PERFORMANCE MEASUREMENT FOR THE DEVELOPMENT OF EMERGING SMART CITIES: THE CASE OF SRI LANKA

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Thesis submitted in partial fulfilment of the requirements of the requirements for the degree Master of Science by Research

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Sri Lanka

May 2020

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DEDICATION

To my parents and Gayan

ACKNOWLEDGEMENT

This research wouldn't have been a success without guidance and help of numerous people. I take this opportunity to express my sincere gratitude to all of them for their valuable time and support.

First and foremost, I would like to express my deepest gratitude to my supervisors Dr. Udayangani Kulatunga and Dr. H.M.N. Dilum Bandara for the priceless guidance, assistance and encouragement provided to me throughout the research. I am greatly indebted to them for their great mentoring and advices throughout the research journey.

Further, I extend my heartiest gratitude to all the staff members of the Department of Building Economics, University of Moratuwa for their immense assistance which has always been the source of strength to enhance my research potential. It is my duty to pay gratitude to all the academics including my external experts and those who have conducted research workshops.

My grateful acknowledgment is made to all the professionals in the industry who contributed to this study by sparing their immeasurable time for data collection and for sharing their valuable knowledge despite their busy schedules. Specially, my sincere thanks delivered to Mr. Amila Cabral and Mr. Isuru Biyanwela for their kind support.

I also wish to extend my sincere appreciation to Senate Research Committee of University of Moratuwa for providing funding to undertake this research under the grant number SRC/LT/2018 & SRC/MT/2018.

Last but not least, I express my heartfelt gratitude to my beloved parents, fiancé, brother and friends for willingly giving me their utmost support, advice and continuously motivating me to carry out the work successfully.

Samarakkody A. L.

May 2020

ABSTRACT

Performance of a Smart City can be measured in terms of the smartness which in turn is defined by means of smart characteristics. Suitable smart characteristics for a particular context can be identified by means of performance measures and the Performance Measurement System prepared as such, can provide means for the emerge of Smart Cities in that context. Thus, this research aims at enhancing the emerging city development projects in Sri Lanka through an appropriate and holistic Smart City Performance Measurement Systems. The objectives of this study were accomplished with a mixed method approach and data were collected through preliminary interviews, case study interviews and questionnaire surveys. Findings were analysed with content analysis using cognitive maps and with statistical analysis using Battelle scoring approach.

As the major findings of this study, a list of Performance Measures for Smart Cities from literature, the appropriate list of Performance Measures for the proposed Smart City project in Colombo Port City and a scoring system as part of the Performance Measurement System for a Sri Lankan Smart City context are produced. The Performance Measurement System includes the themes Smart Mobility, Smart People, Smart Environment, Smart Living, Smart Economy and Smart Governance, embedded in critical success factors in a Smart City project and shows interrelationships between themes. Findings revealed that availability of ICT infrastructure as the most significant Performance Measure while the Smart Mobility was the most significant theme in the scoring system. The researchers in designing the Performance Measurement System have given an equal importance to Smart People theme as well. Additionally, the reasons to proceed with emerging Smart City development projects, barriers to proceed with the developed Performance Measurement System to Smart Cities in Sri Lanka and the recommended solutions to overcome the barriers are discussed.

Key words: *Performance Measurement System, Performance Measures, Scoring System, Smart Cities, Sri Lanka*

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ABBREVIATIONS

API	Application Programming Interface
CPC	Colombo Port City
EMC	Estate Management Company
ICT	Information and Communication Technology
SMCPC	Smart City Project in Colombo Port City
	Application Programming Interface

CHAPTER 01

INTRODUCTION

1.1 Background

According to the United Nations, it is expected that 60% of the world's population will live in urban areas by 2030 (United Nations, 2018). The growing urban population poses broad challenges across domains such as utilities, energy, transportation, health, safety and environment to contemporary cities (Psyllidis, Bozzon, Bocconi, & Bolivar, 2015). Correspondingly, these challenges create complex pressures on the aforementioned domains and several others such as education, public services, waste management, etc. (Caird, 2017). Such pressures urge the need of innovative arrangements which on the other hand become pressing invitations to make cities more intelligent in terms of sustainability, productivity, transparency, effectiveness and efficiency (Gil-Garcia, Pardo, & Nam, 2015). With that arouse a reorientation of city conceptions towards a more economical, environment friendly and provident setting (Anttiroiko, Valkama, & Bailey, 2014). Consequently, cities have turned in to intelligent cities (Komninos, 2019), Smart Cities (Galati, 2018), digital cities (Caragliu, Del Bo, & Nijkamp, 2011), sustainable cities (Elgazzar & El-Gazzar, 2017), etc. These urban metaphors, as conceptual variants to each other, are reciprocally connected with partially overlapping definitions (Nam and Pardo, 2011). Out of them, adopting a "smart" approach via Smart Cities is a widely regarded phenomenon that emerged aiming the mitigation of the aforementioned challenges (Albino, Berardi, & Dangelic, 2015; Chourabi, Nam, Gil-Garcia, Mellouli, Nahon, Pardo, & Scholl, 2015; Dameri, 2017; Yigitcanlar, Kamruzzaman, Buys, Ioppolo, Sabatini-Marques, da Costa, & Yun, 2018).

What are Smart Cities?

The concept of Smart Cities, although proliferating in discussions, is difficult to delineate (Orlowski & Romanowska, 2019). In fact, a consensus was neither reached by the practice communities nor researchers (Gil-Garcia et al., 2015). Previous researchers identified that some of the existing, narrowed definitions for Smart Cities

as marketing solutions for different city level issues; rest of the definitions of Smart Cities varies with the researchers' interest (Orlowski & Romanowska, 2019). This requires researchers to use caution when selecting and adopting a definition for Smart Cities. However, definitional elements the authors spotlight can be identified as the themes with which they exhibit Smart Cities concept as an approach to overcome the problems occurred in basic cities (Yigitcanlar et al., 2018).

While Smart City concept is still evolving (Tomar & Gupta, 2019), most recently developed Smart City definitions include elements such as; all means of innovations in the urban atmosphere (Information and Communication Technology [ICT] - based yet not necessarily) that purpose to improve the city dimensions including economy, people, government, mobility, environment and living (Anthopoulos, Janssen, & Weerakkody, 2019); upgraded quality of life, sustainable urban environment, use of modern advanced ICT, public government openness, encouraged community participation, effective management of traffic and public transport, intelligent device control, optimum utilization of resource, improved environmental protection and improved public services (Xie, Tang, Huang, Yu, Xie, Liu, & Liu et al., 2019).

In addition to that elements like, Complex information, computation and communication systems, critical infrastructure management (Abbas, Shaheen, & Amin, 2019); living solution, integrates different facilities and improve the services for citizens, typify the importance in sustainability of resources and applications for next generations (Samih, 2019); mutual concessions between modern technology and natives' methods (Tomar & Gupta, 2019); Well-being and satisfaction of citizen, Building Information Modelling (BIM) acts as a catalyst to the development of Smart Cities, increasing number of documentations including specifications, reports and guidance (Heaton & Parlikad, 2019) were also highlighted.

Importance and advantages of Performance Measurement in Smart Cities

In order to fulfill the requirements of a Smart City it is important to benchmark appropriate Smart City "characteristics". This implies the need of accurate benchmarks; that can be used in setting city goals and determining priorities (Harms, 2016). Benchmarking would provide a clear basis for the famous maxim, "whatever

is measured will only get done" (Behn, 2003) and lack of this would give negative impacts on determining city goals and requirements (Brorström, Argento, Grossi, Thomasson, & Almqvist, 2018). Out of various definitions, mostly cited includes the definition given by Harbour (2017) which refers performance measures as a numerical expression of the extent to which a desired outcome has been or is being achieved. Benchmarking, which involves the basic steps of Performance Measurement, establishes gaps in performance whereby ensures an action plan is put in place to narrow the identified gaps and measured to verify.

In fact, as per Fredrick W. Taylor's management by exception principle, attempts to control every aspect resulting in controlling of nothing; remarks one of the most popular aphorisms in Performance Measurement (Shafritz, Borick, Russell, & Hyde, 2016). Therefore, planning, controlling and decision making regarding defining and redefining of the priorities and solutions in a Smart City and resource allocation, assigning responsibilities, etc. can be achieved with proper Performance Measurement (Merli & Bonollo, 2014). Performance Measurement System is a set of metrics that is used to quantify how optimally the resources are utilized to provide a desired level of customer satisfaction and the extent to which requirements of the customer are met (Neely, Gregory, & Platts, 2005). Consequently, by developing a Performance Measurement System, not only goal benchmarking but also goal alignment with improved accountability in complex and large city projects is enhanced (Brorström et al., 2018). Peroformance Measurement and benchmarking together with ranking allows identifying and comparing strengths and weaknesses in a Smart City (Carli, Dotolia, Pellegrino, & Ranieri, 2013). Furthermore, modifications to development in smart programmes to enhance smartness can be done through Performance Measurement (Afonso, Brito, Nascimento, Gracia, & Álvaro, 2015). In addition to that, a transparent and common Performance Measurement System is important in creating trust in solutions in Smart Cities and also to monitor the progress of them (Huovila, Airaksinen, Pinto-Seppä, Piira, Bosch, Penttinen, & Kontinakis, 2017). All in all, managers of public agencies including cities use Performance Measurement for performance evaluation, to control the

behavior in civic engagement, for budgeting, promoting, motivating, celebrating success, learning and improving (Behn, 2003).

Importance of selecting a unique Performance Measurement System depending on the context

As far as the Performance Measurement in Smart Cities is concerned, development of various measurement indices and methods of a particular Smart City took the form of the desired definitional elements of that Smart City (Albino et al., 2015). As a result, while some authors believe that Performance Measurement assessment need to be tailor made to the vision of that city (Albino et al., 2015), some others, conversely, reckon that the assessment should be based on a shared Smart City definition and at the same time be flexible to adapt and address the city's specific goals (Dameri, 2017). This was supported by Tommar and Gupta (2019) remarking an important era in the evolvement of Smart City concept, by showing the inessentiality to compromise the identity of an existing city/ culture when building a city. Yet, a typical Smart City would have a suitable and an adequate Performance Measurement System (Merli & Bonollo, 2014). The adequacy of the performance system can be determined with the city context (Lee, Hancock, & Hu, 2014). Therefore, in order to contrive comprehensive Performance Measurement, appraising the context is important (Behn, 2003). As a result, measuring the performance of a Smart City largely depends on the local content of the selected metropolitan area (Dameri, 2015). While various researchers have attempted to evaluate Smart City from the lens of performance and competitiveness (Anthopoulos et al., 2019), it is worthwhile to consider Performance Measurement to Sri Lanka. While a pick up on Smart Cities and its smartness quality concerns in Sri Lanka is observable (De Silva, 2017) the need aroused regarding Performance Measurement is not acknowledged yet.

Level of acknowledgement in Smart Cities in Sri Lanka

"Smart City" is the newest lexicon that is used to hype urban planning in Sri Lanka (De Zoysa, 2017). The complex pressures on urban services created by population explosion requires smart arrangement for Colombo as well (Johansson & Emmanuel,

2006). As per De Silva (2017), quality concerns related to smartness such as robust ICT digitization and connectivity, real time information and management, smart mobility/ parking, clean potable water, smart building, affordable housing, green environment, smart power grids, Smart City maintenance, smart street lighting, smart care, e-governance together with knowledge based innovation driven economy are planned to be incorporated in Sri Lankan flagship Smart City projects. Colombo Port city (CPC) is one such reified flagship project and as a result, significant partnerships were made so as to take up on the aspiration of building the South Asia's premier Smart City project (DailyMirror, 2019). Therefore, the acknowledgement is not in a satisfactory level yet shows potentials.

Positivity in Sri Lanka regarding Performance Measurement for Smart Cities

The demand for land due to population growth in Sri Lankan cities has led to the use of marginal lands which are prone to natural disasters, unsuitable for any habitation and not sustainable (Dissanayake, Hettiarachchi, & Siriwardana, 2018). Use of lands in that way created further problems effecting to the long run and therefore innovative arrangements like smart initiatives have emerged (Johansson & Emmanuel, 2006). Meanwhile for Performance Measurement in quality assurance concerns, a positive environment was created with the applications of Sri Lanka Standards (SLS) and International Organization for Standardization (ISO) standards specifically in respect of smart community infrastructure, smart transport infrastructure, etc. benchmarking the quality with other cities around the world, consistently tracking, reporting and improving the indicators (De Silva, 2017). In fact, CPC has already received the ISO 9001: 2015 certification for the Quality Management System (QMS), adopted by the project company (The Island, 2019). Therefore, introducing a fit-for-purpose Performance Measurement System for Sri Lankan Smart Cities which can integrate the aforementioned existing developments and local requirements is necessitating.

1.2 Problem Statement

According to Lombardi et al. (2012), cities become complex systems because of the unpredictable interrelations of its individuals. Regardless the volatility of the system and intricacy to study it due to its own complexity as a system, measuring the performance of a city with a distinctive set of indicators that can represent the city context and compare it with other countries has become an intensifying requirement in order to evaluate the efficiency levels in nurturing the city (Mavrič & Bobek, 2015).

Meanwhile, the cities tend to adopt smart strategies to deal with the challenges occur due to the immigration and population growth and resulted in constraints related to services provision (Brorström et al., 2018). Therefore, as Smart Cities are built to overcome such challenges with their own characteristics, it is worthwhile to measure if those Smart City characteristics are actually achieved as desired with an appropriate Performance Measurement System (Merli & Bonollo, 2014). In fact, such Smart City characteristics are elusive while the concept is still maturing result in confusions in designing the Smart City requirements in the basic stage which can only be done with accurate Performance Measurement (Harms, 2016). On the other hand, if Performance Measurement is not carried out for Smart City development, defining and measuring smartness performance is strenuous where a shared definition or an outline for smart characteristics are not to be found (Dameri, 2017).

Within the context of Sri Lanka, there is a tendency for Smart City development (De Zoysa, 2017). In fact, the Port City project in Colombo is built on the latest Smart City concepts (CHEC Port City Colombo (Pvt) Ltd, 2019). As argued by Brorström et al. (2018) it is beneficial to have a clear idea of Smart City parameters and objectives from the outset of a project to enable them to be achieved going forward. Therefore, it is important to consider Performance Measurement of Smart City in Sri Lanka as defining smart characteristics with a scientific base, measuring and controlling them is still an industry/project need. Although existing studies can be taken as a guide in preparing a performance system for Sri Lanka, a bespoke Performance Measurement System that reflects the context of Sri Lanka is yet to be

developed. Therefore, a literature gap can also be identified in the Performance Measurement perspective in Sri Lankan Smart Cities.

1.3 Aim and Objectives

The aim of this research is to enhance the emerging Smart City development projects in Sri Lanka through an appropriate and holistic Smart City Performance Measurement Systems.

Following objectives will be achieved to reach the above research aim.

1. To investigate the characteristics of Smart Cities globally and with particular reference to Sri Lanka.
2. To investigate the importance of Performance Measurement in Smart City development.
3. To synthesise different Performance Measurement Systems for Smart Cities.
4. To identify the barriers to implement a Performance Measurement System to Sri Lanka and solutions to overcome the barriers.
5. To develop a Performance Measurement System for Smart Cities in Sri Lanka.

1.4 Scope and Limitations

Smart City in Colombo Port City (SMCPC) is a unique Smart City experience for the Sri Lankan construction industry, therefore there's a case to study. However, finalizing of project objectives is in the process. These objectives are subjected to changes with the project evolvement as well as because of the changes of governments. While smart characteristics needs to be in line with the project objectives, the scope will only be limited to the project objectives as at the time period the interviews were carried out. Due to the confidentiality, interviews were conducted with the professionals directly engaged in the project and they were only willing to reveal the qualitative data (which does not include numbers). Therefore this research is limited to such data and the smartness requirements that comes in regulatory requirements (the updated version as at October, 2019).

1.5 Research Methodology

As an initial step in determining the administered research methodology for this study, the research problem was properly established, followed by a comprehensive literature review and a preliminary round of interviews to obtain the expert opinion. The literature review mainly encompasses an analysis on Smart Cities, Performance Measurement, the importance of Performance Measurement in Smart City development, Performance Measurement Systems in Smart Cities, Smart Characteristics and Smart Indicators/ Performance indicators; globally and with particular reference to Sri Lanka. Interviews were conducted to understand the Sri Lankan context, specifically with refence to the SMCPC.

