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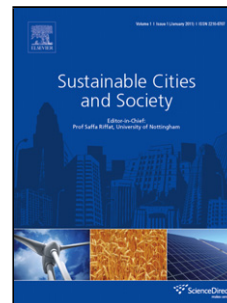
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Smart Sustainable Cities Roadmap: Readiness for Transformation towards Urban Sustainability

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Highlights

- A novel generic roadmap for the transformation towards Smart Sustainable Cities (SSCs) is proposed. To do so, an unprecedented link between the Theory of Change (ToC) and Smart Sustainable Cities (SSCs) is introduced along with a novel theoretical logic model for the transformation towards Smart Sustainable Cities.
- The roadmap provides an overview of the general directions of a transformation process, identifying the main phases and components that should be achieved during a transformation journey.
- The main contribution of this research study is highlighting the need for an additional starting phases throughout the transformation process based on an established theory. These phases ensure examining the current city context regarding its economic, social, environmental, and political state and challenges as well as checking the city readiness for change through assessing its local assets. The proposed roadmap aims at assisting city planners, decision and policy makers, and key stakeholders in understanding the essential aspects to be considered during their cities transformation journey.
- The proposed roadmap was validated by surveying experts in the area from different countries around the world.

ABSTRACT

City planners are currently seeking to transform their cities into Smart Sustainable Cities (SSC) aiming to face the rapid urbanization and its related challenges. This transformation is often represented by a roadmap. Different approaches were introduced in the literature to assist in developing such a roadmap. However; a thorough analysis of these approaches shows none of them cover holistically all aspect of the SSCs. For instance, some roadmaps neglect analyzing the current challenges of a city. Others falls short in addressing one or more of the SSC six dimensions. None considers checking the city readiness for change. This constitutes a gap in knowledge that this research highlights and addresses through a sound theoretical foundation, specifically, by linking the Theory of Change to the SSC concept and introducing a theoretical logic model for the transformation towards SSCs. The latter is used to propose a coherent, systematic transformation roadmap that captures the cross-cutting readiness of a city along its infrastructures. It aims at assisting city planners, decision makers, and key stakeholders in understanding the essential aspects to be considered during their cities transformation journey. This research also summarizes the results of an undertaken validation process, confirming the components of the proposed roadmap.

1. Introduction

The world is experiencing the largest wave of urban growth in history. Over half of the world's population is now living in cities and according to the United Nations estimates, by 2050, 66% of the total world's population is expected to be urban. With this rapid urbanization, cities will face various sustainability challenges (UN, 2014); including, but not limited to, the poverty expansion, social stress, natural resources shortage, spatial dynamics, and urban pollution with its effect on the climate change phenomenon (Choucri et al., 2007). Given this unprecedented global urbanization growth and the need for sustainability at all aspects of a city, the concept of "Smart Sustainable Cities" (SSCs) emerged as a desired goal for present and future urban development and attracted the attention of many researchers and practitioners in the field (Nam & Pardo, 2011). Their challenge is to ensure that cities are offering improved living conditions for their citizens by solving a set of sustainability challenges at the economic, environmental, and social levels. The Information and Communication Technologies (ICTs) offer high potential for solutions to many of these challenges while ensuring that they are environmentally friendly and viable (Ibrahim et al., 2015a).

1.1 Smart Sustainable City Definition and Dimensions

SSC is a fuzzy concept with no standardized terminologies that can be used to comprehensively describing it. Many definitions exist in the literature for the concept and they are used inconsistently. There is neither a single template for framing the concept, nor a one-size-fits-all definition for it (O'Grady & O'Hare, 2012). Depending on the lens or viewpoint taken, there exist various definitions and dimensions of the concept. However; all agree that a SSC is evolving as an urban space that tends to solve urban problems and improve quality of life of citizens, making urban development more sustainable (Negre et al., 2015; Monfaredzadeh & Berardi, 2015).

With the aim of ensuring that the sustainability aspect is not overlooked in the "Smart City" concept, the International Telecommunication Union Focus Group on Smart Sustainable Cities (ITU-T FG-SSC) added the word "Sustainability" to the concept of "Smart Cities" and started using the term "Smart Sustainable Cities" instead. Moreover, they studied and analyzed nearly one hundred existing definitions of smart cities, sustainable cities, and SSCs in the literature and identified the top keywords and characteristics that make a SSC. Based on this, the ITU-T FG-SSC introduced a new definition for the concept, adopted by this research, which reads as follows: "*A Smart Sustainable City is an innovative city that uses Information and Communication Technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects*" (ITU-T FG-SSC, 2014a; ITU-T FG-SSC, 2016). Additionally, a SSC is defined across six dimensions, namely, Smart Economy (competitiveness), Smart Environment (natural resources), Smart Governance (participation), Smart Living (quality of life), Smart Mobility (transport and ICT), and Smart People (social and human capital) (Giffinger et al., 2007). A SSC also uses the ICTs as a cross-cutting enabler to improve quality of life of citizens and competitiveness and ensure a more sustainable future of a city through adequate and green solutions and services (Monfaredzadeh & Berardi, 2015). Figure 1 (Ibrahim et al., 2016) illustrates the SSC six dimensions along with the ICT as a across-cutting enabler.

1.2 Transformation towards Smart Sustainable Cities

Developing cities into SSCs requires an efficient and effective transformation process. The latter should take into consideration the city context and needs, local interests, quality of life of citizens, readiness of a city for the change, and a series of essential smart and sustainable solutions and services to be delivered at all city levels (Ibrahim et al., 2016). Transformation towards SSCs is "*a complex multidimensional process through which changes are applied at all city levels; aiming to enhance the sustainability of a city and provide a high quality of life for its citizens through the use of ICTs and other means*" (Ibrahim et al., 2016).

A SSC transformation process, as illustrated in Figure 2 (Ibrahim et al., 2016), is often represented by two types of diagrammatic forms, namely, the transformation (1) roadmap and (2) framework. The roadmap provides a diagrammatic illustration of the general directions (i.e. phases) and priorities of a transformation process (Withers et al., 2012) (e.g., outline the need for identifying a transformation plan). It guides a SSC team to critical decision points throughout a transformation journey. In (Ibrahim et al., 2016), "*a smart sustainable city roadmap provides a high-level view of the objectives and goals of the transformation process and identifies the transformation phases and milestones in order to realize the city's vision for being smart and sustainable*". Therefore; any proposed generic SSC roadmap must be clear, understandable, achievable, and comprehensive as possible. This research focuses of proposing such a roadmap.

The framework, in turn, provides a diagrammatic form highlighting the needed tools to be used for turning the roadmap phases and components into actions (Di Biase, 2014; Borowik et al., 2015). It aims at providing answers to *how* to realize a SSC transformation roadmap. In (Ibrahim et al., 2016), "*a SSC framework is a layered structure that leads city planners and relevant stakeholders throughout a transformation process by providing guidance on city readiness for change and the innovative solutions needed to grant urban sustainability and high quality of life for citizens*".

Different approaches were introduced in the literature to assist in the development of such a roadmap (Ibrahim, 2015b). This includes the European Platform for Intelligent Cities roadmap (EPIC, 2013), British Standards Institute roadmap (BSI, 2014), Huawei (2014) roadmap, ITU-T FG-SSC (2015b) roadmap, and Smart Cities Council roadmap (SCC, 2015). Each roadmap tackles a transformation process from its point of view. A thorough analysis of these roadmaps clearly shows none of them cover holistically all aspect of the SSCs, which constitutes a gap in knowledge. Using a roadmap that does not consider all aspects of a SSC leads to an incomplete transformation process. Without a thorough transformation roadmap, city planners, policy makers, and key stakeholders will not have a concrete base to follow during their transformation journey. Consequently, the possibility of neglecting essential aspects while transforming a city into a SSC becomes high, or worst, it may cause the whole transformation process to fail (Edwards et al., 2000). Therefore, a coherent, systematic transformation roadmap is a must.

