuels are provided for European countries by the Covenant of Mayor and internationally by IPCC, whereas average consumption per distance travelled for each vehicle is shared by its manufacturer.
This means that the vehicle features (energy consumption and type of fuel consumed) are the only factors that change among baseline and reporting period, whereas other external factors to the vehicle are not analysed since the interventions do not have any influence over them (e.g., driving speed, driving style, road characteristics, traffic and weather conditions).

5.3 Urban Infrastructure/Digitalization via ICTs

Digitalization of the city is also considered in this evaluation framework, which is reached through the implementation of ICT solutions in form of urban data platform. The method for the ICT analysis diverges from the previous infrastructure analysis, as the domain is completely different. In this specific case, software metrics are used to measure the level of digitalization of the city. Basically, the ICTs are quantified as:

• Number of sensors and datasets integrated in the urban platform;
• Number of available services;
• Number of available open data and open APIs (application programming interface);
• Number of different users, such that usability can be determined;
• Response time, as performance metric to determine the time that any user should wait to receive the expected results from the urban platform services;
• Scalability, as the capability for extending the resources of the urban platform;
• Availability, as the time during which the urban platform does not suffer crashes.

5.4 Economy

The economy pillar has as objectives the measurement of the actions' effectiveness and the related business models, as well as the monetary impacts of the demonstrative actions in the cities, citizens and companies involved in their implementation. An analysis of cost–benefit of the solutions is performed after the calculation of KPIs identified with the data provided by the action leaders once the actions are concluded.

The economic evaluation is then implemented as follows:

• Financial performance of the actions through the description of the funding/financial model and the identification of the costs and revenue structure associated with the implementation, operation and maintenance of the actions;

• Societal, economic and environmental benefits of actions in terms of monetary terms through the evaluation of a variety of aspects such as: jobs created, expenditure in local economy, impact in business units and improvement in air environmental quality among others.

5.5. Citizens (Social)

This pillar tries to reveal the degree of satisfaction of citizens with the project solutions deployed in the city and analyze the existence of a behavioral change in the society as well as the factors that influence in the level of acceptation. The analysis is rendered through tailored questionnaires according to the object to be assessed and the target audience defined which must be the citizens affected by the interventions. The tool, which is distributed once the project actions have finished, allows for the evaluation of the final acceptance of the local population about new technologies installed, the willingness to invest in similar solutions and/or recommending these to others. This analysis also includes citizens' perception in the technical and economic design of the solution, the amount of information received and the degree of involvement in decision making. Finally, an analysis of the respondent profile is performed (e.g., age, gender, socio-economic status) for considering this result in future social campaigns focused to upscale/replicate the solutions evaluated.

Additionally, this pillar is addressed to assess the target people reached in citizen engagement activities carried out by the project to inform about benefits of energy efficiency and RES solutions and to empower citizens in the urban transformation planning process. To this regard, the number of people reached and the diverse social background are evaluated.

5.6 Governance

The governance pillar aims to assess how the project has contributed to the urban development by the means of a questionnaire based on Likert Scale and open questions, which is filled in by the main contact point of each lighthouse city at the end of the project. Main aspects to be gathered correspond to:

• Function of the local authority in the development of the project: role in the financing, implementation, management and transferability of knowledge gained;

• The extent to which the project has been able to influence in the local government with re-definition of city policies and the implementation of changes in the organizational scheme of the local administration or development of new rules and regulations;

• To which extent the project has influenced in the identification of city priorities and most promising solutions to achieve the city vision:

  - How Sustainable Energy and Climate Action Plans (SECAP), Sustainable Urban Mobility Plan (SUMP) and others city plans have been benefited from the lessons learned during the implementation of actions;

- How methods applied during the definition of an innovative urban transformation strategy and the outputs obtained from energy demand of the cities, energy scenarios, techno-economic analysis and business models have contributed to the definition of a long-term advanced planning in the city.