Having the research problem established as aforementioned, adopted approach was structured under a research methodological design. Considering the comprehensive organization, "research philosophy; approach for theory development; methodological choice; strategy (ies); time horizon; and techniques and procedures" are identified by adhering to Saunders, Lewis, and Thornhill's (2019) research onion. Accordingly this study was positioned within the philosohpical stance of pragmatism by undertaking an abductive approach. Thus the methodological choice adopted was mixed method while data was collected by conducting a case study and a questionnaire survey. Therefore, the strategies are (single) case study and survey data collection techniques and procedures include expert interviews and questionnaire survey. The collected qualitative data were analysed with manual content analysis whilst the quantitative data was analysed with Battelle method paired with mean score method. Thereafter the results were validated with pattern matching. A detailed further review on research methodology is presented in Chapter 3.

1.6 Chapter Breakdown

1.6.1 Chapter One: Introduction

Chapter one brings in a detailed background to approach the research problem, aims, objectives, methodology, scope and limitations and includes the structure of the report.

1.6.2 Chapter Two: Literature Review

Chapter two presents a comprehensive literature review on the theoretical basis of Performance Measurement in Smart Cities with the identification of the existing Performance Measurement.

1.6.3 Chapter Three: Research Methodology

Chapter three will explain the research methodology with particular reference to each layer of "Saunders et al. (2019)'s Research Onion".

1.6.4 Chapter Four: Research Analysis and Findings

Chapter four presents the ultimate findings and discusses the analysed data in Sri Lankan context with the literature findings.

1.6.5 Chapter Five: Conclusion and Recommendations

Chapter five of this study concludes research findings providing recommendations. Finally, it directs to the further research areas as well.

CHAPTER 02

LITERATURE REVIEW

2.1 Introduction

This chapter comprises of evaluative reporting on the study area of Performance Measurement in Smart Cities without limiting it to a chronological catalog. Initially Smart Cities and Performance Measurement is introduced and concluded remarking the importance of Performance Measurement in Smart Cities development. In order to carry it through the objectives of the study the characteristics of a Smart City is explained in detail through several approaches. Additionally, the existing Performance Measurement Systems for Smart Cities are evaluated by adhering to a top down approach where the themes, sub themes and indicators of the selected Performance Measurement Systems are reviewed one after the other.

2.2 Smart Cities

2.2.1 Evolvement of "Smart Cities" as a response to opportunities and challenges of urbanization and city growth

Unprecedented urbanization and its subsequent consequence, the expansion of cities in size and number wise, resulted in challenges as well as opportunities for a city (Ojo, Dzhusupova, & Curry, 2015). According to the authors, while the urban population growth can challenge conservative ways of lifestyle and city management, city growth offers opportunities for an optimal city management through sustainable resource managing to cope up with the increasing demand, innovative and creative approaches and integration with the wider world economy.

Smart Cities are one of the latest responses to the challenges occurred due to the distinctive nature of the problems that comes with urbanization and the opportunities come in disguise with the consequent reorientation of city conceptions in an economical, environment oriented, and provident setting (Chourabi et al., 2012). Some of the other reoriented city conceptions include Digital city, Intelligent city,

Ubiquitous city (U-city), Global city, Sustainable cities with which definitions the Smart Cities concept oftentimes overlap (Nam and Pardo, 2011).

However, some authors believe that the original rationale in developing Smart Cities was as a potential panacea to the catastrophic global climate change era and later this rationale was shifted towards easing the negative impacts of ill-urbanizational practices, consumerism and industrialization (Taamallah, Khemaja, & Faiz, 2017). As per Yigitcanlar (2018), Smart City concept now is monocentric towards technology due to two main challenges that Smart City practice is facing to overcome; namely the urge for both global cities and cities falling behind to attract, foster and secure innovations and knowledge generation, and the popularity of unidimensional agendas put forward through the programs of the major technology development and consultancy firms. Whatsoever, Smart Cities obviously give good grounds for expecting the ideal upcoming of an urban settlement where the best-case scenario, incorporates integrated and futuristic strategic plans that can define the vision and policy for the development of a city, just the same way it is seen through the prism of knowledge ecosystems and digital technologies (Angelidou, 2017).

2.2.2 Definitions of "Smart Cities"

The definition of "Smart Cities" is inchoate and vague (Alkandari, Alnasheet, & Alshekhly, 2012; Chourabi et al., 2012; Hollands, 2008; Paskaleva, 2011; Nam and Pardo, 2011; Ojo, et al,, 2015; Gil-Garcia et al., 2015). The absence of a commonly accepted interpretation for Smart Cities due to the limited intellectual exchange and divergence among the Smart Cities' researchers has raised concerns of many (Mora, Bolici, & Deakin, 2017). Most of the Smart City definitions are found in scholarly literature with them overlapping only several elements and consequently sharing a common agreement and understanding is impractical (Mora et al., 2017). For an instance, Richter, Kraus, & Syrjä (2015) defines Smart Cities as a city that inherit an interdisciplinary character and therefore integrate city technologies, marketing, knowledge economy, economic geography along with spatial planning (Richter et al., 2015). As per Ojo et al. (2014), Smart Cities can be termed as "urban innovations and transformation initiatives" that aim to utilize ICT/ digital, social and physical

infrastructures and knowledge resources for better city administration and infrastructure management along with economic regeneration and social cohesion (Ojo et al. 2014). Although initial definitions such as definitions given by IBM being a techno firm defines Smart City as the use of ICT to sense, peruse and integrate vital information for the core systems in cities, Smart Cities definitions nowadays tend to define Smart City as an intelligent response to social and city needs (Su, Li, & Fu, 2011). Correspondingly, integrating not only technology but also intelligence to urban space formation and development strategies generation is definitive as per contemporary researches (Vanolo, 2014).

However, Smart City definitions reflect the differing groups that provide the definitions (Dixon, et al., 2017). In a way, collectively the Smart City definitions from different viewpoints depending on the interests of different groups provides a better picture than the popular definitions provided as marketing solutions for numerous city issues or researcher's expertise/ interest areas (Orlowski & Romanowska, 2019). Following Table 2.1 depicts some of the definitions on Smart Cities generated in diverse institutions in the society.

Table 2.1: Definitions of Smart Cities generated in diverse institutions in the society

	Definition	**Source**
Academic	Cities that intends to improve the quality of life of the citizens through supporting the daily life with optimized transportation, electrical and other logistical operations through the sensor capabilities and communication sewn into the cities' infrastructures.	Chen, 2010
	Cities that encompass a comparatively high share of knowledge-intensive jobs, highly educated people, output-oriented planning systems, sustainability-oriented initiatives and creative activities that facilitate high productivity	Kourtit, Nijkamp, & Steenbruggen, 2017
Government	A place where city services and traditional networks are made much efficient through the use of digital and telecommunication technologies targeting the ease of city's inhabitants and businesses.	EU, 2016

	Definition	Source
	The process/ series of steps by following which cities can become "liveable" and "resilient" with an enhanced ability to respond to new challenges in a faster way while bringing hard infrastructure, (digital) technologies and social capital (including community institutions and local skills) together to provide an attractive environment for its citizens and to fuel a sustainable economic development.	BIS, 2013: 2
Technology companies	A city that utilize technology to transform the city's core systems and optimize limited resources which at its highest levels of maturity, is realized as a knowledge-based system that provides a real-time understanding to its stakeholders while enabling decision-makers towards proactive management of the city's subsystems.	IBM, 2013
Industry standards	A term that denotes the effective integration of factors in the built environment, namely, digital, physical and human systems so as to deliver a prosperous, sustainable and an inclusive future for the citizens live in a Smart City.	ISO/IEC, 2014b: 2

Adopted from; (Dixon, et al., 2017)

Looking collectively at the definitions given through different perspectives allows capturing a holistic picture of the definition of a Smart City. By looking at the definitions it can be seen that the Government, technology companies and industry definitions have put emphasis operationality and on digital technologies while the academic definition is more futuristic. Although the main driver of global interest in Smart Cities differ with the interpreter, the definitions in different lenses when put together a socially inclusive, technologically advanced, efficient and green city is promising. This leaves the need for a collaborative effort by Smart City researchers and policy makers to generate a possible agreement on the Smart City concept (Mora et al., 2017). Nevertheless, the same set of researchers and policy makers are in middling agreements on how Smart Cities are characterized (Neirotti, De Marco, Cagliano, Mangano, & Scorrano, 2014). The definition adopted for this study is based on Ahvenniemi, Huovila, Pinto-Seppä, & Airaksinen (2017), which took a

holistic view at different dimensions of smart cities. Accodingly, Smart Cities are innovative arrangements which were made by integrating critical infrastructure, intelligent information management with modern advanced ICT applications, sustainable environment and urban innovations to upgrade the quality of life of its citizens and sustain the urban system development by addressing compulsory city dimensions and domains. In essence, it can be summarized that there are two mainstreams in the present Smart City discussion:

1) the ICT and technology-oriented approach and

2) the people-oriented approach (Ahvenniemi, Huovila, Pinto-Seppä, & Airaksinen, 2017).

2.3 Characteristics of Smart Cities

Mostly the literature discourse on the characteristics of Smart Cities discuss its technology dominant role and several other drivers of the global interest in Smart Cities (Letaifa, 2015). Essentially the characteristics of Smart Cities can be identified mainly by three ways; 1) By reviewing the elements of Smart City definitions, 2) By identifying the unique characteristics with compared to similar city conceptualisations and 3) By reviewing the Performance Measurement models/ frameworks/ systems for Smart Cities.

2.3.1 Elements of recent Smart City definitions

Mostly the problems in cities occur due to inefficient use of resources, inefficient communication, limited access to administrative data, poor disaster resilience and erroneous information; they are acknowledged in characterizing Smart Cities (Batagan, 2011). Correspondingly, Monzon (2015) brought in the international experience in addressing several problems related to infrastructure, economy, community, resources and governance and services in the Smart City projects in Europe and Mediterranean Region. By introducing different unique characteristics, it implies that Smart Cities prevent the problems occurred in basic cities to take place any further. They are known as definitional elements that most researchers highlight (Yigitcanlar et al., 2018). However, as the Smart City concept is still evolving

(Tomar and Gupta, 2019), the concept of Smart City needs to be investigated in the latest context as shown in Table 2.2;

Table 2.2: Smart Cities definitional elements.

Sources / Elements	a	b	c	d	e	f	g	h	i	j
All means of innovations in the urban atmosphere (ICT-based, yet not necessarily)/ innovative engineering approaches/ innovative and advanced services to the community	✓		✓	✓	✓				✓	✓
Improved economy	✓					✓		✓		
Improved people related aspects/ smart incorporation of contribution and activities of self-decisive, free, and updated citizens	✓				✓	✓		✓		
Improved government/ public government openness/ encouraged community participation	✓	✓			✓	✓		✓		
Improved mobility/ effective management of traffic and public transport	✓	✓			✓	✓		✓		
Improved living/ Upgraded quality of life/ improved public services/ Human and societal capital investments	✓	✓		✓	✓	✓		✓		
Improved environment/ sustainable environment/ improved environmental protection	✓	✓		✓	✓	✓		✓		
Use of advanced ICT/ Complex information, computation and communication systems/	✓	✓	✓					✓	✓	✓
Intelligent device control/ critical infrastructure management/ Intelligent use of ICT in an interactive infrastructure/ mutual concessions between modern technology and native methods/ Integration of ICT into the urban structure including the operation of urban services, efficient management of shared resources by operators themselves with the aid of electronic monitoring and		✓	✓	✓	✓	✓	✓	✓	✓	✓

Sources / Elements	a	b	c	d	e	f	g	h	i	j
control, implementation of ICT in different fields to encourage innovations, and knowledge that ICT can convey/ use of BIM										
Optimum resource utilization/ sustainability of resources and their applications for next generations		✓		✓	✓			✓	✓	✓
Increasing number of documentations including specifications, reports, and guidance										✓

a-(Anthopoulos et al., 2019); b-(Xie et al., 2019); c-(Abbas et al., 2019); d- (Ismagilova et al., 2019); e-(Samih, 2019); f-(Blanck et al., 2019); g-(Tomar and Gupta, 2019); h-(Qian, Wu, Bao, & Lorenz, 2019); i-(Sharma and Meyer, 2019); j-(Heaton and Parlikad, 2019)

The above key phrases and key words formed sensible definitions and introductory sentences to describe Smart Cities. Accordingly, they infer that sustainable urban environment, intelligent use of ICT, advanced infrastructure, satisfaction and well-being of citizen, encouraged community participation, optimum utilization of resource, innovations, well-performing governance, sustainable economic growth and information management cannot be disregarded in exploring what makes Smart Cities phenomenal with compared to a basic city. Having mutual concessions between modern and natives' methods, as well as relationship with BIM are quite unpopular, especially, absent in similar reviews carried out earlier (Albino et al., 2015; Gil-Garcia et al., 2015; Yigitcanlar et al., 2018), yet worth noticing. The characteristics identified in the table however are in line with the characteristics summarized in Albino et al.'s (2015) study, namely; integrated infrastructure which empowers political efficiency, cultural and social development, business-led urban growth, futuristic and creative activities aiming urban growth, social inclusion of different urban residents, social capital for urban development, natural environment-a strategic component for future. The above characteristics were abridged from different studies including Mahizhnan (1999), Giffinger et al. (2007), Eger (2009), Thuzar (2011), Nam and Pardo (2011), Barrionuevo et al. (2012), Kourtit and Nijkamp (2012), Chourabi et al. (2102). Similarly, Hollands (2008) has identifies

most of the above characteristics plus improved economic efficiency, social and environmental sustainability.

By and large, with critical infrastructure and information management, modern advanced ICT applications, and urban innovations Smart Cities appear to upgrade the quality of life of its citizens and sustain the urban system development by addressing compulsory city dimensions and domains.

2.3.2 Comparison of city conceptualisations with Smart City initiatives

Several authors have identified that investigating the popularly used city concepts facilitate setting out a multidimensional facet about the characteristics of Smart Cities (Nam and Pardo, 2011). In other words, while defining a basic city is highly subjective, several highlights of different city conceptions allow identifying the novelty of Smart Cities and their unique characteristics. Table 2.3 includes a comparison (based on the most obvious differences) with some of the labels which were controversial in certain marketing contexts.

Table 2.3: Comparison of city conceptualisations with smart-city initiatives.

Different City Conceptions	**Smart City**	**Source**
i) Digital city		
Main focus is on the technological attributes of a city.	Focus is not limited; deals with enhancing the quality of life, sustainable development, pollution reduction, energy management, management of urban green spaces, and all other aspects of daily life.	(Caragliu, Del Bo, & Nijkamp, 2011)
ii) Intelligent city		
Solutions encourage advancing human intelligence and innovative/ quality decision-making / problem-solving using larger datasets and effective user engagement	Provision of solutions are on the basis of improving vibrant communities in urban systems with the use of ICT-based instrumentation, sensors, and smart devices.	(Komninos, 2019)

Different City Conceptions	Smart City	Source
iii) Ubiquitous city (U-city)		
Represents a sustainable and environmental conscious Smart City	U-city's vital services include smart education, transport, homes, and medicare.	(Lee, Han, Leem, & Yigitcanlar, 2008)
iv) Global city		
In means of the inception, Smart Cities are the advanced versions and are number of steps ahead of global cities	Although ICT infrastructure is significant in the both, Smart Cities are more community oriented and are apprehended to deal with community initiatives	(Yadav and Patel, 2015)
v) Sustainable cities		
Concept is developed on the basis that implementation of smart solutions in line with smart technologies leads to sustainability	The concepts were branched out and parallel. Therefore, can rather introduce the compatible version as "smart sustainable city".	(Elgazzar and El-Gazzar, 2017)

Based on the most obvious differences, it is apparent that a Smart City represents something more than the above different types of cities, except for the U-city which defines itself revolving around the term Smart City. Some chronological studies have identified that Smart City is the upshot of the global city development process where it carries the major aspects of global cities, liveable cities, and sustainable cities plus knowledge-based urban development and community participation (Yadav and Patel, 2015). In the process of looking at the variances, ICT plays a main role resulting in most of the concepts to overlap (Hartley, 2005). Comparison with different city concepts remarkably bring out two cornerstones; urban development, attributing to the technology-oriented knowledge economy and public sector development in terms of high-quality government operations with ICT-driven corporate practice and cross-sectoral innovation (Goodspeed, 2014). However, it can be seen that some city conceptualizations are newly incorporated with smart tag due to the marketability of

the Smart City brand; for example, Songdo was originally branded as a ‘ubiquitous city’ and afterwards accepted as ‘compact Smart City’ (Yigitcanlar, et al., 2018).