The purpose of this research is to clarify weather existing SSC transformation roadmaps are considering the overall aspects of SSCs. The research question regards the main aspects that should be considered to ensure a comprehensive, systematic transformation process of traditional cities into SSCs. The methodology consists of studying different SSC transformation roadmaps in the literature, identifying their gap in knowledge, and then introducing a novel transformation roadmap based on the Theory of Change (ToC) elements and stages while considering the SSC objectives and dimensions. The proposed roadmap guides and facilitates the transformation of traditional cities into smart and sustainable ones and has an added value to knowledge and practice. Its main contribution highlights the need for an additional starting phases throughout the transformation process based on an established theory. These phases ensure examining the current city context regarding its economic, social, environmental, and political state and challenges as well as checking the city readiness for change through assessing its local assets. The proposed roadmap aims at assisting city planners, decision and policy makers, and key stakeholders in understanding the essential aspects to be considered during their cities transformation journey. Lastly yet important, transformation of cities from traditional ones into SSCs did not happen yet (Deloitte, 2015). This is related to the long-term nature of a transformation process as a journey of continuous improvements. Accordingly, none of the proposed roadmaps were validated on real case studies. Some were adopted by existing cities and being modified and updated to meet the context and needs of these cities. Others, like the case of this research, are conceptual ones. However; our proposed roadmap was validated by surveying experts in the area from different countries around the world. This validation process confirmed the introduced components and logic of the proposed roadmap.

The rest of this paper is structured as follows. In the next section, the research methodology and significance are highlighted. In Section 3, a brief review and analysis of existing transformation roadmaps in the literature is carried out. Section 4 is devoted to the research results and findings, particularly, introducing a link between the ToC and SSC concept, introducing a novel theoretical logic model for the transformation towards SSCs, proposing a new transformation roadmap along with a tabulated comparison between the proposed roadmap and others, and shedding light on the validation process results. Research discussion and limitations are provided in Section 5. The paper concludes in Section 6 with a brief summary and ideas for future work.

2. Research Methodology and Significance

2.1 Research Methodology

This research paper is based on two years of extensive research, specifically, on studying and analyzing hundreds of research papers, articles, reports, and published studies on smart cities, sustainable cities, sustainable urban development, SSCs and urban development related theories. The research follows a theoretical research method, particularly, a literature based research methodology to identify a gap in knowledge in existing SSC roadmaps in the literature and propose a novel one. The methodology consists of the following:

   (i)   Conduct an extensive literature review on existing SSC transformation roadmaps.

   (ii) Study and analyze existing roadmaps and extract and tabulate the main components constituting each.

(iii) Propose a thorough definition for a SSC transformation roadmap in-line with the objectives of developing cities into SSCs (Ibrahim et al., 2016).

(iv) Due to lack of a theory for the transformation towards SSCs, an extensive literature review on existing theories from neighboring disciplines in addition to theories of change was conducted, such as sustainable change, urban development, human systems integration, ToC, theory of cities, theory of quality of life, and others.

(v) After selecting the appropriate theory to follow, the phenomenon of transforming cities into SSCs was linked to the ToC and a theoretical logic model for the transformation process was introduced, aiming to highlight the minimum essential requirements to be considered while developing the desired transformation roadmap.

(vi) The common phases between all roadmaps studied from the literature were selected and considered as essential phases in the proposed roadmap.

(vii) Neglected phases were identified along with the required justifications based on the ToC, sustainable urban development, and other related theories as needed.

(viii) For each phase, a list of required components to be considered while implementing the proposed phase was identified. As in points (vi) and (vii), common components were adopted and missing components were added supported by proper justification.

(ix) A comparison between the proposed roadmap and existing studied roadmaps was tabulated aiming to highlight the newly added phases and components and demonstrate the strength of the proposed roadmap compared to others.

(x) Undertake a robust validation process to confirm the components of the proposed SSC roadmap.

2.2 Research Significance

According to the literature, different approaches were introduced so far to assist in the development of a roadmap aimed at facilitating the transformation process of traditional cities into SSCs. However, a thorough analysis of these approaches clearly shows that none of them is harmonically structured in a way to consider all aspect of SSCs. In specific, in some instances, existing transformation roadmaps neglect analyzing the current economic, social, environmental, and political state and challenges of a city. Another group of roadmaps falls short in addressing one or more of the dimensions of a SSC. The limitations of the approaches are numerous but what is of utmost importance is that none of the existing roadmaps attributes attention to checking the city readiness for change before planning a smart urban transformation process. The latter constitutes a knowledge gap that this research highlights and addresses through a sound theoretical foundation mainly based on the ToC and the sustainable urban development approach. Accordingly, this research starts by introducing a link between the ToC and SSCs. Using this link, the theoretical logic model for the transformation towards SSCs is introduced. This theoretical model forms the basis for proposing a coherent, systematic transformation roadmap that adopts a holistic modality capturing the cross-cutting readiness of the city along the different city's infrastructures. The proposed roadmap guides and facilitates the transformation of traditional cities into smart and sustainable ones and has an added value to knowledge and practice. It highlights the need for an additional starting phases throughout the transformation process based on an established theory. It aims at assisting city planners, decision and policy makers, and key stakeholders in understanding the essential aspects to be considered during their cities transformation journey. Lastly yet importantly, this article summarizes the results of a robust validation process undertaken to confirm the components of the proposed SSC roadmap. This is done via surveying several global experts in the area from different countries around the world.

3. Literature Review

The extensive conducted research on existing SSC transformation roadmaps shows the availability of limited number of proposed solutions in the literature, each tackling the transformation process from its point of view. The latter includes EPIC (2013) roadmap, BSI (2014) roadmap, Huawei (2014) roadmap, ITU-T FG-SSC (2015b) roadmap, and SCC (2015) roadmap. This section aims at highlighting the phases of each of the studied roadmaps, their weaknesses and shortages, and their mapping to the SSC six dimensions, namely, smart economy, smart environment, smart governance, smart living, smart mobility, and smart people (Giffenger et al. 2007). To start with, Table 1 illustrates the phases of existing studied and analyzed roadmaps in the literature.

Table 1
Phases of existing SSC Transformation Roadmaps in the Literature

Transformation Roadmap	Roadmap Phase
EPIC (2013)	Vision phase Plan phase Design phase Build phase Deliver phase Operate phase
BSI (2014)	Plan phase Initiate phase Deliver phase Consolidate phase Transform phase
Huawei (2014)	Plan phase Initiate phase Deliver phase Consolidate phase Transform phase
ITU-T FG-SSC (2015b)	SSC Vision SSC Targets Achieve Political Commitment Build a SSC Measure the City Progress Ensure Accountability and Responsibility
SCC (2015)	Assessment phase Vision phase Project plan phase Milestones phase Metrics phase

The analysis of existing roadmaps shows that they are not solid and are not developed based on a systematic and theoretical logic, which constitutes a knowledge gap. For example, BSI and Huawei roadmaps are defining a city vision during their proposed planning phase. Based on (KU, 2015), the vision should be defined before planning the transformation process solutions and services. This vision is then supported by a vision statement, mission statement, objectives, goals, and strategies. Following the vision phase, the transformation change activities (i.e. solutions) could be identified and prioritized during the planning phase.