6.Applying corresponding measures on the new Administrative Capital

Dimension	Weight (%)	Subdimension	Weight (%)	Charecteristics	KPI	Weight	Evaluation
Smart Economy	12.5	Innovative Spirit	2.5	Total Research & Development Expedinetures	Expenditures from GDP	0.8	
					Employment Rate	0.8	
				Patents	Patent application relative to population	0.8	
		Entrepreneurship	2.5		self employment rate	1.0	
				Create job opportunities	No of new registered companies	1.0	
		Economic Image & Trademarks	2.5	Commercial Licenses	Decision Making Centers and Brands	1.3	
		Productivity		Individals standard of living	GDP / Capital	1.3	
		Flexibilty of Labour Market	2.5		Unemployment rate	1.3	
				Market Labour requirements	Partial Employment Rate	1.3	
		International Embeddeddness	2.5	Pushing towards Globalization	The HQ of international Companies	0.6	
				Local Stock Market	Market Contribution	0.6	
					Transportation for Air	0.6	

					Passengers		
					Goods' air transportation	0.6	
Smart Governance	12.5	Participation in Publlic Life	4.2	The rate of participation	city representatives in relation to the population	1.4	
				The rate of participation	political activities for individulas	1.4	
				type of participation	the importance od politics for individuals	1.4	
		Public and social services	4.2	spending rate	municipal spending in relation to the population	1.4	
				childhood represnetation	children's participation in care centers	1.4	
				Quality satisfaction measurement for education	Individual satisfaction with the quality of schools	1.4	
		Transparent Governance	4.2	Equal opportunity	Satisfaction with tanspaency	2.1	
				Accountability	consensus on fighting corruption	2.1	
Smat Mobility	12.5	Local Accessibility	3.1	Public Transportation availbility	public transpot network in relation to the number of individulas	1	
				Access to public Transport	individual satisfaction with ease of access	1	
				Public Transportation Efficiency	individual satisfaction with the quaity of public transportation	1	

		International Accessibility	3.1	International Mobility	global accessibility	3	
		Infastructure - Availability of IT	3.1	Home Coomunications Capability	availability of computers	1.6	
				Internet Service	Availability of Broadband internet in homes	1.6	
		Sustainability of the transport System	3.1	preservatio of the environment	transport sharing	1.1	
				safety and security	traffic safety	1.1	
				economic Mobility	use econmomical cars	1.1	
Smart Environment	12.5	Environmneta l conditions	3.1	clean Energy sources	sunrise hours	1.6	
					availability of green areas	1.6	
		Air Quality(No pollution)	3.1	air pollution	summer smog	3.1	
		Ecological Awarness	3.1	awarness of environmental protection	individual efforts to protect the environment	1.6	
				awarness of environmental protection	opinion on the subject of environmental protection	1.6	
		Suistainable Resource Management		water waste	Effective water consumption /use in relation to the GDP	1.6	
			3.1	waste of energy	electrical consumption /usage relative to GDP	1.6	
Smart Living	12.5	Cultural Facilities	1.8	Entertainment	Cinema visit rate / person	0.4	
				Education	museum visit	0.4	

					rate / person		
				Entertainment	theatre vist rate / person	0.4	
				public health measurements	Life rate / average age of individuals	0.4	
		Health conditions	1.8	material resources for healthh	number of hospital beds / population	0.6	
				HR for health	number of doctors / population	0.6	
				public healh system	quality of the health system	0.6	
		Individual Security	1.8	security	crime rate	1	
					Crime rate (deaths)	1	
				measuring security efficiency	peresonal satisfaction with personal activity	0.4	
		Housing Quality	1.8	The right to housing	providing minimum standards	0.4	
				per capita	area of populated /number of individuals	0.4	
				measuring housing efficiency	individual satisfaction with housing	0.4	
			1.8		No of students : number of residents	0.45	
		Education Facilities		Teaching and Learning	Easy access to the education system	0.45	
					Quality of the educational system	0.45	
					Importance as touristical site	0.45	