In conclusion, the key terms can be conceptualised in a diagram as shown in Figure 2.1;

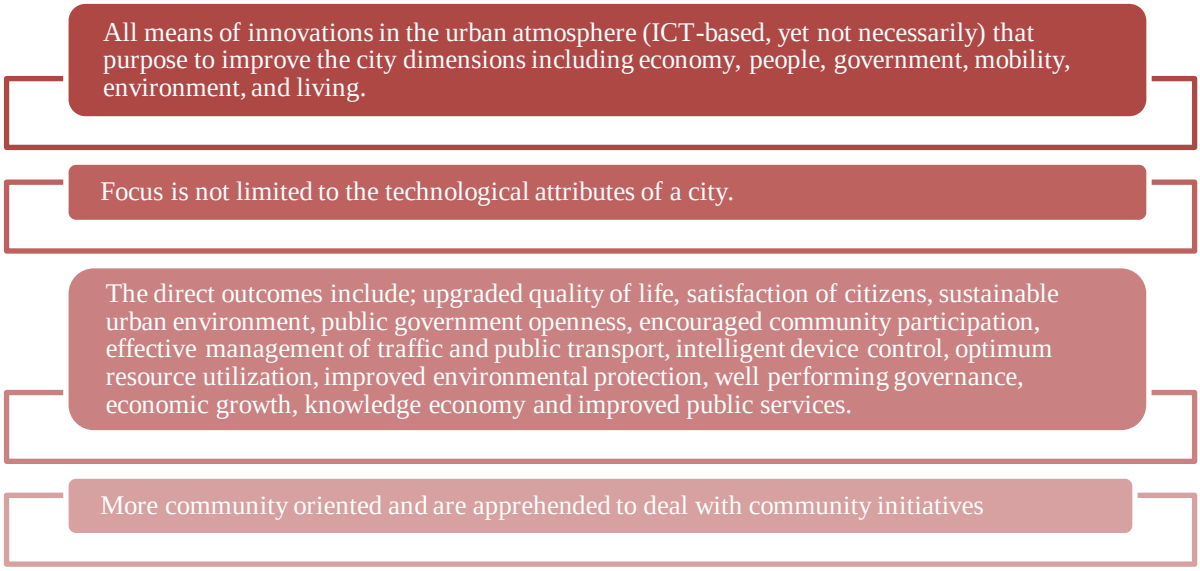

Figure 2.1: Key terms of Smart Cities

2.4 Performance Measurement

Performance Measurement is known to as a process with which an organization monitors the important aspects of its operations, programmes, systems, etc. by measuring the performance and comparing it with organizational goals (U. S. Department of Health and Human Services, 2011). Heini (2007), followed by a review of existing minimal number of definitions, defines Performance Measurement as an activity or process where the end results are quantified and compared with a set of predefined goals.

2.4.1 Key concepts in measuring performance

Performance Measures and Performance indicators

Harbour (2017) refers performance indicators as a numerical expression of the extent to which a desired outcome has been or is being achieved. Capturing that

aforementioned extent requires stated performance goals and accompanying performance metrics (Harbour, 2017). By that means the terms performance measures and performance metrics play different measuring roles and therefore are essentially synonymous as they possess specific attributes of (performance) measurement (Keong Choong, 2013). Performance indicators on the other hand are the performance metrics that measure an output, defined along a particular performance dimension and its associated performance goal (Heini, 2007). Performance Measures in this study is referred to as the all the performance indicators as well as the categories of those indicators.

Performance Measurement Systems

Performance Measurement System is referred to as a set of metrics that is used to quantify the effectiveness and efficiency of outcomes/actions where efficiency refers to a measure of how optimally the resources are utilized to provide a desired level of customer satisfaction and effectiveness depicts the extent to which requirements of the customer are met (Neely, Gregory, & Platts, 2005). According to Theoretically, the major purposes of developing a Performance Measurement System is to document the performance and assist decision making (Moynihan, 2005). In support of that, Harbour (2017) emphasized how critical it is to quantitatively measure the performance so as to achieve desired performance goals. Despite Performance Measurement was initially limited to measuring the financial performance in terms of profit, return on capital employed, cashflow, etc., now a greater emphasis is given on rather multidimensional and non-financial measures that allows a better understanding of the performance of an organization so as to achieve organizational goals and business results (Harvey & Technical Information Service, 2008). Ensuring to strike a balance between financial and nonfinancial measures, multidimensional Performance Measurement Systems were proposed intending to facilitate organizations to define suitable measures that can reflect organizational objectives and assess organizational performance satisfactorily (Kennerley & Neely, 2002). In essence, the vital feature of a Performance Measurement System is the incorporation of the organization's strategic objectives (Soltes & Gavurova, 2015).

Whatsoever, Performance Measurement is realized mostly as just another mandate and, therefore, the benefits expected to be higher than the required effort (Nudurupati, Bititci, Kumar, & Chan, 2011).

2.4.2 Performance Measurement in cities

Regardless the type of the organization, effective Performance Measurement provides the basis in ensuring the successful implementation of the organisational strategy (Landy, Zedeck, & Cleveland, 2017). Especially the public sector and all other central agencies in government having their major concerns upon proving transparency and accountability, started to have strong considerations on Performance Measurement and management (Goh, 2012). Even in the context of cities, Performance Measurement refers to an internal informational tool which allows the evaluation of operations and make programme related and budgetary decisions; and has showed a significant progress in use over the past few decades (Ho & Ni, 2005). In present developing performance analysis tools/ frameworks / indices and city benchmarking is mostly taken place as a part of the academic, private, public and non-for-profit agencies in city (Yigitcanlar, 2014).

Performance Measurement has become increasingly important with the growth of nonprofit sector in a more professionalized manner and consequent changes in to the requirements with accountability and increased number of stakeholders (LeRoux & Wright, 2010). In fact, as per Ho & Ni (2005) sophistication and depth of Performance Measurement has been expanded both in less technical customer-oriented areas such as recreational spaces as well as highly technical areas such as street maintenance.

2.4.3 Performance Measurement in Smart City development

According to Landy et al. (2017), performance and the measurement of performance, is a situational expectation that differs with various occasions in conducting human affairs. While this situational expectation turns out to be a “superior expectation”, in other words, the common expression “success” measuring performance is problematic as the definition of success is changing (Landy et al., 2017).

Consequently, when such occasions happen to be “Smart Cities”, a vision with regards to the aforementioned situational superior expectation is indubitably even more convoluted, as the superior expectation has not reached a consensus yet (Gil-Garcia et al., 2015). In fact, due to the complications of interests gravitated around public administration in Smart Cities, as a result of the wide variety of work performed and their complex interconnection, the concept of Performance Measurement needs to appreciate the multi-dimensionally (Bouckaert and Halligan, 2008). Moreover, determining the depth of performance of Smart Cities’ administration at different levels such as local government, organisations, and individuals and the span in classified content dimensions is rather comprehensive (Merli and Bonollo, 2014).

Number of authors have come up with different Performance Measurement Systems addressing a broad span (Lombardi et al., 2012; Komninos, 2008; Merli and Bonollo, 2014; Shen et al., 2018; Australian Government, 2017; Ambrosetti, 2012). Meanwhile, some have distinguished between the depth over span to a given content dimension, e.g., Garau et al. (2015) benchmark only the Smart Urban Mobility. Whatsoever, these systems witness the need of Performance Measurement in Smart Cities (Albino et al., 2015). Alternatively, to fulfil the requirements of a Smart City it is important to benchmark appropriate Smart City “characteristics” and that again implies the need of accurate benchmarks; which can be used in setting city goals and determining priorities (Harms, 2016).

2.5 Importance of Performance Measurement in Smart City Development

According to the famous maxim, “whatever is measured will only get done” (Behn, 2003) and consequently the absence a Performance Measurement System would give negative impacts everything starting from determining city goals and requirements (Brorström et al., 2018). Wide availability of Performance Measurement in Smart City reached the point where smartness of the Smart City itself is determined by the implemented Performance Measurement System for the particular Smart City (Albino et al., 2015). Following are some of the advantages that prove how important Performance Measurement is in Smart City development.

2.5.1 Performance management of smart cities

According to Pollitt (2013) performance management refers to the process shown in Figure 2.2;

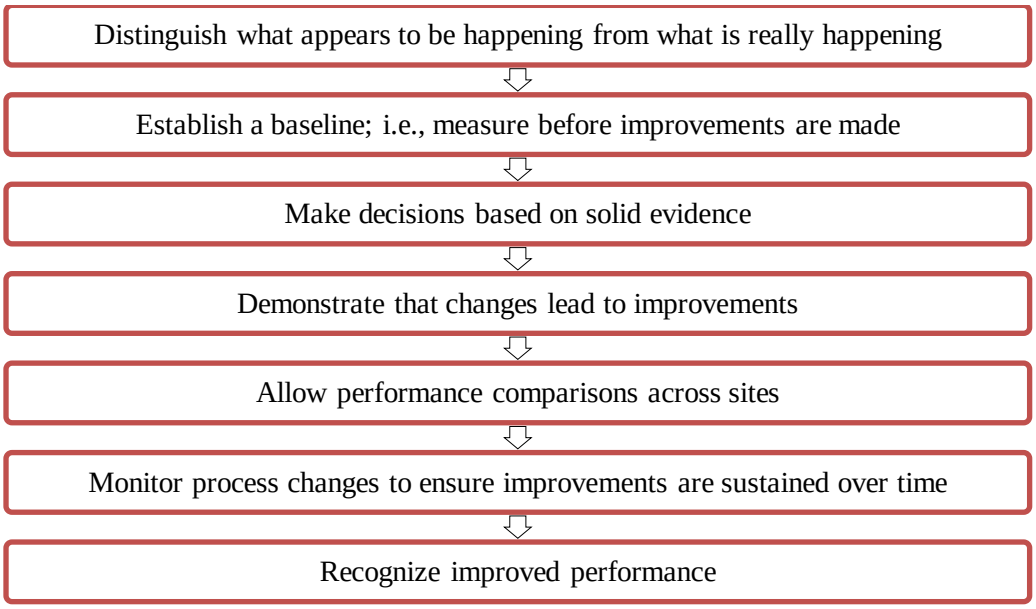

Figure 2.2: Performance Management Process

Source: Pollitt (2013)

According to the above illustration, Performance Measurement provides an answer regarding the progress tracking of an implemented strategy whereas performance management manages achieving that whole strategy (Moynihan & Pandey, 2010). While the two terms are complementary to one another, without Performance Measurement, establishing the conditions of performance management success is challenging (Moynihan & Pandey, 2010). This obviously can be related to smart cities as well.

2.5.2 Monitoring and controlling the applications of smart city requirements

As per Fredrick W. Taylor's management by exception principle, attempts to control every aspect resulting in controlling of nothing; remarks one of the most popular aphorisms in Performance Measurement (Shafritz et al., 2016). According to Harbour (2017), having performance measures together with performance goals

allows tracking goal achieving progress and ensuring the maintenance of it. As a part of the same process, the performance level can then be compared and benchmarked against the competitors' levels of performance with which variations can be identified and controlled (Harbour, 2017).

2.5.3 Improved decision making by smart city policymakers and other involved parties

Performance Measurement can be considered as a reliable process to determine how well the current system of an organization is working (U. S. Department of Health and Human Services, 2011). Performance data equip the responsible parties with information solid evidence-based decisions can be made (LeRoux & Wright, 2010).

2.5.4 Accountability of smart city administration

Given the demand in today's economy for scrutiny and transparency in operations and practices of an organization, outcome and process data is an ideal source to demonstrate the organizational performance (U. S. Department of Health and Human Services, 2011).

2.5.5 Strengthened local democratic institutions

When local government is made more accountable in terms of reflecting citizens' interests, citizens tend to keep more trust on the government institutions which results in such institutions to be more result driven (Sanger, 2008).

2.5.6 Supported strategic planning and target setting for smart cities

Use of a proper Performance Measurement System allows linking operational objectives with strategic objectives of an organization (Soltes & Gavurova, 2015). A progress direction and a point of reference for the results progress direction is provided (Yigitcanlar, 2014).

2.5.7 Improved communication among smart city project participants

Performance Measurement plays the role of a common language other than sharing the knowledge among the stakeholders who are engaged in a project (Keong Choong, 2013)

2.5.8 Continuous improvement of smart cities

Performance Measurement not only increased visibility of the performance but also directs behaviour and focuses attention. With a proper Performance Measurement System that integrates strategic and operational objectives in an organization ensures the continuous improvement along with everyday activities (Soltes & Gavurova, 2015). Information produced by Performance Measurement Systems as a result of continuous evaluation of work, permits tracking the improvements in operations overtime and that guides the executives to introduce and tailor new strategies for varying priorities (Sanger, 2008).

2.5.9 Overall success of the smart city

A predetermined set of measurement attributes included in a Performance Measurement System provides measurable expectations in line with organizational vision and strategy to its employees in understanding each of their roles and thereby they may contribute to the overall success of their organization (Keong Choong, 2013). Performance data provides valuable insights regarding the organizational strengths and weaknesses (LeRoux & Wright, 2010). Having the lessons learned from comparisons done using the Performance Measurement System, cities may explore beyond their borders in the means of stimulating development and learning resulting in the cities to discover potential development, early warning signals and problem-solving strategies (Huggins, 2010).

2.5.10 Funding/ budgeting on smart cities

Many cities around the world have put efforts link budgeting with Performance Measurement and as a result budget documents included performance measures reported along with mission statements and goal statements (Ho & Ni, 2005). With

increased demonstrative evidences the trust on government can be restored and therefore many funding agencies active in developing countries especially tend to rely on performance information (Putu, Jan van Helden, & Tillema, 2007).

2.5.11 City benchmarking

Holloway & Wajzer (2008) elaborates the ultimate process of gaining a competitive advantage through benchmarking as shown in Figure 2.3;

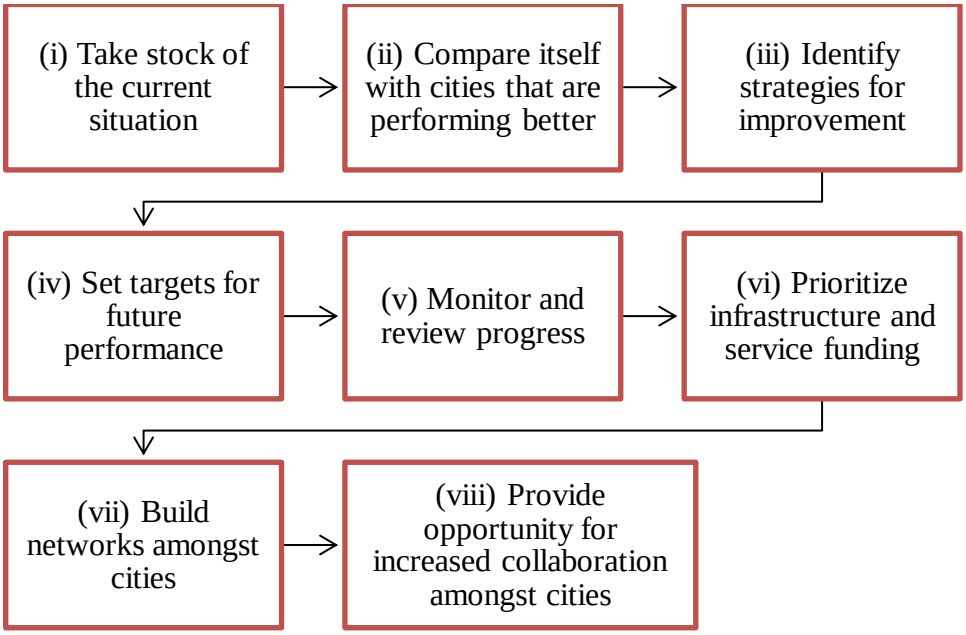

Figure 2.3: Steps to obtain a competitive advantage through benchmarking
Source: Holloway and Wajzer, 2008

Corresponding to the above steps, Yigitcanlar (2014) highlighted the importance of benchmarking the progress against high achiever cities as a clear gap analysis can only be done with the benchmarking together with a comparative analysis.

2.5.12 Politically valuable outcomes in contested environments

Creating a win win situation, citizens can know the quality of services delivery while the legislators may get an idea on how well they should meet the desires of their constituents (Sanger, 2008).

2.5.13 Civic support for public efforts

With the increased legitimacy of public authorities, the tax payers of the city can be made satisfied when they attempt to hold the local officials accountable for service delivery (Sanger, 2008).

2.6 Evaluation of Performance Measurement System for Smart Cities

Performance Measurement System, often referred to as a numerical/ graphical information system, is designed to monitor, evaluate, diagnose and accomplish anticipated performance levels through defining, collecting, producing, delivering and demonstrating performance-related information (Harbour, 2017). Complying to this definition, Performance Measurement Systems/frameworks/ models produced for Smart Cities too define the smartness of a Smart City with related to performance-related information. Thereby various Performance Measurement methods and indices have been developed throughout the evolvement of the concept Smart Cities and its definitional elements (Albino et al., 2015). The actual measurement objectives in measuring the performance of Smart Cities were categorized with content dimensions of a Smart City as observed by different institutes (Merli and Bonollo, 2014). They are the same aspects in which Smart Cities mostly require indicators to measure their performance (Huovila et al., 2017). In other words, it is these aspects which different authors term as themes/sub-themes (Bosch et al., 2016); characteristics/factors (Giffinger et al., 2007); clusters (Lombardi et al., 2012); blocks (Komninos, 2008); dimensions (Merli and Bonollo, 2014); categories (Shen et al., 2018); and layers (Zygiaris, 2013) measure the performance of a Smart City in terms of smartness of those each aspect.