Moreover, none of the proposed roadmaps considers checking the city readiness for change before planning the transformation activities (i.e. solutions). In this context, city readiness refers to the current city capacities regarding its hard, soft, and digital infrastructures as well as the level of existing digital literacy. Only the ITU-FG-SSC and SCC provide lightly touch upon city assessment in their developed roadmaps. Although one aspect of the earliest stage of the ITU-T FG-SSC (2015b) roadmap is collecting the relevant data in relation to the city's ICT infrastructure status and its usage at a city-level, the ICT infrastructure is not the only resource required throughout the transformation process (Ruhel, 2014; Vogel, 2012; Kohel, 2016). Existing non ICT-based infrastructure, such as policies, laws and regulations and healthcare, education, and government systems, are essential and should be assessed as well (Any reference?). In relation to the SCC (2015), the proposed roadmap includes an assessment phase focusing only on assessing the current status of a city in relation to available SSC initiatives and goals, which is also not adequate.

On another note, none of the studied and analyzed solutions is based on a theoretical foundation or systematic logic to be followed while developing the proposed roadmaps; neither identifying their point of view behind the techniques used for selecting the proposed phases, ordering of phases, and identifying each phase components.

Finally, none of the studied roadmaps considers the six dimensions of a SSC, as illustrated in Table 2. Only EPIC (2012) indicates their consideration of the six dimensions; however; EPIC provides all SSC solutions and services over EPIC platform based on cloud computing techniques using PaaS and SaaS delivery models. All suggested services are web-based services and controlled by EPIC team. According to its various downsides (Apostu et al., 2013), developing a SSC based only on cloud computing techniques is insufficient. Moreover, ICTs are only an enabler or purveyor which allow providing solutions that enhance the smartness level of a city

(BSI, 2014, ISO/IEC, 2015, ITU-T FG-SSC, 2016). There are many issues to be considered at all city levels that have nothing to do with ICT, e.g. government policies, laws and regulations.

As a result, this research aims at closing this gap in knowledge by introducing a holistic SSC transformation roadmap based on a concrete theoretical foundation. The theoretical foundation is used to introduce a novel theoretical logic model for the transformation towards SSCs. The proposed roadmap is designed to consider all aspects of a SSC including its six dimensions. The latter is covered by showing the need to identify, prioritize, design, implement, and deliver a set of solutions under each dimension of a SSC.

Table 2.

Mapping of existing SSC transformation roadmaps to the SSCs six dimensions

	Dimensions - SMART						
Study	**Economy**	**Environment**	**Governance**	**Living**	**Mobility**	**People**	**Others**
EPIC	YES	YES	YES	YES	YES	YES	-
BSI	YES	YES	YES	YES	-	-	-
Huawei	YES	YES	YES	YES	-	-	-
ITU-T FG-SSC	YES	YES	YES	YES (named as smart society)	-	YES (named as smart society)	-
SCC	-	-	-	-	-	-	Smart Transportation; Energy efficiency; Smart Grids; Smart water networks; Public safety; Digital gov. services; Smart payment.

* Note: the symbol (-) indicates the disuse of the the dimension in the study

4. Research Findings and Results

With the aim of closing a knowledge gap in existing SSC transformation roadmaps, this section starts by introducing a link between the ToC and SSCs. This link used to propose a novel theoretical logic model for SSCs' transformation process. The latter form the basis for proposing a state-of-the-art SSC transformation roadmap. Resulted roadmap is compared to existing ones in the literature, highlighting its added value comparing to others. Finally, the results of an undertaken robust validation process to confirm the introduced components of a proposed roadmap are summarized.

4.1 Theoretical Foundation: Smart Sustainable Cities and Theory of Change

The ToC has emerged in the mid of 1990s from the fields of evaluation theory and social change theory (i.e. practices of community initiatives) with the aim of providing new ways of analyzing and evaluating programmes and initiatives related to social and political changes (James, 2011; Stein & Valters, 2012; Vogel, 2012). There is also a strong link between the ToC and the planning process (i.e. planning theory), as the former is widely used as a tool for strategic planning (Anderson, 2004; NPC, 2012; Vogel, 2012; Innes & Booher, 2014). It provides the methodological and logical thinking and models required to identify the current context and situation, address the needs, and achieve these needs through a series of change events/activities (NPC, 2012; Rogers, 2014).

From the development perspective, a ToC could be used as a way to focus on the theoretical underpinning of a project, identify linkages between project inputs and outputs, and explain how a project is expected to work. It helps in developing the required logical planning model of an initiative and programme (Vogel, 2012). From the evaluation perspective, a ToC has emerged to model and evaluate social programmes and community initiatives including complex ones (Stein and Valters, 2012; Vogel, 2012). As a result, a ToC could be considered as a central building block that lays the foundation for the strategic planning, measurement, learning, and evaluation planning and design of an initiative and programme (ORSIMPACT, 2015).

There are various definitions of a ToC depending on the area of research over which it will be applied; however; it is commonly realized as a term of why and how a given intervention will lead to a specific change taking into consideration the context in which a change will take place. It is a way of describing a set of

assumptions that are used to explain both a set of mini-activities (i.e. solutions) that leads to the long-term change and the connections between these activities and the desired outcomes of a programme or initiative (Weiss, 1995). The Ecosystem Services for Poverty Alleviation (ESPA) defines a ToC as a dialogue-based process that is used to generate a description of a sequence of events expected to lead to a desired outcome in a particular context. The description is often presented in a diagrammatic form and narrative summary to provide a guiding roadmap and framework, showing to the project team and related stakeholders how and why the desired goals can be achieved (Vogel, 2012).

To reach a better understanding of a programme or initiative, a ToC process provides five essential elements that should be addressed in order, as stages (i.e. phases), namely: (1) context of the initiative, (2) long-term change, (3) sequence of events, (4) assumptions, and (5) change diagram and narrative summary (Vogel, 2012; Allen, 2016). Figure 3 provides a summary of a ToC and its elements/stages, noting that the fifth stage aims at representing a ToC process using a diagrammatic form, such as a roadmap, and narrative summary.
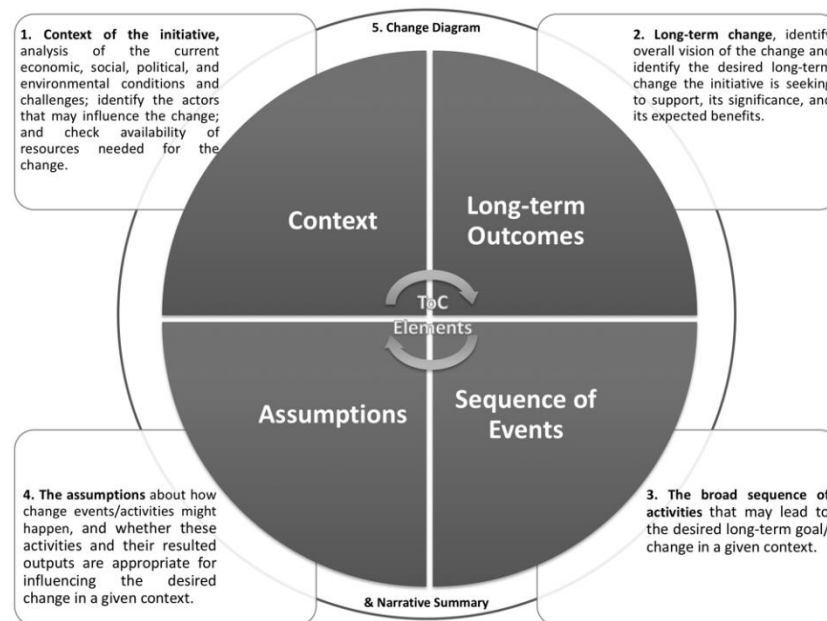

Figure 3: Theory of Change Elements and Stages

A ToC has strong roots in a number of disciplines, including sociology, political science, communications, environmental and organizational psychology (Stachowiak, 2013), education, public health (Laing & Todd, 2015), community development, and international development (Stein & Valters, 2012, Vogel, 2012; Laing & Todd, 2015). These strong roots come from the power of a ToC to focus not only on generating the required knowledge about the effectiveness of programmes and initiatives, but also on explaining the methods that are needed to be used to make a programme and initiative effective (Chris et al., 2011).