		Touristic Attactiveness	1.8	Turism Development	No of annual tourists' stays : Totaal population	1.8	
		Economic Welfare	1.8	Economic Awareness	realizing the seriousness of poverty	1.8	
Smart People	12.5				poverty rate	0.7	
		Level of Qualification	3.1	Importance as a knowledge center	best research centers and universities	0.7	
				International Standard classification of education	number of qualified individuals at level 5-6	0.7	
				stage (1 & 2) of Higher Education	The number of members of the 2 phases of the population	0.7	
				Cognitive Competence	Language skills	0.7	
		Learning Lifelong	3.125	perception cognitive	borrowing books according to the number of individuals	1	
				continous education	contribution to long term education	1	
				cultural awarness	contribute to language courses	1	
		Ethnic Plurality		citizinship	participation of forigners	1	
			3.1		participation of citizens residing abriad	1	
					providing a climate conductive to migration	1.0	
		Open - Mindness	3.125	importance of regional	turnout for regional	0.5	

				participation	elections		
					information about regonal associations	0.5	
					getting a new job	0.5	
				creativity	others participate in creative industry	1.5	
Civilization and Urban Identity	12.5	Cultural Identity	2.5	Symbolism	Historical /philosphical /functional reference	0.90	
				Tie to intellectual significance	political /religious /social significance	0.90	
				Development of the spirit of national belonging	civilizational Trait	0.90	
		Iconography	2.5	Formation	singularity /adding personality /meaning affirmation	0.715	
				Amazingness	Voumetric /technological /strength /control / glory	0.715	
				urban context	Harmony with the surrounding environment	0.715	
				economic return	attracting investment (Regional /Local /Global)	0.715	
		Mental Image	2.5	Visual structure elements	Landmarks	0.625	
					Visiual sequences and tracks	0.625	

					squares and visual nodes	0.625	
					neighborhoods , borders and landscape	0.625	
		Zero Carbon	2.5	energy consumption	reduction of energy consumption	0.8	
				Land use	standard ratios (zero carbon)	0.8	
				Environmental sustainability	materials , technologies and operating systems	0.8	
		Strategic Plan	2.5	Site	Ease of access/Availability of resources	0.625	
				The influence	Global/Regional /Local Level	0.625	
				The economic base	Renewable Growth Poles	0.625	
				The possibility of growth	Growth Opportunities (Horizontal - Vertical)	0.625	
Energy and cleanliness	12.5	Energy Conservation (EC)	2.5	Reducing utilization of non-renewable energy resources	energy consumption per Individual	0.6	
				Generation and utilization of renewable energy resources	utilization of renewable energy sources	0.3	
					social awareness and training on renewable energy	0.3	
				Determination of policies and basic principles for	· Legislating and enforcement of the law on	0.2	

				compliance and preventive actions for climate change	climate change		
					· Regulations for increase of energy efficiency and savings for controlling and mitigating greenhouse gas emissions	0.2	
					· Preparation of climate maps of settlements, and keeping them updated	0.2	
				Reduction of pollution	green spaces within settlements per area	0.6	
		Land Conservation (LC)	2.5	Conservation of topographic structure of land	· Provision of harmony between land usage and topographic structure	1.2	
				Conservation of habitat	agricultural areas : total area	1.2	
		Water Conservation (WC)	2.5	Increasing utilization efficiency of water resources	Utilization of systems allowing efficient usage of water	0.8	
					enforcement of the law on water management	0.8	
					Reduction Rate of water consumption	0.8	
		Waste Reduction	2.5	Formation of waste and	· Promotions to local	0.8	

		(WR)		recycling systems	administrations for waste systems and recycling		
					· Increasing public sector supervision in waste management	0.8	
					· use of recycling technologies	0.8	
		Accessibility Ensuring (AE)	2.5	Generation of environment-friendly urban transportation policies and plans	o Encouraging public transport usage	0.8	
					o Developing energy-efficient transportation means and systems	1.2	
					o Minimization of private vehicle ownership	1.2	

7.Conclusion

This paper was an attempt to define measures of goals on smart sustainable clean cities. The main contribution of this paper is to set an agenda for future works: find out direct and clear connections between SCs and SDGs; propose SCs strategies that are committed to achieve the goals and measure the effects of such strategies on maintaining a smart sustainable city to ensure a high quality of life that works for Egypt's 2030 Vision

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