2.6.1 Performance Measurement Systems for Smart Cities

The progression of Performance Measurement Systems in Smart Cities can be traced back to 2007, with the formation of Giffinger et al.'s (2007) system to assess the performance of Smart Cities (Merli and Bonollo, 2014). despite the application of the system has meant to be decisive for cities, it is the most cited and widely used due to its comprehensive nature (Bifulco et al., 2016). Therefore, the characteristics of this

very system is used as a base in combining all the aspects of a Performance Measurement System in this study as well.

However, the interpretation of a particular theme may not be compatible with the meaning a similar theme from another system hence subthemes becomes informative Airaksinen et al. (2017). Therefore, in this study, the themes/classifications of eight Smart City Performance Measurement Systems are compared intending to form a constructive set of themes and subthemes that can lead to producing comprehensive indicators under each of such themes/sub-themes. Table 2.4 depicts each of the selected Smart City Performance Measurement System's themes and sub-themes (if available).

Table 2.4: Content Dimensions in Performance Measurement Systems for Smart Cities

Source / **Content Dimensions**	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**
People/ Smart People	✓	✓	✓	✓		✓	✓	
Planet/ Smart Environment	✓	✓	✓		✓	✓	✓	✓
Prosperity/ Smart Economy	✓	✓	✓	✓	✓	✓	✓	
Governance/ Smart Governance	✓	✓	✓			✓	✓	
Propagation – Replicability and scalability, Factors of success	✓							
Smart Mobility	✓	✓	✓	✓		✓	✓	✓
Smart Living	✓	✓	✓	✓	✓	✓	✓	✓

a-(Bosch et al., 2016); b-(Giffinger et al., 2007); c-(Lombardi et al., 2012); d-(Komninos, 2008); e-(Merli and Bonollo, 2014); f-(Shen et al., 2018); g-(Australian Government, 2017); h-(Ambrosetti, 2012)

Out of a number of Performance Measurement Systems, only the above were selected for this study due to their holistic approach. In other words, they have looked at all the city domains and were not limited to an in depth study on a particular theme. Moreover all these Performance Measurement Systems included indicators and indicator classifications which were defined for this study as Performance Measures (refer 2.4.1 Performance Measures and Performance indicators). Accordingly, a basic PRISMA (Preferred Reporting Items for Systematic

Reviews and Meta-Analyses) Analysis where the literature sources were shortlisted based on the aforementioned criteria. According to Table 2.4, it can be seen that axes focused under Giffinger et al.'s (2007) system based on the theories of human and social capital, ICT economics, regional competitiveness, transport, natural resources, participation of societies and quality of life of citizens in a city have been an underlying support in forming the successive Performance Measurement Systems. The other reason for this system to be controversial is the commonly accepted grounds such as 'regional, traditional, and neoclassical theories on urban development and growth' on which this is based (Ojo, et al., 2015).

The indicator system produced by Komninos (2008) was originally named as Metrics for "intelligent cities". However, the author did not provide a clear-cut difference between the intelligent cities and Smart Cities; in fact, by referring the terms as of having similar meanings (Komninos, 2008), it was implied that metrics for intelligent cities can be applicable to Smart Cities as well. Given that Smart Cities look beyond intelligent cities, the indicator system may have issues in its scope as well. However, Merli and Bonollo (2014) in their research have identified the four blocks that measure fundamental dimensions of the intelligent city and their indicators which were presented in Komninos (2008) study as also applicable as a Performance Measurement System for Smart Cities. Consequently, Merli and Bonollo's (2014) Performance Measurement System was inspired by the aforementioned two systems along with The European House Ambrosetti's system. Similarly, Lombardi et al.'s (2012) system was inspired by Giffinger et al. (2007)'s system with particular reference to the (revised) triple helix.

Similarly, the Performance Measurement System developed by Bosch et al. (2016) covered similar content dimensions which were also identified in Giffinger et al.'s (2007) system while emphasizing some aspects like Prosperity and Propagation through theming. Whereas Shen et al.'s (2018) system, which aimed the Chinese context, replaced the themes Smart Living and Smart Mobility with Smart Infrastructure. Meanwhile, the system constructed for the Australian context by Australian Government (2017) took a completely different form of theming.

2.6.2 The Most Significant Themes/ Dimensions in a Performance Measurement System for a Smart City

Given the significance of Giffinger et al.'s (2007) system, it was used as the basis to understand the most significant themes. The sole purpose of signifying themes is to incorporate every possibility of the indicators so as to form the comprehensive summary Performance Measurement System for Smart Cities. Although the themes Smart People and Smart Living are usually considered separate two themes, the compared systems convince that both can be considered as a single theme when amalgamating the systems/themes. Therewith it can be observed the following as the most significant themes.

Smart Economy

Bosch et al.'s (2016) content dimensions "Prosperity" refers to the "economic viability" and "project value" to users, stakeholders, neighbourhood, and indirectly affected entities. Authors also consider the subtheme "Economic Performance", which provides a compatible definition to the focus area of Smart Economy introduced by Giffinger et al. (2007). Similarly, in Komninos's (2008) system, "innovation performance" covers aspects of Giffinger et al.'s (2007) Smart Economy in general. However, Giffinger et al. (2007) emphasized much on the economic competitiveness and therefore the factors around that. Although this is the case, the other systems specify the economic outcomes of Smart City initiatives as per Chourabi et al. (2015) such as business/job creation, development of the workforce, and improved productivity as their content dimensions. For example, Production - Merli and Bonollo (2014), Jobs and Skills and Innovation and Digital Opportunities (Australian Government, 2017).

Smart People and Smart Living

According to Giffinger et al.'s (2007) classification smartness of people refers not only to the level of education/qualification but also to their open-mindedness, social interactions, public life, and other aspects like flexibility and creativity while the classification of smart living encompasses the aspects of quality of life of citizens

with regards to housing, health and safety, education, cultural facilities, social cohesion, and touristic attractivity. These similar aspects under smart living are mentioned under the people factor in Bosch et al.'s (2016) classification. Importance is given to the "education and skills of the population" and "knowledge and innovation institutions" in Komninos (2008)'s classification as well. Similarly, in Merli and Bonollo's (2014) classification the quality of life of the community factor is highlighted. In the Australian Government's (2017) Performance Measurement System relatable content dimensions are mentioned. For instance, "Jobs and Skills", which was aforementioned under smart economy has additions like educational attainment which comes under the smart people classification as per Giffinger et al. (2007). In addition to that the two policy priorities in Australian Government (2017)'s Performance Measurement System; "Liveability and Sustainability" which represent indicators purely based on the quality of life factor of citizens and "Housing" come under Giffinger, et al. (2007)'s Smart Living classification.

Smart Governance

Giffinger et al. (2007) emphasized governance as a key factor that requires attention in three main areas; the political participation, public administration, and services for citizens. Governance is classified with a similar interpretation by Bosch et al. (2016). In fact, both the classifications highlight the transparency of governance together with community involvement in decision making. In the Australian Government's (2017) system Governance together with Planning and Regulation are discussed with regards to governance fragmentation. Similarly, in Shen et al.'s (2018) system, although the classification termed as Smart Governance, new aspects like e-Government availability, participation by social media, and trading platforms for public resources have raised the concerns. Having users of e-gov as an indicator under digital infrastructure and e-services, Komninos (2008) has also paid attention on this regard.

Smart Environment

Giffinger et al. (2007) described Smart Environment mainly in terms of the attractivity of natural conditions such as green spaces, and climate the efforts taken towards resources and pollution management and environmental protection. The areas such as resource management, pollution and waste management, and attractivity and conservation of ecosystem which Giffinger et al. (2007) considered as important are also emphasized by Bosch et al. (2016) as well. They further added the focus areas like energy and mitigation, as well as climate resilience under Smart Environment/planet classification. Similarly, Merli and Bonollo (2014), Australian Government (2017), and Ambrosetti (2012) too have themed Eco-sustainability and Resource management respectively under their classifications.

Smart Mobility

While Giffinger et al. (2007), Lombardi et al. (2012), and Ambrosetti (2012) refer smart mobility under transport and ICT infrastructure authors like Komninos (2008), Merli and Bonollo (2014), and Shen et al. (2018) rather highlighted the importance of the ICT infrastructure. Alternatively, the Australian Government, (2017) has considered mobility under the two classifications, namely "Infrastructure and Investment" and "Innovation and Digital Opportunities". Under "Infrastructure and Investment" they referred to transportation where they have specified the indicators such as Jobs accessibility (in 30 minutes), work trips by the public, and active transport and peak travel delay. Under "Innovation and Digital Opportunities" they have discussed the indicator Broadband connections which is one of the indicators used by Komninos (2008) under his Digital infrastructure and e-services classification. Shen, et al. (2018) have also specified a similar set of indicators in elaborating their classification of smart infrastructure.

Propagation

This theme is classified under the Bosch et al.'s (2016) system where propagation is referred to as the potential of a Smart City solution(s) to replicate and scale to other locations/contexts/cities depending on the Smart City project's inherent

characteristics. However, this theme should be construed in a way that it does not show any intention to compromise the identity of an existing context to where the Smart City is designed, as ideally the whole Smart City concept should be understood without disturbing the existing conditions (Tomar and Gupta, 2019).

The importance of layer wise classification (University, Government, Civil society, and Industry) of each theme can be considered as the most vital lesson to be obtained from Lombardi et al.'s (2012) system. Therefore, listing of indicators for each layer of themes/subthemes is an ideal way to cross check the summary Performance Measurement System.

Likewise, the outcome of the reviewing of themes resulted in briefing of the themes to six, namely Smart Economy, Smart People and Smart Living, Smart Governance, Smart Environment, Smart Mobility, and Propagation. Figure 2.4 depicts sub-themes that have been identified under each of the themes.

SMART ECONOMY

- Economic performance
- Innovation, Innovative spirit, and Innovation performance
- Entrepreneurship
- Economic image & trademarks
- Production and Productivity
- Employment, Flexibility of labour market, and Jobs and Skills
- International embeddedness
- Equity
- Green economy
- Attractiveness & competitiveness
- Education and Research and Development

SMART GOVERNANCE

- Organization composition, process, leadership, and transparency
- Community involvement in decision-making
- Multi-level governance
- Governance fragmentation
- Public and social services
- Transparent governance
- Planning and Regulation

SMART ENVIRONMENT

- Attractivity of natural conditions
- Eco-sustainability
- Environmental protection
- Sustainable resource management
- Energy & mitigation
- Materials, water, land, Ecosystem
- Climate resilience
- Pollution & waste

SMART PEOPLE

- Level of qualification, Education and skills of the population
- Affinity to lifelong learning
- Social and ethnic plurality
- Flexibility
- Creativity
- Cosmopolitanism and open-mindedness
- Knowledge about the region/ country

SMART LIVING

- Cultural facilities
- Health conditions
- Safety
- Education facilities
- Touristic attractivity
- Access to (other) services
- Diversity and social cohesion
- Quality of housing and the built environment
- Quality of life of the community
- Liveability and Sustainability
- Added value intelligent services
- Quality of industry-based services

SMART MOBILITY

- Local accessibility
- (Inter-)national accessibility
- Availability ICT infrastructure
- Sustainable, innovative and safe system

PROPAGATION

- Replicability & scalability
- Factors of success

Figure 2.4: Themes and sub-themes for Performance Measurement in Smart Cities

Indicators, the elements that complete Performance Measurement Systems are introduced for each of these subthemes. At a glance on the Performance Measurement Systems for Smart Cities, it can be seen their difference with compared to the traditional Performance Measurement Systems which focus mainly/ only on the financial aspects of an organisation. As result the Performance Measurement Systems for Smart Cities belong to the next generation Performance Measurement Systems as per Kulatunga (2008), where the indicators are not limited to financial indicators but broaden to the non-financial, quality related and customer based measures.

2.7 Performance Measures for Smart Cities

Bosch et al.'s (2016) system with compared to Giffinger et al.'s (2007) system includes propagation as a concern while smart mobility is missing. Bosch et al. (2016) in their study have identified the indicators in project level as well as city level. As a result, the theme, propagation only comes with project level indicators. As per Bosch et al. (2016), these project indicators allows comparing the with and without situations of Smart City project and thereby the difference the project has made can be assessed.

As the ultimate purpose of combining the system is to generate a holistic common platform in means of a Performance Measurement System, features inherent to the specific geographical region are generalized. For an instance, sub theme and indicator named 'knowledge about EU' coming under Giffinger et al.'s (2007) system is modified as 'knowledge about the region/ country'. However, level of qualification measured with related to ISCED (International Standard Classification of Education) is kept as it is since the qualification equivalents in many countries are given (having ISCED as a baseline). For example, ISCED level 5 is compatible with Higher National Diplomas and level 6 is equivalent to Bachelor's Degree in Sri Lanka (UNESCO Institute of Statistics, 2019).

Lombardi et al.,'s (2012) clusters are classified under the revised triple helix. Following the study on themes and sub themes the revised triple helix was thought to

be incorporated in to the Performance Measurement System to be created at the end of this study.

In reviewing all Performance Measurement Systems except for Lombardi et al.,'s (2012), theming/ sub theming was useful as a common format under each of which indicators can be identifyed. However with Lombardi et al.,'s (2012) revised triple helix classification was disregarded in classifying the indicators under the previously identified summary set of themes/ subthemes. The following Table 2.5 includes a summary of all the Performance Measurement Systems studies;

Table 2.5: A Comprehensive list of Performance Measures for Smart Cities from literature

Theme	Sub Theme	Indicators
1. SMART ECONOMY	1. 1 Economic performance	Financial benefit for the end user *Total cost savings in euros for end-users per household per year*
		Net Present Value (NPV) *of the project calculated over the lifetime*
		Internal rate of return (IRR)
		Payback Period
		Total cost vs. subsidies *The percentage of subsidies as share of total investment of the project*
		Debt of municipal authority per resident
	1. 2 Innovation, Innovative spirit, and Innovation performance	Involvement of extraordinary professionals *The extent to which the project involved professionals normally not* *encountered in these type of projects- Likert scale*
		Stimulating an innovative environment *The extent to which the project is part of or stimulates an innovative* *environment- Likert*
		Quality of open data *The extent to which the quality of the open data produced*

Theme	Sub Theme	Indicators
		by the project was increased -number of stars
		New start-ups- *number of start-ups resulting from the project*
		Improved interoperability- *The extent to which the project has increased interoperability between community infrastructures*
		Employment rate in: High Tech and creative industries; Renewable energy and energy efficiency systems Financial intermediation and business activities; knowledge-intensive sectors; Culture and entertainment industry; Commercial services; Transport and communication; Hotels and restaurants; All companies (total number)
		Number of local units manufacturing High Tech & ICT products
		Patent applications per inhabitant
		Number of incubators (per million of population)
		Number of S&T Parks (per million of population)
		Number of Technology Transfer and Innovation Centres (per million of population)
		Exports high-tech services (per cent total exports)
		New trade marks (per million of population)
		Enterprises having internal R&D (Research and Development) department (per cent of all enterprises)
		Sales of new-to-market products (per cent of turnover)
		Sales of new-to-firm not new o-market products (per cent of turnover)
		New business models for smart growth and quality of life • New business models • Living Labs • Creative class • Web of Trust
	1. 3 Entrepreneurship	Self-employment rate
		New businesses registered
		Percentage of projects funded by civil society
	1. 4 Economic image & trademarks	Importance as decision-making centre (Head Quarters-HQ etc.)