Focusing on communities, a community can be a nuclear family, urban community, suburban community, rural community, national region, region within a state, or entire nation (Debertin & Goetz, 2008). As one type of a community, many national and international studies use a ToC for urban development (LTS & ITAD, 2012; Mackinlay et. al, 2013; Gottret, 2013; PD&R, 2013). In this matter, a ToC helps in developing an overall picture of a required urban change that could be achieved through a series of change activities to be applied at different city levels based on a city context, needs and local interests. It is worth noting that the change activities in the context of a ToC refer to any activity (i.e. solution) that may be identified for the benefit of achieving the desired long term change and goals. In other word, they are a series of actions that may help in achieving the predefined and agreed on vision. For instance, one activity may focus on creating new policies to encourage citizens' engagement in the city governance, others may provide the needed solutions to reduce greenhouse gas emission, improve healthcare and education systems, and enhance transportation systems.

In turn, urban development is the main constituent of cities' vision, particularly SSCs' vision. For the latter, this vision could be achieved through a series of change activities to be applied at all city levels (i.e. as smart and sustainable solutions over the SSC six dimensions). These activities should take into consideration the city

context, needs, and local interests while ensuring the sustainability of a city in respect to its economic, environmental, and social aspects. With this urban development vision, a ToC, as a result, could be applied on the area of developing cities into SSCs. Its tools could be used to simplify the process of understanding the required transformation flow, components, and set of change activities (i.e. solutions) that are needed to transform a city into a SSC, keeping in mind that the long-term change of a transformation process is developing a city in question into a SSC. Figure 4 illustrates how a ToC concept is applied on urban development discipline and how transforming a city into a SSC is being linked to a ToC.
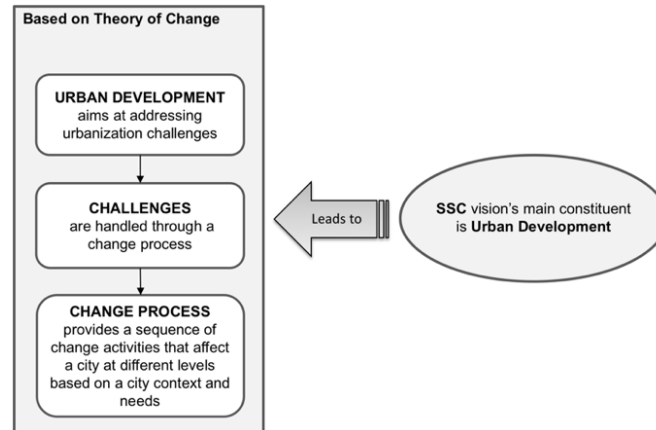
Figure 4. Theory of Change and Smart Sustainable Cities

Applying the ToC elements and stages shown in Figure 3, on a SSC concept and studying different techniques used to represent a ToC logic model (Vogel, 2012; KU, 2015; Allen, 2016) made it possible to introduce a theoretical logic model for transforming cities into SSC. This is illustrated in Figure 5. This logic model highlights the minimum essential elements and stages (i.e. phases) to consider during a SSC transformation process. The introduced logic model forms the basis for proposing a new transformation roadmap for SSCs. Return arrows from 'OUTCOMES-IMPACT' stage to "CITY CONTEXT" and 'INPUTS' stages indicate the continuity of the transformational change process. The double-headed arrows between 'INPUTS' and 'ACTIVITES, 'ACTIVITES' and 'OUTPUTS', and 'OUTPUTS' and 'OUTCOMES-IMPACT' indicate a bidirectional relationships and correlations between their elements that are neither predictive nor casual (Hair Jr et al., 2011), which is the case in the transformational change where long-term outcomes of a change are complex and unpredictable (Rikerjoe, 2009; Folke et al., 2010).

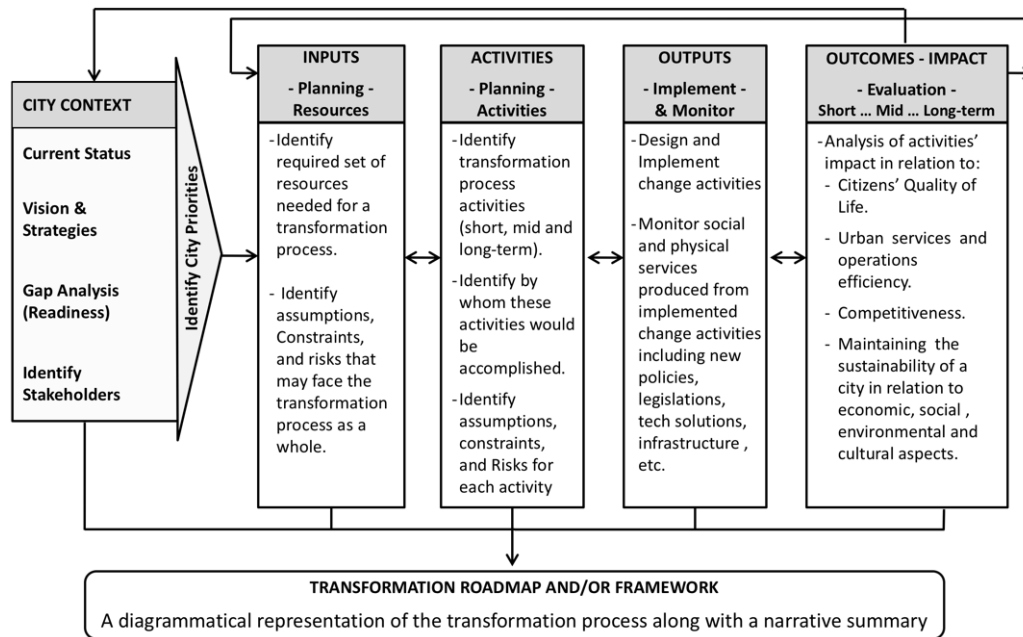| CITY CONTEXT	INPUTS - Planning - Resources	ACTIVITIES - Planning - Activities	OUTPUTS - Implement - & Monitor	OUTCOMES - IMPACT - Evaluation - Short ... Mid ... Long-term
Current Status **Vision & Strategies** **Gap Analysis (Readiness)** **Identify Stakeholders**	-Identify required set of resources needed for a transformation process. - Identify assumptions, Constraints, and risks that may face the transformation process as a whole.	-Identify transformation process activities (short, mid and long-term). -Identify by whom these activities would be accomplished. -Identify assumptions, constraints, and Risks for each activity	-Design and Implement change activities -Monitor social and physical services produced from implemented change activities including new policies, legislations, tech solutions, infrastructure , etc.	-Analysis of activities' impact in relation to: - Citizens' Quality of Life. - Urban services and operations efficiency. - Competitiveness. - Maintaining the sustainability of a city in relation to economic, social , environmental and cultural aspects.