Theme	Sub Theme	Indicators
	1. 5 Production and Productivity	GDP (Gross Domestic Product) per employed person
		GDP per head of city population
	1. 6 Employment, Flexibility of labour market, Jobs and Skills	Increased use of local workforce
		Local job creation
		Unemployment rate
		Proportion in part-time employment
	1. 7 International embeddedness	Companies with HQ in the city quoted on national stock market
		Air transport of passengers
		Air transport of freight
	1. 8 Equity	Fuel poverty- *The percentage of households unable to afford the most basic levels of energy*
		Costs of housing - *% of population living in affordable housing*
		Median or average disposable annual household income
	1. 9 Green economy	Certified companies involved in the project
		Green public procurement- *Percentage annual procurement using environmental criteria as share of total annual procurement of the city administration*
		CO2 reduction cost efficiency- *Costs per ton of CO2 saved per year*
		Energy intensity of the economy -gross inland consumption of energy divided by GDP
	1. 10 Attractiveness & competitiveness	Decreased travel time
	1. 11 Education and Research and Development	Public expenditure on R&D -percentage of GDP per head of city population
		Public expenditure on education -percentage of GDP per head of city population
		Number of research grants funded by international projects
2. SMART GOVERNANCE	2.1 Organization composition, process, leadership, and transparency	2.1.1 Leadership- *The extent to which the leadership of the project is successful in creating support for the project. - Likert*
		2.1.2 Balanced project team - *The extent to which the project team included all relevant experts and stakeholders from the start- Likert*
		2.1.3 Involvement of the city administration- *The extent to which the local authority is involved*

Theme	Sub Theme	Indicators
		in the development of the project, other than financial, and how many departments are contributing- Likert
		2.1.4 Clear division of responsibility- *Has the responsibility for achieving the social and sustainability targets been clearly assigned to (a) specific actor(s) in the project? Yes/no*
		2.1.5 Continued monitoring and reporting - *The extent to which the progress towards project goals and compliance with requirements is being monitored and reported- Likert*
		2.1.6 Market orientation- *The extent to which the project was planned on the basis of a market analysis- Likert*
	2.2 Community involvement in decision-making	*2.2.1* Professional stakeholder involvement- *The extent to which professional stakeholders outside the project team have been involved in planning and execution- Likert*
		2.2.2 Bottom-up or top-down initiative-*Has the project idea originated from the local community? -yes/no*
		2.2.3 Local community involvement in planning phase- *Extent to which residents/users have been involved in the planning process-Likert*
		2.2.4 Local community involvement in implementation phase *Extent to which residents/users have been involved in the implementation process-Likert*
		2.2.5 Participatory governance % *Share of population participating in online platforms*
		2.2.6 City representatives per resident
		2.2.7 Political activity of inhabitants
		2.2.8 Importance of politics for inhabitants
		2.2.9 Share of female city representatives
		2.2.10 Participation by social media
	2.3 Multi-level governance	2.3.1 Smart City policy - *the extent to which the project has benefitted from a governmental Smart City policy- Likert*
		2.3.2 Municipal involvement - Financial support- *extent to which the local authority provides financial support to the project- Likert*
	2.4 Governance fragmentation	2.4.1 Governance orchestration
		2.4.2 Infrastructure Alignment
		2.4.3 District Regeneration
	2.5 Public and social services	2.5.1 Expenditure of the municipal per resident in PPS
		2.5.2 Share of children in day care
		2.5.3 Satisfaction with quality of schools
		2.5.4 Trading platform for public resources
	2.6 Transparent governance	2.6.1 Satisfaction with transparency of bureaucracy
		2.6.2 Satisfaction with fight against corruption

Theme	Sub Theme	Indicators
	2.7 Planning and Regulation	2.7.1 Smart Urban Planning
		2.7.2 Smart Identity Branding
SMART ENVIRONMENT	3.1 Attractivity of natural conditions	3.1.1 Sunshine hours
		3.1.2 Green space share
	3.2 Eco-sustainability	3.2.1 % Increase in green and blue space due to the project
		3.2.2 Increased ecosystem quality and biodiversity- *Extent to which ecosystem quality and biodiversity aspects have been taken into account-LIKERT*
		3.2.3 Percentage of new buildings and renovation which were assessed in terms of sustainability
	3.3 Environmental protection	3.3.1 Individual efforts on protecting nature
		3.3.2 Opinion on nature protection
		3.3.3 An assessment of the ambitiousness of CO2 emission reduction strategy
		3.3.4 Carbon dioxide emission reduction
		3.3.5 Reduction in lifecycle CO2 emissions
		3.3.6 An assessment of the comprehensiveness of policies to contain urban sprawl and to improve and monitor environmental performance
	3.4 Sustainable resource management	3.4.1 Efficient use of electricity (use per GDP)
		3.4.2 The total percentage of the working population traveling to work on public transport, by bicycle and by foot
		3.4.3 An assessment of the extensiveness of efforts to increase the use of cleaner transport
		3.4.4 Percentage of citizens engaged in environmental and sustainability-oriented activity
		3.4.5 The percentage of total energy derived from renewable sources, as a share of the city's total energy consumption, in terajoules
		3.4.6 Proportion of recycled waste per total kilogram of waste produced
	3.5 Energy & mitigation	3.5.1 Reduction in annual final energy consumption
		3.5.2 Reduction in lifecycle energy use
		3.5.3 Reduction of embodied energy of products and services used in the project
		3.5.4 Increase in local renewable energy production
		3.5.5 Combined heat and power generation percentage of gross electricity generation
		3.5.6 Alternative Energy Master plan
		3.5.7 Maximum Hourly Deficit
		3.5.8 An assessment of the extensiveness of city energy efficiency standards for buildings
	3.6 Materials, water, *land*, Ecosystem	3.6.1 Increased efficiency of resources consumption
		3.6.2 Share of recycled input materials
		3.6.3 Share of renewable materials

Theme	Sub Theme	Indicators
		3.6.4 Share of renewable materials
		3.6.5 Life time extension-*The extent to which measures were taken to* 3.6.6 *prolong the service lifetime of products - Likert*
		3.6.7 Reduction in water consumption
		3.6.8 Increase in water re-used
		3.6.9 Self-sufficiency – Water- *Increased share of local water resources*
		3.6.10 Increase in compactness
	3.7 Climate resilience	3.7.1 Climate resilience measures- *The extent to which adaptation options have been considered in the project*
	3.8 Pollution & waste	3.8.1 Decreased emissions of Nitrogen dioxides (NO2)
		3.8.2 Urban population exposure to air pollution by particulate matter micrograms per m3
		3.8.3 Decreased emissions of Particulate matter (PM2,5)
		3.8.4 Reduced exposure to noise pollution
		3.8.5 Reduction in the amount of solid waste collected
		3.8.6 Summer smog (Ozon)
		3.8.7 Fatal chronic lower respiratory diseases per inhabitant
SMART PEOPLE	4.1 Level of qualification, Education and skills of the population	4.1.1 Importance as knowledge centres (top research centres, top universities etc.)
		4.1.2 Population qualified at levels 5-6 ISCED
		4.1.3 Foreign language skills
		4.1.4 % of population aged 15-64 with secondary-level education living in Urban Audit
		4.1.5 % of population aged 15-64 with higher education living in Urban Audit
		4.1.6 % of inhabitants working in education and in research & development sector
		4.1.7 Individual level of computer skills
		4.1.8 Individual level of internet skills
	4.2 Affinity to lifelong learning	4.2.1 Book loans per resident
		4.2.2 Participation in life-long-learning in %
		4.2.3 Participation in language courses
	4.3 Social and ethnic plurality	4.3.1 Share of foreigners
		4.3.2 Share of nationals born abroad
	4.4 Flexibility	4.4.1 Perception of getting a new job
	4.5 Creativity	4.5.1 Share of people working in creative industries
	4.6 Cosmopolitanism and open-mindedness	4.6.1 Voters turnout at European elections
		4.6.2 Immigration-friendly environment (attitude towards immigration)
		4.6.3 Knowledge about the region/ country
	4.7 Knowledge about the region	4.7.1 Voters turnout at city elections
		4.7.2 Participation in voluntary work

Theme	Sub Theme	Indicators
SMART LIVING	5.1 Cultural facilities	5.1.1 Cinema attendance per inhabitant
		5.1.2 Museums visits per inhabitant
		5.1.3 Total book loans and other media per resident
	5.2 Health conditions	5.2.1 Improved access to basic health care services- *The extent to which the project has increased accessibility to basic health care*
		5.2.2 Encouraging a healthy lifestyle
		5.2.3 Waiting time
		5.2.4 Life expectancy
		5.2.5 Hospital beds per inhabitant
		5.2.6 Doctors per inhabitant
		5.2.7 Satisfaction with quality of health system
	5.3 Safety	5.3.1 Reduction of traffic accidents
		5.3.2 Reduction in crime rate
		5.3.3 Improved cybersecurity
		5.3.4 Improved data privacy
		5.3.5 Crime rate
		5.3.6 Death rate by assault
		5.3.7 Satisfaction with personal safety
	5.4 Education facilities	5.4.1 Improved/ satisfaction with access to educational resources/ system
		5.4.2 Increased environmental awareness
		5.4.3 Improved digital literacy
		5.4.4 Students per inhabitant
		5.4.5 Satisfaction with quality of educational system
		5.4.6 No. of universities and research centers in the city
		5.4.7 No. of courses entirely downloadable from the internet/total no. courses
		5.4.8 Percentage of professors and researchers involved in international projects and exchange
		5.4.9 Percentage of accessible courses for People with Disabilities (PWD)
	5.5 Touristic attractivity	5.5.1 Touristic Importance as tourist location (overnights, sights)
		5.5.2 overnight stays in registered accommodation in per year per resident
	5.6 Access to (other) services	5.6.1 Access to public transport
		5.6.2 Quality of public transport
		5.6.3 Improved access to vehicle sharing solutions
		5.6.4 Extending the bike route network
		5.6.5 Access to public amenities
		5.6.6 Access to commercial amenities
		5.6.7 Increase in online government services/ e-Government on-line availability (percentage of the 20 basic services that are fully available online)
		5.6.8 e-Government usage by individuals

Theme	Sub Theme	Indicators
		(percentage individuals aged 16-74 who have used the Internet, in the last 3 months, for interaction with public authorities)
		5.6.9 Proportion of the area in for recreational sports and leisure use
		5.6.10 Number of public libraries
		5.6.11 Number of theaters and cinemas
	5.7 Diversity and social cohesion	5.7.1 People reached
		5.7.2 Increased consciousness of citizenship and social coherence
		5.7.3 Increased participation of vulnerable groups
		5.7.4 Perception on personal risk of poverty
		5.7.5 Poverty rate
	5.8 Quality of housing and the built environment	5.8.1 Diversity of housing types
		5.8.2 Connection to the existing cultural heritage
		5.8.3 Design for a sense of place
		5.8.4 Increased access to urban public outdoor recreation space
		5.8.5 Increased access to green space
		5.8.6 Share of housing fulfilling minimal standards
		5.8.7 Average living area per inhabitant
		5.8.8 Satisfaction with personal housing situation
		5.8.9 Green Building Policies
	5.9 Quality of life of the community	5.9.1 Public and community housing
		5.9.2 Homelessness rate
		5.9.3 Rent stress
		5.9.4 Mortgage stress
		5.9.5 Housing construction costs
		5.9.6 Dwelling price to income ratio
		5.9.7 Population change per building approval
		5.9.8 Free time
	5.10 Liveability and Sustainability	5.10.1 Adult obesity rate
		5.10.2 Support in times of crisis
		5.10.3 Suicide rate
		5.10.4 Volunteering
		5.10.5 Office building energy efficiency (New)
		5.10.6 Access to public transport (New)
	5.11 Added value city wide intelligent services	5.11.1 i-energy
		5.11.2 i-transport
		5.11.3 i-democracy
		5.11.4 i-government
		5.11.5 i-services
		5.11.6 i-home
	5.12 Quality of industry-based services	5.12.1 Number of enterprises adopting ISO 14000 standards
		5.12.2 Proportion of people undertaking industry-based training

Theme	Sub Theme	Indicators
SMART MOBILITY	6.1 Local accessibility	6.1.1 Public transport network per inhabitant
		6.1.2 Satisfaction with access to public transport
		6.1.3 Satisfaction with quality of public transport
	6.2 (Inter-)national accessibility	6.2.1 International accessibility
	6.3 Availability ICT infrastructure	6.3.1 City area covered by cable networks (per cent of total area)
		6.3.2 City area covered by Wi-Fi networks (per cent of total area)
		6.3.3 City area covered by xDSL networks (per cent of total manufacturing enterprises)
		6.3.4 Computers (per million of population)
		6.3.5 Internet connections (per million of population)
		6.3.6 Broadband connections (per million of population)
		6.3.7 Users of e-gov services (per million of population)
		6.3.8 City enterprises owning a website (per cent of total enterprises)
		6.3.9 City enterprises involved in B2B or B2C (per cent of total enterprises)
		6.3.10 Number of telephones per household (Telephones/person)
		6.3.11 Number of handphones per household (Handphones/person)
		6.3.12 Development of cloud platform and application Utilization
		6.3.13 Open and Integrated Urban Operating System 6.3.14 Urban OS (Operating System) 6.3.15 Geospatial 6.3.16 Smart Grids 6.3.17 Ontologies 6.3.18 Semantic 6.3.19 Linked APIs 6.3.20 Cloud
		6.3.21 City Infrastructure for “real and connected” Life 6.3.22 Sensors 6.3.23 Activators 6.3.24 WSAN (Wireless Sensor and Actuator Network) 6.3.25 B_WISE (Baltimore/Washington Information Systems Educators) 6.3.26 RFID (Radio-Frequency Identification) 6.3.27 Internet of Things

Theme	Sub Theme	Indicators
	6.4 Sustainable, innovative, and safe transport system	6.4.1 Green mobility share (non-motorized individual traffic)
		6.4.2 Traffic safety
		6.4.3 Use of economical cars
		6.4.4 Peak travel delay
Propagation	7.1 Replicability & scalability	7.1.1 Social compatibility
		7.1.2 Technical compatibility
		7.1.3 Ease of use for end users of the solution
		7.1.4 Ease of use for professional stakeholders
		7.1.5 Trialability
		7.1.6 Advantages for end users
		7.1.7 Advantages for stakeholders
		7.1.8 Visibility of Results
		7.1.9 Solution(s) to development issues
		7.1.10 Market demand
	7.2 Factors of success	7.2.1 Changing professional norms
		7.2.2 Changing societal norms
		7.2.3 Diffusion to other locations
		7.2.4 Diffusion to other actors
		7.2.5 Change in rules and regulations
		7.2.6 Change in public procurement
		7.2.7 New forms of financing
		7.2.8 Smart City project visitors

The Performance Measurement Systems used in measuring the Smart City performance often comprised of themes, sub themes and indicators. However, the terms given for sub themes/ themes differ with the study. The following Table 2.5 presents the terms given for themes/ subthemes in each study,

Table 2.6: Different forms under which the indicators were classified in Performance Measurement System from literature

Study	Theme	Sub theme	Indicators
(Bosch et al., 2016)	Themes	Sub themes	Indicators
(Giffinger et al., 2007)	Characteristics	Factors	Indicators
(Lombardi et al., 2012)	Clusters	Revised triple helix	Indicators
(Komninos, 2008)	Dimensions	Blocks	Indicators
(Merli and Bonollo, 2014)	Dimensions	Focus	Indicators

Study	Theme	Sub theme	Indicators
(Shen et al., 2018)	Category		Indicators
(Australian Government, 2017)	Policy priorities		Objectives/ Indicators
(Ambrosetti, 2012)	Themes	Goals/ drivers	Indicators

Lombardi et al.'s (2012) study having a triple helix form has agencies act as the sub themes. In Bosch, et al.'s (2016) study the subthemes and indicators are defined while in Australian Government's (2017) study the indicators are described. Bosch, et al.'s (2016) study in fact provides a clear description for the measurement basic.While the basis for theme identification was Giffinger et al.'s (2007) study, sub themes were identified by having Bosch, et al.'s (2016) study as the basis. Accordingly, different types of indicators were found as shown in the Table 2.6;

Table 2.7: Different types of performance indicators

Indicator type	Description
Input Indicators	• Report the amount of fnancial, human and material resources used for smart services • Useful for tracking policy decisions, because they can be updated quickly once an action occurs.
Output Indicators	• Measure the results of an activity. • Can be updated quickly once an action has occurred.
Activity Indicators	• Quantity of smart services provided by a smart local government or the amount of work performed
Effectiveness Indicators	• The degree which predetermined goals of a particular activity or program are achieved • Related to the Smart City capacity to satisfy citizens' needs (quantitative and qualitative effectiveness)
Effciency Indicators	• The ability of maximizing the quantity and/or quality of the smart services provided in relation to the resources used
Outcome Indicators	• The positive and negative effects on stakeholders; they can be referred to social and economic aspects (outcome) or focused

Indicator type	Description
	only on environmental aspects (environmental outcome)

Adapted from (Bosch et al., 2016); (Merli and Bonollo, 2014); (Australian Government, 2017)

The variety of indicators show the need of having a holistic system to measure the performance of Smart Cities. The activity indicators, effectiveness indicators and efficiency indicators can be measured also for innovative outputs. In addition to these types, there are lagging and leading indicators incorporated in the above Performance Measurement Systems. Leading indicators allow making decisions regarding future performance levels while lagging indicators are used to notify final results of the actions performed or in other words measure what has already happened (Macpherson, 2001). For instance, Bosch et al.'s (2016) study includes both leading and lagging indicators. Giffinger et al. (2007) have mainly focused on lagging indicators. However, the studies like Maccani, Donnellan, and Helfert (2013) have also produced Performance Measurement Systems without indicators, yet this study only reviewed the Performance Measurement Systems with indicators.

2.8 Barriers for Performance Measurement in Smart Cities

At a glance on the extent, variety and complexity of work performed and the resulted in inestimable value production in a Smart City, the prevailing idea with regards to the Performance Measurement in Smart Cities lies in a dissatisfying stage (Dameri & Rosenthal-Sabroux, 2014). As a result, Performance Measurement in Smart Cities is not much perceived in multidimensional terms (Merli & Bonollo, 2014). Above all, lack of an accepted definition for Smart Cities becomes the main barrier in developing a holistic Smart Cities system (Huovila, et al., 2017). The difficulties found in the implementation of Performance Measurement Systems in general is possible to be related to the Smart Cities context as follows.

2.8.1 Problems in Implementations

One of the mostly concerned barriers in the Performance Measurement context is the implementation barrier (Harvey & Technical Information Service, 2008). According to Keathley and Van Aken (2013), many implementation failures are reported causing the efforts geared towards the failed implementations a complete loss. Implementation procedure is very much known to be complicated and lengthy, involving a number of obstacles which prevents organizations from adopting Performance Measurement Systems (Kolingerová, 2016). Smart Cities themselves often comes with various complications such as insufficient state backing, budgetary issues, stakeholder resistance, bureaucracy and failure to attract funding, etc. (Angelidou, 2014). Having such snags left in the feasibility stage of Performance Measurement, the acceptance of Performance Measurement System would definitely be an underlying problem to Smart Cities as well.

2.8.2 Cost Vs Benefits

Halachmi (2002) has argued about the increased cost of implementation and introduction of Performance Measurement Systems with compared to its potential benefits. With regards to the non-monetary benefits, the practice to use performance systems just for the sake of satisfying auditors is criticized and so that the true benefits for the society and system are unattainable (Halachmi, 2005). On the other hand, higher the complexity of measuring and excessiveness of performance measured in a Performance Measurement System, higher chance of negative effects due to the time consumed and efforts and investment made (Martinez and Kennerley, 2005). Cost benefit analysis is an imperative in the Smart Cities which themselves are built as a substitute for costly city solutions (Dameri and Garelli, 2014).

2.8.3 Complicated and diversified interests of different stakeholders

This was described in detail in Halachmi and Greiling's (2011) study in reference to stakeholder management as "Beauty as seen in the eye of the beholder". Diversified interests makes hard times in the performance appraisal stage due to subjectivity and therefore detain the Performance Measurement implementation by requiring to make

the critical decision with regards to prioritizing the stakeholders (Sanger, 2008). According to Halachmi (2005) this decision can raise a number of methodological and conceptual issues with rework in measuring performance in any type of an organization.

2.8.4 Technology aspects

Cavalluzzo and Ittner (2004) asserts that technical issues revolving around Performance Measurement has a worse impact that the cost does. Technological implications usually in developing countries have their limitations and unavailability which cause delays in information and automation issues in the process of Performance Measurement (Nudurupati et al., 2011). As far as the Smart City administration is concerned, data is collected and databases are more often than not are automated (Gomez and Paradells, 2015). Therefore, in the Smart City aspects this might not seem like a problem with compared to different other organizations. Yet, that again depends on the resource availability.

2.8.5 Difficulties in obtaining information

Difficulties to access different sources involves extra work and therefore either inaccuracies occur or the Performance Measurement System becomes completely useless without required information timely (De Vries, 2010). This difficulty sometimes takes place in the middle of the procedure, for instance in the refining stage (Halachmi, 2011). The nature of Performance Measurement involves uncertainty, negotiations, ambiguity and constant change (Gao, 2015) and that is even more problematic in a context like Smart Cities where a number of social political and cultural factors can influence.

2.8.6 Data availability and management issues

Lack of information can happen due to various reasons depending on the context in which the Performance Measurement System is used (Martínez-Ballesté, Pérez-Martínez, & Solanas, 2013). For instance, in a city the data to be collected to measure the performance sometime is confidential due to security reasons and data may only be available with certain restrictions (Halachmi, 2011). Duplications due to

storing data in different formats in different departments create delayed decision making due to poor linkages and slow retrieval of data (Nudurupati et al., 2011).

2.8.7 Privacy issues

This has been a problem in public sector which involves personal data which could become a threat to people if hacked (Khatoun and Zeadally, 2016). While data management plays a significant role in Performance Measurement with privacy issues there may be a resistance from general public (Sanger, 2008). Jeopardizing the privacy of Smart Cities citizens is also widely discussed and solutions like off-the-shelf privacy enhancing technologies are introduced (Martínez-Ballesté et al., 2013). However, the until the reliable application of such new technologies, obtaining data without putting citizen's privacy endanger remains a problem (Zhang et al., 2017).

2.8.8 Workload

Performance Measurement usually becomes an additional effort which requires a proper training in respect to data collection, meaningful data management and reporting (Landy, Zedeck and Cleveland, 2017). This extra work is not just a once-in-a-project, but keeps continuing with the changing goals and dynamic context demanding the performance measures and reports also to refine and update (Sanger, 2008). Insufficient number of software license agreements to access databases can be another problem where the workload stagnates without being distributed (De Vries, 2010). Unless the roles are defined beforehand along with properly planned governance and city administration, centralized Smart City administration is strenuous (Meijer and Bolívar, 2016).

2.8.9 Human involvement

Although the Performance Measurement procedure is comparatively automated to a significant extent, certain operations such as data collection or appraisals involving a cognitive attribute require human involvement which can create problems due to subjectivity and human errors (Carnochan et al., 2014). Moreover, in terms of Performance Measurement in public sector is quite known for political undue

interventions and influences (Halachmi and Holzer, 2010). This is mostly probable in a Smart City like people-oriented context.

2.8.10 Lack of integration

Performance Measurement Systems are ideally designed aligning to the organization's strategic objectives (Kulatunga, Liyanage and Amaratunga, 2010). However, if these objectives are incomprehensible and unclear, developed key performance indicators too become irrelevant (Ittner, 2015). In the same way difficulties take place in breaking down the objectives to lower levels (Nudurupati et al., 2011). Similarly, the inconsistency in defining performance measures across the organizations result in arguments between different units of an organization as the measurement systems for each function/ operation vary in terms of data definitions, ease in accessibility, unit of analysis and the amount of data retained (Bititci, Garengo, Dörfler and Nudurupati, 2012). In this study the organization happens to be the Smart City and the different unit would be the policy making units with regards to each of the identified themes.

2.8.11 Internal resistance

While use of Performance Measurement Systems create the conduct transparent, there is a higher chance for the members in that organization to feel uncomfortable and in danger and that can result in a resistance to set in (Bjørnholt and Larsen, 2014). Although this can be easily prevented by linking a reward system with the accomplishment of desired performance, likewise rewarding are barely seen. Further decision-making authority level delegated to the Performance Measurement System's users can cause conflicts in the organization (Ittner, 2015). However, the positive and collaborative environment expected in Smart Cities encourage to achieve greater benefits (Bolívar, 2018).

2.9 Summary

While there are a number of characteristics that depict what a Smart City is, none of them have been evaluated in the Sri Lankan context. Therefore, a thorough

investigation on smart characteristics has been carried out by taking the three approaches;1) Reviewing the definitional elements in Smart City definitions put forwards in year 2019, 2) Comparing Smart City concept with similar city conceptualizations, and 3) Reviewing the Performance Measurement frameworks/ systems. The existing Performance Measurement frameworks/ systems for Smart Cities took a similar form and the indicators themselves were smart characteristics. As a result, it was seen that an amalgamation of such systems would produce a holistic frameworks/ system to reflect the smartness of a Smart City depending on the context to which it is applied. However, the implementation comes with barriers and they can be looked in terms of the barriers that are encountered in applying any type of a Performance Measurement System to any industry.

CHAPTER 03

RESEARCH METHODOLOGY

3.1 Introduction

This chapter intends designing a scientific and systematic way to unravel the research problem. Accordingly, the available research approaches and methods are discoursed by providing justifications to the selected. Subsequently, data collection and analysis procedures are explained. In the latter part, the research process starting from problem definition till analysing and evaluating results, is denoted.

3.2 Research methodological design

Research design simply refers to as the blueprint of the research which outlines the data collection and analysis techniques in advance (Kothari, 2004); while research methodology refers to the most justifiable, transparent and clear way the researcher intents to deal with a particular research problem having an idea about the commencement, direction of the research, action plan with suitable data collection and analysis techniques (Jonker & Pennink, 2010). Therefore, research methodological design is the overall framework to answer the research problem (Blanche, Blanche, Durrheim, & Painter , 2006), in the way that is approached and proceeded with a theoretical underpinning on the selection of the suitable method, practice, technique, etc. (Igwenagu, 2016). With a properly designed research methodology, soundly based conclusions on the expanded knowledge frontier through conducting the research, is validated (Walliman, 2011).

It is the adopted research methodology design that directs solving the research problem in a systematic and scientific way (Bhattacharyya, 2006; Kothari, 2004). The choice of research methodology design for built environment researchers mostly becomes either the nested approach (Kaglioglou et al., 1998) or the research onion approach (Saunders et al., 2019) and depending on the nature of the research objectives, the researcher can prefer the most suitable system (Omotayo & Kulatunga, 2015). With both the systems embracing a systematic process towards

conducting a research while providing a basis to make informed decisions, research onion with further layers than the nested method is much more comprehensive (Kulatunga, Amaratunga, & Haigh, 2007). Therefore, the research onion is administered in as the research methodology design in this study. The relevance of the research onion to this study can be illustrated as shown under the Figure 3.1 which shows the research onion;

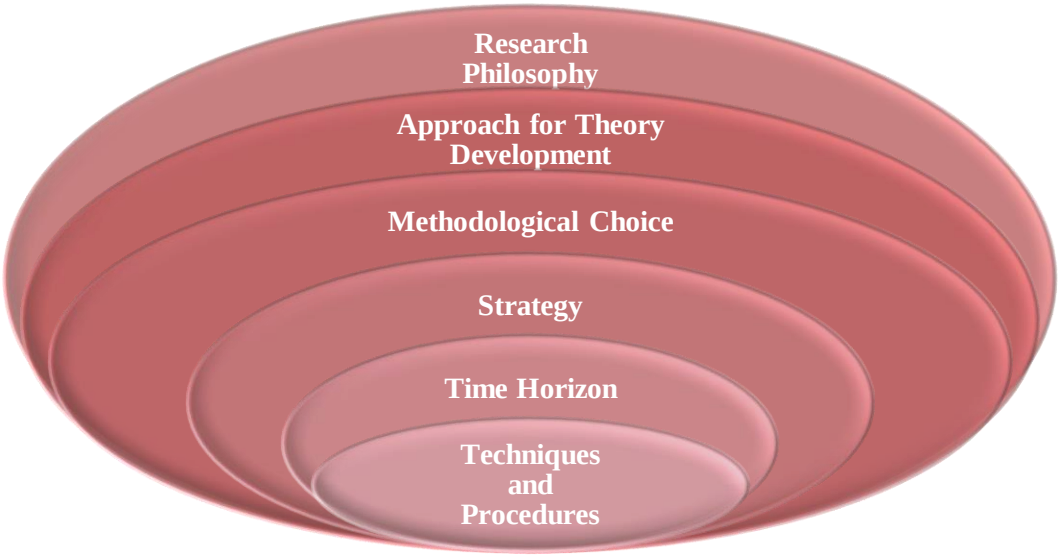

Figure 3.1: Saunders, Lewis, and Thornhill (2019)'s Research Onion

According to Saunders et al. (2019), the researcher's major concern, data collection and analysis, lies in the core of the onion. However, as a result of the meticulous structure, expected act of "peeling" several layers before reaching the onion core, signifies the concerns to be taken into account prior to the data collection and analysis (Al Zefeiti & Mohamad, 2015). Accordingly, those concerns represent the peels namely, starting from the outermost, philosophy; approach for theory development; methodological choice; strategy (ies); time horizon; and techniques and procedures. The layers are summarized under following topics. Therefore, the discussion is presented in a way that the outermost layers are first described and then the other layers.

3.2.1 Philosophy

The view of the researcher with respect to acquiring appropriate knowledge, understanding the holistic picture and interpreting those facts, is based on

researcher's philosophical stance (Walliman, 2011). In educational researches, research paradigms are the worldviews of the researchers based on their philosophical orientations (Mackenzie & Knipe, 2006). These research philosophical "paradigms" can be identified as a set of guide actions as well as standpoints which narrates how to construct meanings from a gathered set of data (Kivunja & Kuyini, 2017). Out of the number of research paradigms, the dominant in educational research are, positivist, interpretivist, critical/ transformative and pragmatic paradigms (Melnikovas, 2018). However, each of these paradigm feature different phenomena and it is important to employ the most suitable paradigm to answer each research question in the study, which is known to as the philosophy of pragmatism (Antwi & Hamza, 2015).

Philosophical paradigms can be understood through a set of essential elements namely, ontology, epistemology and axiology (Saunders et al., 2019). Accordingly, ontological, epistemological and axiological assumptions are made by the researcher on realities, human knowledge and the extent/ ways the researcher's value influence that research, respectively (Willis, 2007).

The proposed study expected to produce a Performance Measurement System for the Smart City in Colombo Port City (SMCPC) and thereafter to a Smart City in Sri Lanka which has a similar context to SMCPC based on the literature findings and empirical findings. However, the proposed smart characteristics are not yet thoroughly reviewed. Therefore, an accepted truth is questionable. While the researcher has an opinion on a suitable set of smart characteristics to form a Performance Measurement System, based on the knowledge gained through reviewing existing literature, experts on the area, based on their experience and expertise knowledge may view smart characteristics and performance measurement differently. Even when the researcher requests an expert to evaluate the suitability of a particular smart characteristic obtained from literature, the interpretation is subjective and experts did not construe it the same way the researcher did. Consequently, this research revolves majorly around those interpretative smart characteristics by means of constructing knowledge.

However, once the Performance Measurement System, which is suitable to Smart City, was developed with the expert opinion obtained from the limited number of professionals engaged in the CPC project, that was assessed by the professionals who are having a vision for Smart Cities. The applicability of the constructed knowledge through the generated Performance Measurement System was evaluated by a broader sample of respondents making it less subjective. With the development of the system suitable for SMCPC, it was implied that the system would be suitable to a Sri Lankan Smart City with the same city context like in SMCPC. However, as most of the indicators in SMCPC are futuristic and case specific, assessing the suitability of that system to Sri Lanka requires the most significant which essentially does not demand a descriptive approach but an objective approach. Therefore, the study incorporated the features of positivism as well.

According to Thanh and Thanh (2015), when understanding a particular context, interpretivism relies on multiple perspectives and therefore the conclusions or judgements are accepted, influenced by and based on different judgments of the participants of the study; not only the researcher's, which has been the case in developing the system to SMCPC whereas in generating the system suitable for Sri Lanka in general, different opinions were obtained only to signify the indicators and therefore were conclusive. In addition to that, it is the interpretivists who focus on evaluating and refining theories instead of creating completely new theories while the results from positivism are generalizable findings (Antwi & Hamza, 2015). As the gaining of the true knowledge can be done in this study initially is with deep interpretation of the subject, axiologically, the research is more leaned towards value laden. In other words, researcher plays a major role and is a part of the research; exactly the same as this study desires. Therefore, the study adopts pragmatism as its philosophical orientation.

3.2.2 Approach

The approach shed light on the research design developed upon the basis of the extent to which the study concerns on theory testing or/and theory building (Saunders et al., 2019). Different authors have come up with several Performance

Measurement Systems to certain contexts. However, such systems cannot be directly used without customizing to Sri Lanka, as a result of the contextual differences. Therefore, based on the theoretical findings (existing Performance Measurement Systems in literature), a suitable Performance Measurement System for Sri Lanka was formed. Likewise, if a research attempts to build a relationship with theory, by bringing data back and forth by means of combining induction and deduction either to modify an existing theory or to define a new theory is known as the abductive approach (Saunders et al., 2019). In fact, Awuzie & McDermott (2017) identifies this as as an appropriate approach to be used in built environment researches.