Identify City Priorities

TRANSFORMATION ROADMAP AND/OR FRAMEWORK
A diagrammatical representation of the transformation process along with a narrative summary

Figure 5. Theoretical Logic Model for Transformation towards Smart Sustainable Cities

4.2 Proposed SSC Transformation Roadmap

As a high-level view of a SSC transformation process, the proposed roadmap aims at providing an overview of the minimum required aspects to be considered during a SSC transformation process. As required by a ToC, checking the city context at an early stage (i.e. during the Vision and City Readiness phases) of the proposed roadmap ensures the possibility of customizing the components of the following phases based on a city context and according to its specific attributes, needs, local interests, starting point, and specific sustainability objectives. Its continuity approach assures the sustainability of a transformation process through learning from previous SSC experiences, continuous improvements, and producing of additional changes at all city levels. It requires checking the city readiness for change before start planning and implementing the change activities (i.e. solutions), which is not considered by any of the studied roadmaps in the literature. The proposed roadmap is designed in a way taking into consideration the six dimensions of a SSC and ensuring the sustainability of a city over its economic, environmental, and social levels. Based on the results of analyzing existing roadmaps in the literature, the proposed roadmap's phases and components under each phase are either adopted from existing SSC solutions, or added based on the ToC required elements and sustainable urban development needs.

The proposed roadmap, as illustrated in Figure 6, consists of six phases named as: (1) City Vision, (2) City Readiness, (3) City Plan, (4) City Transformation, (5) Monitoring and Evaluation, and (6) Sustain Change. Each phase has a list of components to be carried out at a certain level of a transformation process. Dividing each phase into smaller components makes it easier to understand, implement, monitor, and evaluate. Return arrows from "Sustain Change" phase to "City Vision" phase and "City Transformation" phase indicate the continuity of a transformation process; meaning that the resulted outputs of this phase either show a need to update and enhance the previously identified transformation strategies, goals and objectives or improve the ability to maintain implemented solutions and introduce more new changes.
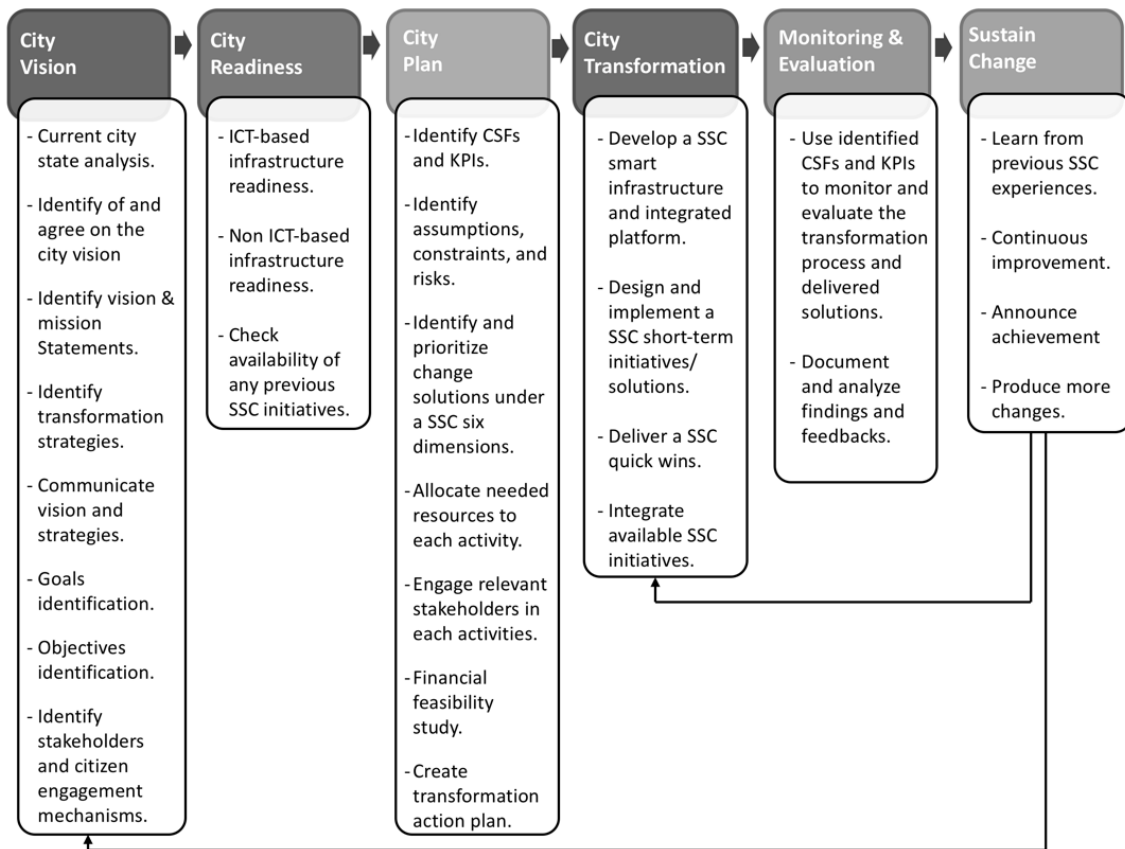
City Vision	City Readiness	City Plan	City Transformation	Monitoring & Evaluation	Sustain Change
- Current city state analysis. - Identify of and agree on the city vision - Identify vision & mission Statements. - Identify transformation strategies. - Communicate vision and strategies. - Goals identification. - Objectives identification. - Identify stakeholders and citizen engagement mechanisms.	- ICT-based infrastructure readiness. - Non ICT-based infrastructure readiness. - Check availability of any previous SSC initiatives.	-Identify CSFs and KPIs. -Identify assumptions, constraints, and risks. -Identify and prioritize change solutions under a SSC six dimensions. -Allocate needed resources to each activity. -Engage relevant stakeholders in each activities. -Financial feasibility study. -Create transformation action plan.	- Develop a SSC smart infrastructure and integrated platform. - Design and implement a SSC short-term initiatives/ solutions. - Deliver a SSC quick wins. - Integrate available SSC initiatives.	- Use identified CSFs and KPIs to monitor and evaluate the transformation process and delivered solutions. - Document and analyze findings and feedbacks.	- Learn from previous SSC experiences. - Continuous improvement. - Announce achievement - Produce more changes.

Figure 6. The Proposed Smart Sustainable City Transformation Roadmap

The first two phases of the proposed roadmap, namely, "City Vision" and "City Readiness", are related directly to the city context. The first phase focuses on checking the current state and challenges of a city regarding its economic, social, environmental, and political aspects. This helps in identifying existing challenges to be closed throughout a transformation process. The latter also facilitate agreeing on the overall vision of a city to be identified in collaboration with a group of relevant stakeholders and citizens. A series of strategies that can be followed to realized the agreed upon vision along with the transformation goals and objectives are identified during this phase as well (KU, 2015; Hofstrand, 2016). The final component to consider during this phase is identifying the stakeholders and citizen engagement mechanisms (BSI, 2014; Huawei, 2014; SCC, 2015; ITU-T GF-SSC, 2015b). These mechanisms ensure the engagement of a wider range and types of stakeholders including citizens, from all city levels, in a transformation process from its early stages, aiming to boost transparency and improve citizens buy-in. Therefore; there is a need to communicate the new city vision, mission, and strategies with locals using all possible communication channels (Kotter, 1995; Carpenter et al., 2012). If communicated properly, a wide range of city stakeholders including different types of citizens will get a city vision in a right way and participate into it (Kotter & Cohen, 2012).