3.2.3 Methodological choice

According to paradigm of choices, different situations require different research choices (Amaratunga, Baldry, Sharshar, & Newton, 2002). The study adheres to both qualitative as well as quantitative research choices. In pragmatism paradigm, the researcher is encouraged to use both qualitative and quantitative choice and strengthen the study while averting the weaknesses (Samar, 2017). This study investigating how a suitable Performance Measurement System can be formed to Sri Lanka which is exploratory as well as conclusive. It requires a clear understanding about the current context together with the long-term situational facts. In fact, the research possibly will be instructive for future than now, with the maturity of Smart City projects and project concepts which are currently in the inception stage. The authors specify the qualitative paradigm as the methodological choice in a research when it is exploratory, involves why and how investigation (Rajasekar, Philominaathan, & Chinnathambi, 2013) and when it assists understanding a situation (Castellan, 2010). Once the findings of why and how questions are in place the research further seeks to find out an answer to “what” type questions. It includes finding the significant indicators. Further, the experts’ contribution in reviewing the suitability of smart characteristics is much high as the relatable literature evidence cannot be found. Nevertheless, such smart characteristics are found in literature in Performance Measurement Systems with particular reference to performance indicators as well. Such literature should be verified. According to Mafuwane (2011), pairing qualitative choice with quantitative choice promotes an improved

self-understanding, a greater intuition with human experience and behavior towards a specific condition and verification and extension of theories. Moreover, collecting data using mixed methods increased the credibility of the researcher as he/she has taken every approach to address the research problem (Antwi & Hamza, 2015). Therefore, aiming a rich collection of data, the methodological choice for this study is mixed method.

3.2.4 Strategy

Research strategy provides the direction for a research including the process with which the study is carried out (Remenyi, Williams, Money, & Swartz, 1998). According to Saunders et al. (2019), who emphasized the importance of selecting the most advantageous strategy out of the number of strategies such as experiment, participative enquiry, survey, action research, case study, grounded theory, archival research, ethnography, cross sectional studies and longitudinal studies.

According to Antwi and Hamza (2015), researchers who look at the qualitative approach engross in a culture where they can observe human behavior and interactions, generally, by participating whenever they should attend to observe, interviewing important stakeholders/ participants along with searching histories and analyzing case studies, reviewing documents and important cultural artifacts. This implies a suitability of having a case study for a qualitative phenomenon. In fact, the research question itself being “how and why” type and requiring an in-depth describing of a certain social phenomenon, should be a dawn on the researchers to make case study the strategy of their researches (Yin, 2014). Aiming an in-depth analysis, a single case study has been selected. This case being the most ideal case study available in Sri Lanka falls under the unique category as per Yin’s (2014) study. While the initial part of this study, which was to produce a case study to emerging Smart Cities in Sri Lanka was based on a unique single case study, the latter part was to study the suitability of the formed Performance Measurement System to Sri Lanka at large. According to Gomm, Hammersley, & Foster (2000), a case is known to as a microcosm of a large system and therefore the case findings are supposed to be symptomatic of what is going on in the general context. Although this

research was started on grounds of this argument at the end of the preliminary interviews it was seen that the selected case was unique and more of a standing alone occasion with compared to the general Sri Lankan context. However, the argument was not completely thrown away as the case still was a part of the general context although it has unique features. Consequently, the case study findings were not generalized; instead a separate system was developed to the general context based on the findings from a unique case. Therefore, the added features in the system as unique indicators would be insignificant in the general scenario. That significance/ insignificance therefore is important to be assessed and the indicators would be a predesignated set of answers. When the response categories are fixed and collected in number forms to identify the implications of a particular area of research, surveys proved to be useful (Antwi & Hamza, 2015). According to Adolphus, Lawton, & Dye (2013) case studies and surveys are complementary and convenient in sifting the case study findings.

Case study design

According to Gustafsson (2017), case studies have a double function, where the case studies become studies of its own unit, as well as case studies of a larger group of units. Researcher are studying multiple cases whenever they are available so as to understand the similarities and the differences between the each other cases (Baxter & Jack, 2008). Single case study design is suitable when the study represents a unique case or critical case or an extreme case or a representative/ typical case or a longitudinal case or a revelatory case (Yin, 2003).

Although there are several cases in Sri Lanka where smart initiatives were tested, a city which is introduced widely as a Smart City is found in only one place; and that is the Proposed SMCPC. In such incidents where the case studies are chosen on the grounds that it would offer an exception to an engrained theory, are known as critical instance case (Sammut-Bonnici & McGee, 2015). At the same time, it can be argued that this case falls under the unique case category as per Yin's (2003) study. Further, it can also be argued that this case to be a representative for probable/ emerging

Smart City projects in the future in Sri Lanka. Therefore, the choice was to do an in-depth study with the single case.

According to Yin (2003), by defining a boundary it allows the researcher to identify the scope of the study. Therefore, the boundary simply is the SMCPC in this study. With the selection of the proposed SMCPC as the case study the researcher has to make several critical decisions. The proposed SMCPC is in the feasibility stage with potential utility providers have their own proposals developed and they are yet to be evaluated by the project consultants.

The next step is, defining the unit of analysis. According to Lune and Berg (2016), before beginning the research, researcher should determine the unit of analysis in the study precisely as the focal point in a case or in other words what exactly the case focus on, whether it is an organisation, a group, an individual, "a city", or so forth. In line with their definition, although the main focus in this study is appeared to be a city; specifically, it is the Performance Measurement aspect in the SMCPC. The indistinguishability of the case and unit of analysis is addressed in Grünbaum's (2007) study.

3.2.5 Time horizons

The time frame for the given research being limited, the study is taken at a snap shot is a cross sectional study at a particular time, with compared to a longitudinal study that allows the researcher to study a variable over time (Saunders et al., 2019).

3.2.6 Techniques and procedures

In order to develop a Performance Measurement System to a particular context, citizen's day to day setting, city administration, etc. are required to be known. Especially in determining the performance indicators. However, direct observation and participant observations are unable as the project is yet in the inception stage. In the same way, due to the confidentiality, most of the project data are not available for public and therefore the researcher cannot go beyond the system, but properly work on building the system with the support of experts and make this study a basis for future studies on Performance Measurement of Sri Lankan Smart Cities. Although

document analysis also seemed to be an ideal technique to collect data, the authorities restricted the document use by public, and therefore the researcher did not have the accessibility for the documents. As a result, the best method is expert interviews so that the experts who deal with the confidential data for which the researcher couldn't access, can provide their insights. In other words, an in-depth information gathering with regards to SC, PM aspects can be done. According to Du Toit and Mouton (2013), expert interviews enable the researchers to verify the literature review findings from expert views.

The sample was selected adhering to purposive sampling approach. Purposive sampling ensures the purpose of the study is achieved (Singh and Masuku, 2014), by shortlisting a sample of respondents with the knowledge in the research area (Alvi, 2016). In this study, for instance, it is the selected interviewee who know everything in detail of the proposed SMCPC. Purposive sampling technique is recommended to obtain the views from the sample units regarding an existing provision, for example an existing part of literature (Singh and Masuku, 2014). The data collection of the study consisted of 3 stages.

Stage 1: Preliminary Interview Round

Initially, a face-to face preliminary interview round was carried out with four of the experts from Port City project team. The expectation of this was to depict an answer for the question "will a Performance Measurement System be a helpful tool for the proposed SMCPC?". Therefore, one objective of the preliminary round was to evaluate the importance of the research purpose. On the other hand, for a research student who isn't directly involved in the proposed SMCPC, the indecisive objectives can be an obstruct in developing a Performance Measurement System. However, the professionals who are engaged to this project have an idea about the objectives which are kept in confidentiality without revealing to general public. With preliminary interviews it was intended to find out to which extent that information can be revealed for the research purpose together with the reasons to proceed with the project and the barriers for the implementation. Similarly, the project details available for public wasn't same in all resources, therefore, the preliminary interview

round was used to confirm the accuracy of those details. Interview guideline as APPENDIX A, findings analysis was condensed into two sections and questions were straightforward.

Stage 2: Case Study Interviews

The case study interviews were carried out for two major purposes. One was to assess the suitability of the developed Performance Measures from the literature to Sri Lanka and the other purpose was to identify the solutions to overcome the barriers (identified through preliminary interviews) in implementing the Performance Measurement System to Sri Lanka. The suitable Performance Measures were the basis for producing a Performance Measurement System as the final outcome of this study. They were conducted face to face for 90 minutes. Interview guideline as APPENDIX B and the questions were straightforward. Case study interviews were conducted with 15 professionals who work attached to the Smart City project. Those professionals represented the Port City Project Company (Contractors' Party), Consultant party (Ministry of Megapolis) and Smart City utility providers/ potential smart experts for the SMCPC (Sri Lanka Telecom); in other words, all the related parties for the SMCPC. At the end of that interview round, a list of Performance Measures that is applicable to the SMCPC was generated as the first step in developing a Performance Measurement System.

Details of interviewees

The experts were selected initially with purposive sampling and thereafter using "snowballing technique". The interviewees for the preliminary interview (P1, P2, P3, P4 as mentioned in the below table) were professionals from the consultancy team of Colombo Port City (CPC) project on behalf of the client's party including the project director, deputy director and the responsible planners. They have been found as the most reliable source to get the information about the project in its current development stage. These same set of professionals were interviewed in the case study expert interview rounds as well. Apart from them, another 11 interviewees were selected to be interviewed for the case study and all of them are professionals

who are engaged in the proposed SMCPC. Following Table 3.1 includes the profiles of those respondents;

Table 3.1: Profiles of the respondents for expert interviews

Interviewee code (ID)	Profession	Designation	Years of experience	Related Key Role
I1	Engineer	General Manager-Digital Projects/ Enterprise Sales	17	Potential Smart City Expert for CPC/ Utility providers
I2	Engineer	Deputy General Manager-Product Development & Management	13	Potential Smart City Expert for CPC / Utility providers
I3	Engineer	Deputy General Manager/Enterprise Digital Services	13	Potential Smart City Expert for CPC / Utility providers
I4	Marketing Manager	Marketing Manager Digital Products	13	Potential Smart City Expert for CPC / Utility providers
I5	Engineer	Deputy General Manager-Corporate Strategy	14	Potential Smart City Expert for CPC / Utility providers
I6	Urban Planner	Senior Urban Planner	14	Senior Urban Planner for CPC (Contractor party)
I7	Engineer	MEP Manager	27	MEP Manager for CPC (Contractor party)
I8	Engineer	Deputy Manager – Sales and Marketing	16	Deputy Manager – Sales and Marketing for CPC (Contractor party)
I9	Urban Planner	Architect	5	Landscape architect for CPC (Contractor party)
I10	Quantity Surveyor	Company associate	14	Cost consultant for CPC
I11/P1	Chartered Architect	Port City Project Director	26	Port City Project Director (Consultant party)
I12/P2	Chartered Architect	Deputy Project Director	21	Deputy Project Director CPC (Consultant party)
I13/P3	Planner	Town Planner / Project Management Unit	8	Town Planner for Consultants' Project Management Unit- CPC Development Project
I14/P4	Planner	Town Planner / Project Management Unit	9	Town Planner for Consultants' Project Management Unit- CPC Development Project
I15	Software Engineer	CEO	10	Smart City Project Consultant - CPC Development Project

As the table summarized, the main bodies involved in the SMCPC are the consultant, contractor company of PC and the potential companies that compete to be the smart expert of SMCPC. Likewise, all 5 professionals who are assigned to this project from

the company which was most likely to selected as the smart expert were interviewed. Next different professionals such as planners, architects, engineers, sales and marketing officials representing the contractor company were interviewed. One of the professionals from the outsourced cost consultant company and an external advisor for the project were also interviewed. That covered all of the professionals who are available in Sri Lanka who knew about the proposed project.

Case study interview guideline design

The interview guideline comprised of both closed and open-ended questions. The suitability of the Performance Measurement System was investigated with closed ended questions whilst the justifications for the unsuitability and the solutions for barriers in implementing, the question were kept open ended. Mostly the findings from literature whenever acted as a guidance to the respondents were included. The gathered data were analysed manually with content analysis and followed by a discussion based on pattern matching.

Stage 3: Questionnaire Survey Round

Following the aforementioned data collection that was used to develop the list of appropriate Performance Measures for SMCPC, the next stage was to develop a list of Performance Measures for the emerging Smart Cities in Sri Lanka, in general. Accordingly, a questionnaire survey was carried out. The case study findings are specific to the SMCPC which should be looked in two perspectives. One is that SMCPC being built in Sri Lanka, the city will obviously encompass the Sri Lankan identity and therefore the contextual behavior matters in developing the Performance Measurement System. The other perspective is that SMCPC benchmarks the top world class Smart Cities in developed countries like Dubai, Singapore, etc. On the other hand, by the time the project is completed future Sri Lanka could also be a different place and that should also be considered. Therefore, the research intends to conclude that, although the list of Performance Measures with experts' opinions would end up being a list of Performance Measures that is suitable to 'Sri Lankan cities which can be facilitated similar to SMCPC', yet it is mostly suitable to

SMCPC. In other words, the developed list of Performance Measures at the end of case studies would be one step higher containing futuristic vision for Smart Cities in Sri Lanka. Therefore, that list of Performance Measures can be taken as a basis to develop a Performance Measurement System that is suitable to any kind of Smart City in Sri Lanka, which was done with the questionnaire survey. Survey questionnaire (attached as APPENDIX C) was distributed via online and also the hardcopy, regardless the method, the researcher had to clarify the scoring method as well as how different indicators are interpreted. The allocated time was 90 minutes to fill the questionnaire.

In a comparison study carried out by Fellows & Liu (2015), in terms of breadth vs depth of a question-based studies, out of the different methods, questionnaires are the ideal when the choice is for a broad and shallow study. In this stage of the study the potential smartness indicators for a Smart City in Sri Lanka are known and the respondents will only have to assess their relative importance/ significance. The selected sample (purposive) are the town planners in private and public sectors, policy makers and academics who are having a vision for Smart Cities. They are geographically dispersed. In such situations questionnaires are a more flexible, easier, quicker and convenient tool which allows a fair chance of getting a true reply from the respondents (Walliman, 2017).

Details of the respondents

The details of questionnaire survey respondents are analysed under to three main topics; they are, rate of response, type of work involved and the years of experience of the respondents.

Rate of response

45 questionnaires were distributed among the professionals who are engaged in city planning and having a vision for Smart Cities in Sri Lanka, out of which 31 professionals responded to the questionnaire. Therefore, the response rate for the questionnaire is nearly a three quarter (69%). Even though there is no any agreement reflected in literature with regards to the acceptable minimum response rate in survey

studies, for biomedical studies some argue it to be 60% (Livingston, 2012) while the others state an adequate rate is 50% (Draugalis, Coons, & Plaza, 2008). Given the low response rate lies in 20% (Kumar, 2019; Fellows and Liu, 2015), the rate of response in this study is above the adequate rate. In fact, the acceptable number of questionnaires to be filled given the data saturation is taken place, is being argued as thirty (Bacon-Shone, 2015). Figure 3.2 illustrates the rate of response and absence in response for the questionnaire survey.

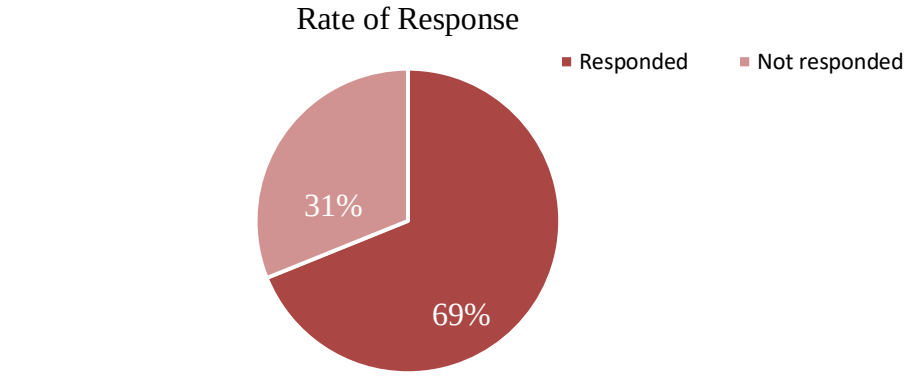

Figure 3.2: Rate of response for the Questionnaire Survey

Type of work involved

From the 31 respondents, 7 (23%) were academicians who are having a vision for Smart Cities and coming from a relatable background, 12 (39%) were town and country/ city planners who are having a vision for Smart Cities and working in the public sector and the rest (39%) were the town and country/ city planners who are having a vision for Smart Cities and working in the private sector. The percentages are shown in Figure 3.3;

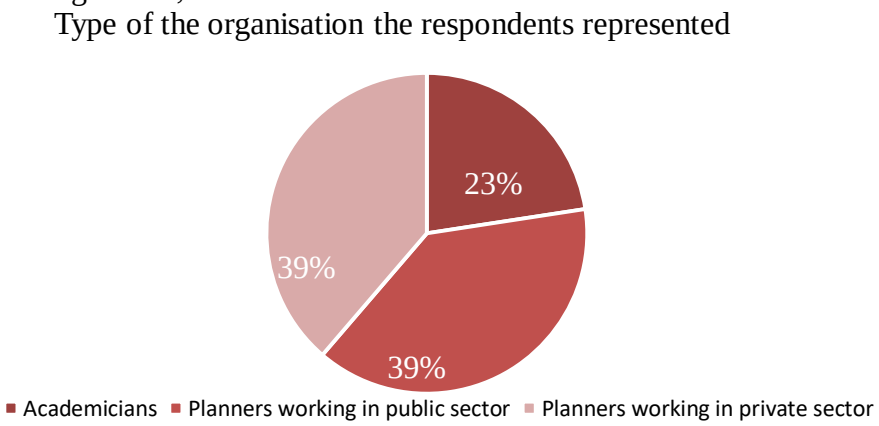

Figure 3.3: Type of the organisations the respondents of the Questionnaire Survey represented

Years of experience of the respondents

Although the Smart City concept is quite novel to the Sri Lanka, one can argue that the experience matters in order to have a vision for Smart Cities. However, the planners having more than 25+ years was difficult to find and the responded planners regardless of their experience provided quality answers with justifications. Therefore, the sample consists of a mix of short and long years of work experience. Table 3.2 represents the working experience of the respondents;

Table 3.2: Years of experience of the respondents involved in the Questionnaire Survey

Role of respondents	**Working experience (in years)**				
	5-10	**11-15**	**11-20**	**21-25**	**25+**
Academicians	-	-	57%	14%	29%
Planners from public sector	33%	50%	8%	8%	-
Planners from private sector	67%	33%	-	-	-

While Sri Lanka is still in the process of developing Smart Cities, most of the local professionals involved in the SMCPC and other smart initiatives in cities work in the public sector as planners as the Sri Lankan government is the major client. Some of the planners who responded and are working in the private sector have worked in overseas Smart City projects as well. Mostly the academicians who responded take part in different research groups related to Smart Cities/ city planning and some of them are engaged as advisors in the emerging Smart City projects in Sri Lanka. It was seen that the professionals directly engaged in emerging Smart Cities in Sri Lanka as planners are mostly less experienced in work yet having a vision for Smart Cities are dynamic professionals.