This research new added value to knowledge and practice is represented by adding a new phase focuses on checking the city readiness for change before planning a transformation process, namely, "City Readiness" phase; noting that none of the studied roadmaps highlights the necessity of such a phase. The ITU-T FG-SSC (2015b) only suggests gathering the relevant data in relation to the status of the ICT infrastructure and its usage at the city level during its "Vision" phase. According to its importance and effect on a transformation process, this research tackles the city readiness for change as a stand-alone phase, during which the status of the current ICT-based infrastructure, Non ICT-based infrastructure, and availability of any previous SSC initiatives are examined.

In the context of this research, checking the city status regarding its current ICT-based infrastructure means checking the status of the current city (1) hardware infrastructure, such as wired and wireless networks infrastructure, (2) software infrastructure, such as social, business, and government applications, and (3) level of digital literacy, which requires sets of skills that are interdisciplinary in nature, such as the level of ICT skills, information skills, media skills, learning to learn skills, and civic skills. Checking the city status regarding its Non

ICT-based infrastructure refers to the current status of the city (1) hard infrastructure (i.e. tangible structures), such as buildings, roads, green areas, and bridges and (2) soft infrastructure (i.e. intangible structures), such as laws and regulations, policies, and healthcare and education systems. Finally, checking previously implemented or being implemented SSC initiatives aims at benefiting from these urban development initiatives and avoiding the duplication of efforts as well as learning from existing experiences.

The aim of the "City Readiness" phase is to help city planners, decision makers and relevant stakeholders to assess where their city is, identify the gap, and plan the transformation process accordingly. After checking the city readiness for change, a list of change activities could be designed, implemented, delivered, monitored, and evaluated to help closing the identified gap and providing solutions that are relevant to the objectives of a SSC. These activities should be planned based on the six dimensions of a SSC taking into consideration the current city context, needs and local interests with the aim of improving the quality of life of citizens, urban operations and services, and competitiveness. For example, if one of the city challenges is to increase its regional or international economic level, a city under a SSC smart economy dimension could plan and design a series of change activities (i.e. solutions). The latter may include activities to change the current city policies to encourage the establishment of new small and medium-sized business. Other change activities may focus on creating of new sectors for local, regional, and international investments.

A SSC transformation process, as a continuous long-term process, must be sustained and its continuity should be ensured. For this purpose, once the performance reports and documentations of the "Monitoring & Evaluation" phase become available, a SSC project team along with relevant stakeholders can use them as a reference to plan the appropriate future actions to be taken. As illustrated in Figure 7, this research divides the "Sustain Change" phase into four categories, namely:

   (i) **Learning from previous experiences**, to avoid repeating the same previous mistakes,

  (ii) **Continuous improvements**, to update and/or improve the transformation strategies, objectives, and goals if needed as well as to improve and maintain implemented and delivered solutions and services,

 (iii) **Announce achievements**, to maintain the transparency of a SSC transformation process, share experiences with others to learn from, and increase citizens and stakeholders buy-in, and

 (iv) **Produce more changes**, to ensures the continuity of a transformation process by stimulating the change process through producing a new series of change activities, aiming to realize the long-term goal of developing a city into a SSC.
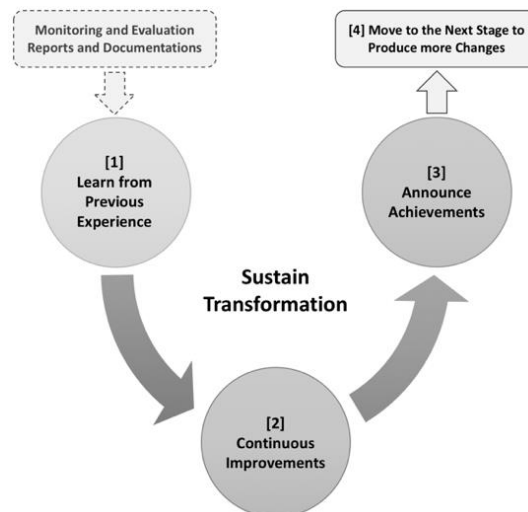

Figure 7. Sustaining a Smart Sustainable City Transformation Process and moving Forward

A comparison between the proposed roadmap and studied ones is carried out, focusing on the newly added phases and components to demonstrate the strength of the proposed roadmap comparing to others. Table 3 provides a sample of the compression results.

Table 3.

Comparison between the proposed smart sustainable city roadmap and existing studied roadmaps from the literature

Roadmap	Consider the SSC six dimensions*	City governs solutions	Check current city state	City Readiness			Identify assumptions/ constraints
				ICT Infrastructure	Non ICT Infrastructure	Previous initiatives	
Proposed roadmap	YES	YES	YES	YES	YES	YES	YES
BSI	NO	YES	NO	NO	NO	NO	YES (constraints)
Huawei	NO	YES	NO	NO	NO	NO	NO
EPIC	YES	NO	NO	NO	NO	NO	YES
ITU-T	NO	YES	NO	YES	NO	NO	NO
SCC	NO	YES	YES	NO	NO	YES	NO

* See Table 2 for more information about which dimensions are covered by each study

4.3 Validation Results

The transformation of traditional cities into SSCs did not happen yet (Deloitte, 2015). Accordingly, none of the proposed transformation roadmaps were completely validated on real case studies. Some were adopted by existing cities and are being updated and modified to meet the context and needs of these cities, such as the case of Dubai city (SCC, 2015; ITUT FG-SSC, 2016). Others are still in their conceptual stage without even validating their performance and correctness (EPIC, 2013; BSI, 2013; Huawei, 2014).

To check the soundness of the proposed approach, a validation exercise should be considered. In fact, validating a conceptual roadmap aims at determining its correctness, ensuring that its representation (e.g. its components) is reasonable for its intended purpose (Sargent, 1992; Kleijnen, 1994; Robinson, 1997). A trustful validation technique that captures the level of significance of the proposed approaches must be selected. According to the literature, numerous are the validation techniques that researchers may adopt to validate their work. These include examining the effectiveness of the proposed models via its application on real cases, conducting surveys, undertaking interviews with experts, among others (Sargent, 1992; Robinson, 1997; Banks, 1998). Given that the novelty of this research is of conceptual nature, it becomes important to validate it via capturing the insights of experts in the field on the various components of the model and refine it accordingly prior to applying it to real cases. Therefore, this research uses the survey questionnaire method to validate the different components of the proposed roadmap. It captures the insights of a group of experts from Europe, Americas, and Asia with a notable professional and/or Academic expertise in SSCs, sustainable cities, urban development, and ICT. Countries include Canada, Colombia, Estonia, Germany, Italy, Japan, Russia, United Kingdom (UK), United States (USA), and South Korea. The validation exercise mainly took place in the United Kingdom. The feedback of the experts is then used to modify and update the roadmap; either by adding the missed components or modifying existing ones if needed. This aims at enhancing the credibility of the proposed roadmap to be used on real-world systems and case studies (Sharp et al., 2002; FoF, 2012; Mureddu et al., 2014; Grafakos, 2015). Levels of experiences of surveyed experts are summarized in Table 4.

Table 4: Levels of experiences of surveyed experts

Experience	Level of Experience			
	None	Knowledgeable	Advanced	Proficient
SSC Concept	0%	31%	54%	15%
Sustainability Concept	0%	8%	23%	69%
City Planning & Evaluation	0%	38%	15%	47%
City Transformation Process	0%	23%	69%	8%
Cities' Stakeholder Engagement	0%	23%	15%	62%

Technology & Innovation	0%	0%	23%	77%

   The validation questionnaire consisted of two types of questions, close-ended and open-ended questions. The former was used to ask respondents about their level of satisfaction on the posed question. The latter aimed at collecting suggestions to realize the posed question. A 4-point Likert scale was used to collect respondents' answers on most of the close-ended question. The scale allowed the respondents to select their answers from a set of categories, that are: "very important OR strongly agree", "important OR agree", "moderately important OR disagree", and "unimportant OR strongly disagree". Collected data was then analyzed using two different types of statistical methods, namely, the consensus and dissention measures test and frequency method.

The level of consensus (Cns) and dissention (Dns) were calculated to measure the level of agreement and disagreement on the posed hypothesis. Assume the 4-point Likert scale categories are represented by the set $X=\{1,2,3,4,5\}$, then the Cns and Dns could be measured using the following formulas (Tastle et al., 2005; Tastle and Wierman, 2006 & 2007):

$$Cns\,(X) = 1 + \sum_{i=1}^{n} p_i\,\log_2\left(1 - \frac{|X_i - \mu_X|}{d_X}\right) \qquad where\ 0\ \leq Cns(X) \leq 1 \tag{1}$$

$$Dns\,(X) = 1 - Cns(X) \qquad\qquad where\ 0\ \leq Dns(X) \leq 1 \tag{2}$$

where pi is the relative frequency associated with each category X_i, is the mean, and d_x is the width of X. The degree of consensus and dissention measures is a value between 0 and 1. For consensus, the value '0' means that there is no consensus/agreement, leaving the dissention value equal to '1'. On another hand, the consensus value '1' indicates the existence of a complete consensus/agreement making the dissention value equals to '0'. Sample of the both measures is illustrated in Table 5.

Table 5: Consensus and Dissension Measures of the proposed SSC Transformation roadmap

Question		Mean (μ_X)	Standard Deviation (σ)	Consensus (Cns)	Dissention (Dns)
Q1		3.54	0.63	0.68	0.32
Q2	Q2.1	3.77	0.42	0.81	0.19
	Q2.2	3.85	0.36	0.86	0.14
	Q2.3	3.69	0.46	0.78	0.23
	Q2.4	3.54	0.50	0.74	0.26
	Q2.5	3.15	0.77	0.63	0.38
	Q2.6	3.62	0.62	0.70	0.30
	Q2.7	3.62	0.62	0.70	0.30
	Q2.8	3.62	0.62	0.70	0.30
Q3		3.77	0.42	0.81	0.19
Q4 & Q5		Not Applicable			
Q6	Q6.1	3.31	0.72	0.64	0.36
	Q6.2	3.46	0.63	0.68	0.32
	Q6.3	3.62	0.62	0.70	0.30
	Q6.4	3.77	0.42	0.81	0.19
	Q6.5	3.54	0.63	0.68	0.32
	Q6.6	2.69	0.46	0.78	0.23
	Q6.7	3.38	0.62	0.69	0.31
	Q6.8	3.46	0.50	0.74	0.26
	Q6.9	3.46	0.63	0.68	0.32
	Q6.10	3.92	0.27	0.93	0.08
	Q6.11	3.77	0.42	0.81	0.19
	Q6.12	3.92	0.27	0.93	0.08
	Q6.13	3.77	0.42	0.81	0.19
	Q6.14	3.62	0.62	0.70	0.30

| Q6.15 | 3.46 | 0.63 | 0.68 | 0.32 |

In turn, the frequency method was used to calculate the percentages of respondents on each Likert scale category for each question and illustrate results using a proposer statistical chart or graph. One of the added values of this research is proposing a stand-alone phase for checking the city readiness for change before planning a transformation process solutions and services. This phase focuses on assessing the current city assets regarding its non ICT-based (i.e. hard and soft) and ICT-based (i.e. hardware and software) infrastructures. As illustrated in Figure 8, about 85% of views (i.e. summation of "very important" and "important" options) tended to assess the hard infrastructure and software digital infrastructure of a city before planning a SSC transformation solutions and services. There was a collective agreement on the necessity of assessing the soft infrastructure and digital hardware infrastructure in turn.

On a final note, this research provides a brief summary on the respondents' reviews regarding different aspects considered in the proposed SSC transformation roadmap as illustrated in Figure 9.

The above figure shows that the majority of the respondents (92%), confirm the need for considering the components related to the city context and needs, stakeholders' engagement, city assets and readiness, CSFs, prioritization of activities, announcing achievements, and producing of more changes. As for other components, all respondents agreed unanimously on their significance.

5. Discussion and Limitations

This research study provides an insight into what are the aspects that should be considered before and during the process of developing cities into SSCs, introducing an easy to follow SSCs transformation roadmap. It is the result of two years of research studying and analyzing hundreds of technical reports and publications related to the subject matter in the literature and applying an in-depth analysis on these that provide detailed information about the required stages for the transformation journey. The results show a gap in knowledge in relation to the required aspects that should be taken into consideration throughout a transformation process. For instance, none of the studies mentions the need to check the city readiness for change before planning the needed transformation activities, which has a critical effect on the success of a transformation process that may only lead to failure. On another note, the introduced roadmap is not designed to a specific city, neither applicable on a particular context. The first two phases of the proposed roadmap aim at checking the city context in relation to its economic, environmental, social and political status before agreeing on a city transformation vision and its related strategies, goals and objectives as well as assessing the current city assets. After checking the city context and its readiness for change, a SSC project team can plan a transformation process based on the city context, needs, and local interests taking into consideration a SSC objectives and dimensions. This research also introduced an unprecedented link between the ToC and SSCs and came up with a novel theoretical logic model for its transformation process.

Although the research has reached its aims, there are some limitations to shed light on. The concept of SSCs is recent, limiting the availability of references that provide detailed information on roadmaps to assist the transformation towards SSCs. After conducting numerous research on the subject matter, only five appropriate studies were existing to collect the needed information from. Moreover, with a lack of a theory for the transformation towards SSCs and after studying different theories related to sustainable urban development, sustainable change, theories of change, human systems integration, theory of cities, theory of quality of life and others, this research selects a ToC as a solid theoretical foundation to highlight the needed stages throughout a transformation process as it is being used in many disciplines including sustainable urban development and strategic planning ones. This opens the door for others to select different theories to be applied on developing cities into SSCs or even develop a new theory for SSCs. Last but not least, a SSC transformation is a long-term process that cannot be achieved overnight; therefore; the proposed roadmap, like others, is still in its theoretical phase with no real implementation of it on existing city(ies).

6. Conclusion and Future work

Transforming a city into a Smart Sustainable City (SSC) is a continuous long-term process that requires changes to be introduced at all city levels. To be planned effectively and efficiently, a thorough high-level overview roadmap of needed aspects to be considered during a transformation process is highly needed. Different attempts exist in the literature to develop such a roadmap; each tackles a transformation process from its point of view without taking into account all required aspects of developing cities into SSCs, which denotes a gap in knowledge. This research starts by introducing a novel relation between Theory of Change (ToC) and SSCs along with a new SSC theoretical logic model, providing the basis for the proposed roadmap. It then proposes a novel transformation roadmap that could be customized based on city context, needs, and local interests. The roadmap provides an overview of the general directions of a transformation process, identifying the main phases and components that should be achieved during a transformation journey. It is being developed while taking into consideration the six dimensions of a SSC, city readiness for change, and sustainability of a city over its economic, environmental, and social levels. Its phases and components are adopted from existing SSC solutions, ToC elements, and/or sustainable urban development needs. The proposed roadmap guides and facilitates the transformation of traditional cities into smart and sustainable ones and has an added value to knowledge and practice. It highlights the need for an additional starting phase throughout the transformation process based on an established theory. It aims at assisting city planners, decision and policy makers, and key stakeholders in understanding the essential aspects to consider during their cities' transformation journey. Lastly yet important, the proposed roadmap was validated by surveying different experts in the area from different countries around the world. Validation results confirm the components of the proposed roadmap.

The proposed roadmap lays the foundation stone for developing a SSC transformation framework. The latter aims at providing the necessary tools needed to meet and achieve the identified phases and components of a SSC transformation roadmap. It also provides a generic list of areas under each of the SSC six dimensions to observe when transforming a city into a SSC, after which a city could be transformed into a SSC. Another planned future work is applying the proposed SSC transformation roadmap on real case studies.

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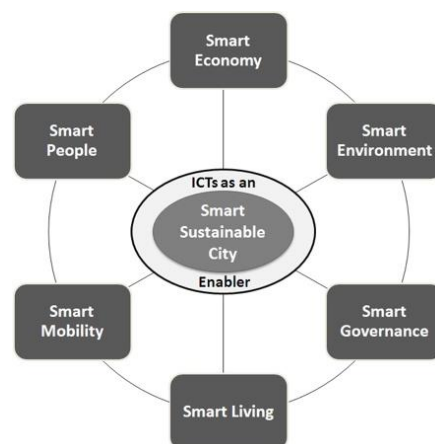
Figure 1. Smart Sustainable City six dimension and ICTs
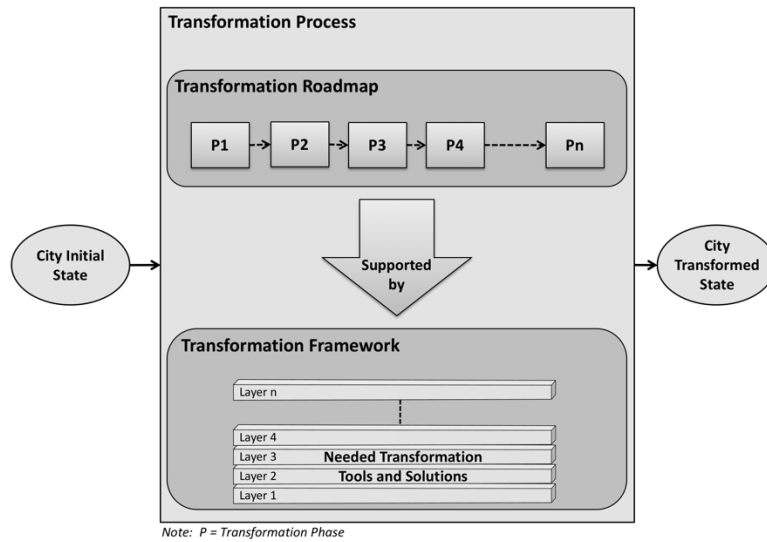
Note: P = Transformation Phase

Figure 2. Relationship between a Smart Sustainable City Transformation (1) Roadmap and (2) Framework (without the detailed phases, components, and tools of each)
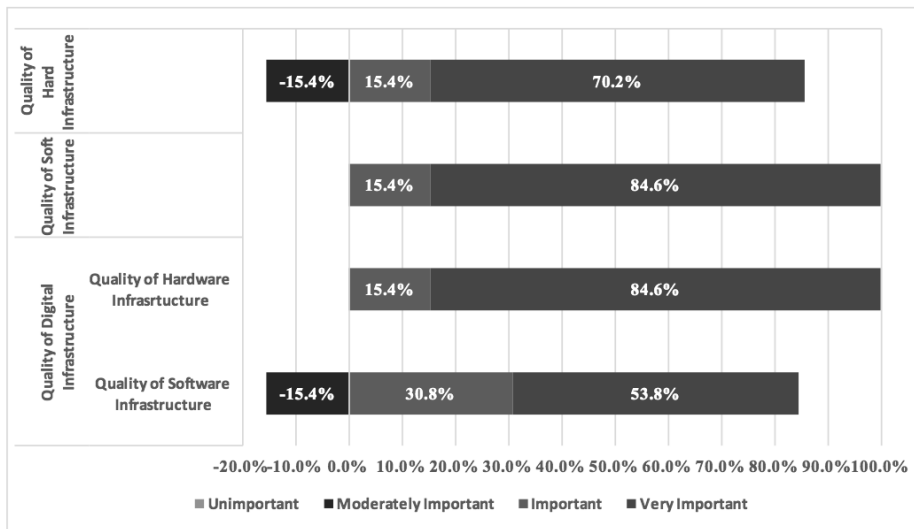

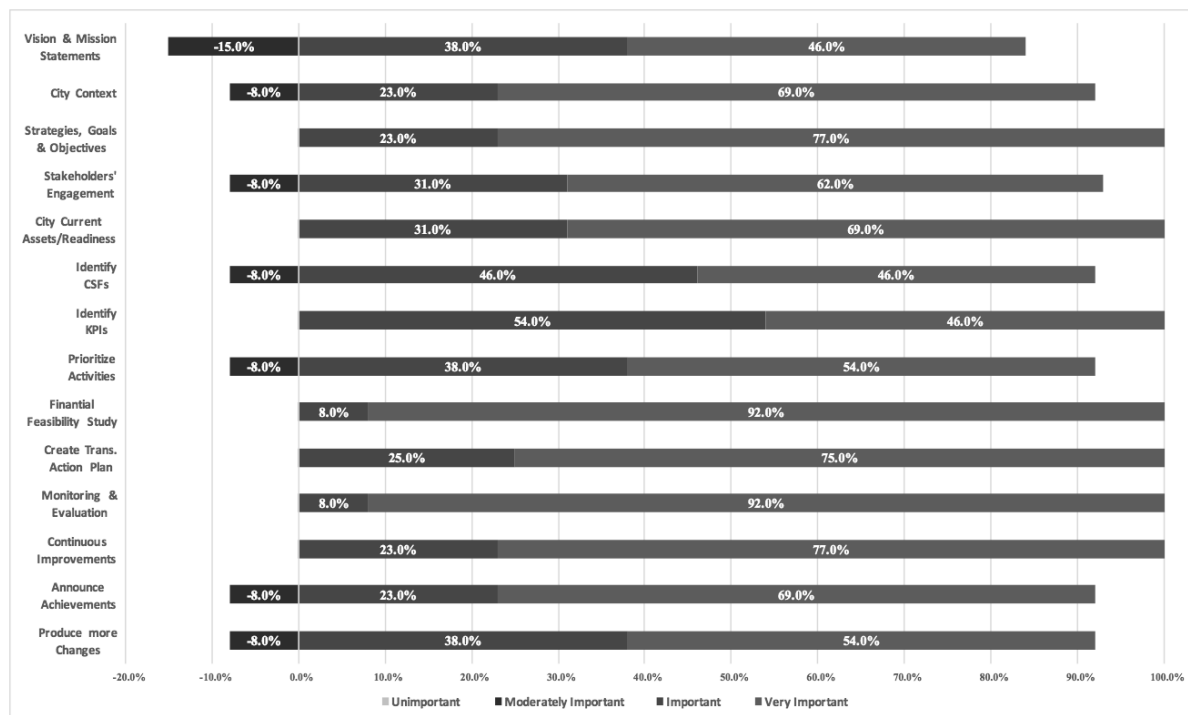**Figure 8:** Significance of Assessing the Current City Assets

Figure 9: Significance Level of Considering different Aspect in a SSC Transformation Proposed Roadmap