Questionnaire survey template design

The questionnaire only included closed ended questions; i.e. the themes, subthemes and indicators in the system. They were distributed both as hardcopies and softcopies depending on the convenience of the respondents. The respondents were supposed to evaluate the significant using the principles in "Battelle method". In the Battelle method, which is common as a tool in Environmental Impact Assessment, a Parameter Importance Unit (PIU) is defined which is given as a whole number that needs to be shared among the indicators by user of the framework (Wagh, 2014). The shared value of PIU reflects the relative importance of each parameter. In this study the relative importance of each theme, subtheme and indicator can be assessed with the average relative weights each of them obtained.

3.3 Data analysis

The first part of the study, only being depended on a single case study attempted an in-depth analysis of the interview findings. The gathered data was analysed manually with content analysis and followed by a discussion based on pattern matching. According to Easterby-Smith, Thorpe, & Jackson (2012) content analysis is an analysis technique where the researchers interrogate research data to constructs ideas which have been decided quite in advance. Likewise, the data obtained from the questionnaire was analysed with mean score method.

According to Yin (2003), in seeking for evidences that address the initial proposition of the research, the analysis helps to reconstruct the data in a meaningful way. In order to analyse the data to a meaningful form, Ryan and Bernard (2003), came up with two main methods, that is through word base and code base analysis. In code base data analysis method, collected data is linked to prior established codes or researcher derived codes whereas in the word base data analysis method relationships are encouraged to emerge from the interviewees' responses, instead of researcher forcefully creating the relationships (Kumar, 2019). However, both the approaches alone have their limitations (Zamawe, 2015), and therefore for this study they are used together. Accordingly, the initial analysis is done with content analysis and thereafter cognitive mapping is used for an in-depth analysis. For better familiarization with data, researcher has analyzed data manually.

With analysis carried out at the end of the case study a system which is suitable to the SMCPC in Sri Lanka was produced. This has been next taken to the industry to assess the suitability to be applied in the general Sri Lankan context. There the relative weightage for each indicator in the system were ranked using the average score each indicator obtains through the Battelle scoring approach. Therewith a scoring system is developed to be used as a guide in determining objectives for Smart Cities in general Sri Lankan context.

Validation

As the topic is a seldom researched, data generalization was done with pattern matching. Adhering to Yin (2014)'s study, the findings which are limited to the views of a small group of people can be generalized to a wider community of researchers through matching the theoretical validity. Pattern matching ensures the validation of data with a theory-based testing (Yin, 2014).

3.4 Research Process

The research design is applied so that suitable research methods are used to ensure the attainment of the objectives set out in Chapter One as shown in Figure 3.4;

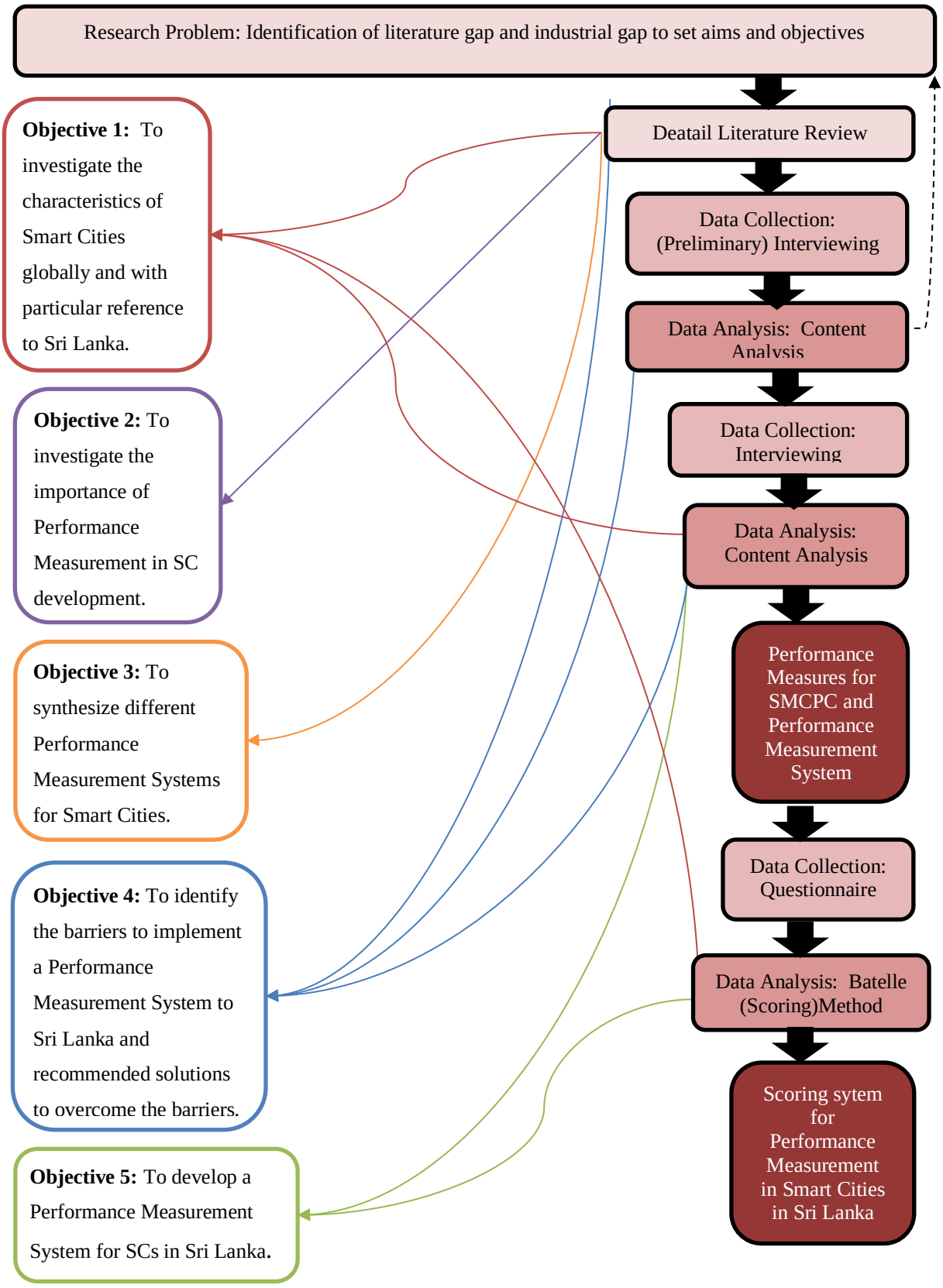

Figure 3.4: Research Process of the study

Figure 3.4 depicts how different research strategies were used throughout the research to accomplish different research problems in form of research objectives. At the end of each analysis stage except for the preliminary interview stage, a system was developed, as shown.

3.5 Summary

This chapter designs how the research methodology of this study should be carried out to achieve the objectives. Both qualitative and quantitative research choices were selected depending on the type of the research question. Selected research strategies were surveys and case studies. Data were collected by interviewing and through a questionnaire. While the qualitative data were analyzed with content analysis and cognitive mapping quantitative data were collected and assessed administering Battelle method. Case study findings were validated with pattern matching. Finally, the research process is shown to summarize the plan of work.

CHAPTER 04

DATA ANALYSIS

4.1 Introduction

Chapter dissects research findings generated from the data collected by interviewing professionals involved in the proposed Smart City Project in Colombo Port City (SMCPC). Most of the findings originated in the literature review chapter conceived the basis for interview guidelines. The analysis is structured in a way comprehensive system are developed at each stage of data collection. Thereupon objectives are discussed with pattern matching approach, for bye the Performance Measurement System.

Stage 1: Findings of preliminary interviews

4.2 Case Study Description

According to the Port City Project Director (P1) "the dream of the creators of Port City is to make it a sustainable addition to the City of Colombo, generating business, tourism and a place with high quality life, which goes in well with the definitions/ definitional elements/ characteristics of a Smart City". This as a new city is supposed to be well connected to and integrated with the existing city of Colombo. In terms of the location, Port City is located along the 21st century maritime silk road, is a key link between the east and West, offers access to a thriving region poised for accelerated growth. Spanning for 269 hectares, CPC when developed will have a total of gross floor area for more than 5.65 million square meters. P2 added that "most importantly Port City will be the pioneer in developing Smart Cities in Sri Lanka, where IT expertise using cloud computing and the latest cutting-edge technology creates a seamless living environment, making smart living, smart working and smart estate management a reality". According to P4 "it has adopted the latest sustainable city concepts which emphasis a people friendly environment". It uses the Transit Oriented Development concept to minimize commuting and enhances project's sustainability goals. The ultimate goal is to make Port City the

most liveable city and the most desired travel destination; ideally a world class city in the South Asian Region. However, as per P1, the Smart City feature/ characteristics are not exactly established as yet. Yet the Port City is definitely being developed to facilitate all available Smart City feature. Therefore, the respondents in unison bear the opinion that most of the state of art features and the future developments thereafter will get going within the environment the Port City has created. Figure 4.1 shows a birdeye view of the Colombo Port City Project

Figure 4.1: Birdeye view of the Colombo Port City Project

One of the main features of the new city will be the high quality of public spaces and residential environment. Port City is preplanned to be sectored into main 5 divisions, namely, marina, central park living, port city CBD, international island and living island, having a comparatively small distance from North to South at 2km and East to West at 2km. In other words, an entity of 500 acres land. Each of these areas will have plots for living with different characteristics. For instance, in marina all the houses get the view of sea, and the housing facilities will go along with the marina. Likewise, northern end ends with a canal. P3 added “the housing quality of space differs in villa compound, park living, marina, etc.” A new LRT (Light Rail Transit) line will be built by 2023 with which transportation network are to be broaden. Further, the roads are to be connected to the existing express ways. The city management will not be done by the Colombo Municipal Council to which the city is related, but by a high-class city management company and a separate law will be established. The financial city is planned to be developed by the investor company itself. The international school, international convention centre and international

hospital draws a major attention and have call for bidding. The state of art convention and exhibition centre is capable of hosting large scale international events.

The government of Sri Lanka is actively working on turning this city in to an international financial city. With new commercial legislation modeled after British laws, coupled with preferential tax, custom, immigration, regulations and many other attractive policies, Port City is designed to attract global talent and top multinational corporations. However, every plot in Port City is built by someone, it's not a land freely available. Therefore, a certain cost is involved for each centimeter of the land in the project. As far as human development strategies and policies are concerned, human attitudes need to be developed to achieve an innovation driven knowledge-based economy.

When the respondents were asked about the extent to which they can contribute and reveal information, they have said that except for the statistics and extremely confidential data they can disclose the rest. In fact, at a glance on the drafted Performance Measurement System they believed that the research can richly proceed without such information.

4.3 Importance of implementing a Performance Measurement System to Sri Lankan Smart Cities

In asking about the enablers and barriers of the application of a Performance Measurement System to Sri Lanka, the experts replied with justifications which are shown as a cognitive map in the following analysis. The barriers will be analysed and listed out for the reference in the next round where solutions were asked. Therefore, that will be analysed together under the case study results. The following Figure 4.2 illustrated the enablers as a cognitive map;

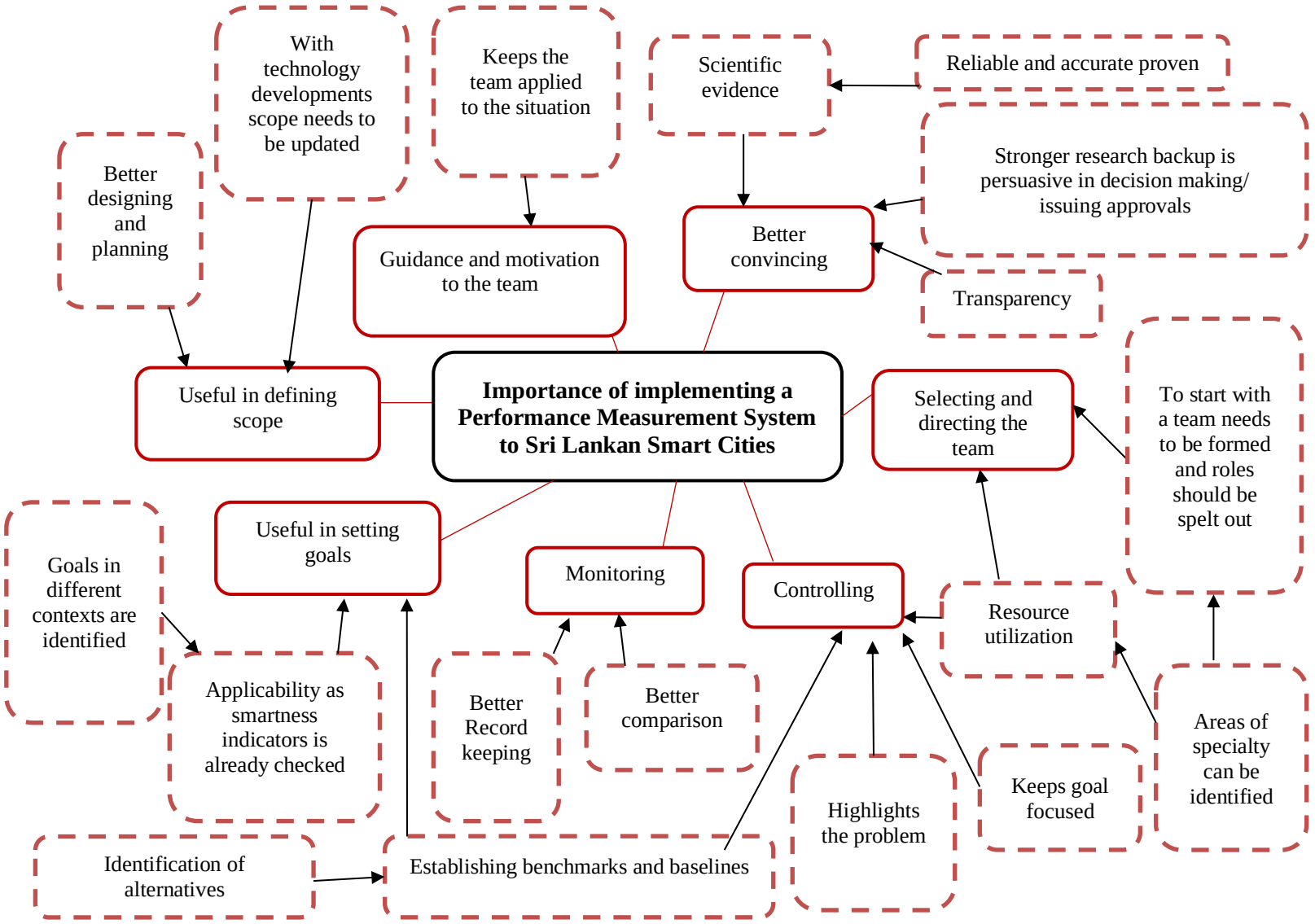

Figure 4.2: Cognitive map on the importance of implementing a Performance Measurement System to Sri Lankan Smart Cities

According to P3 “a project is known to be more reliable and accurate when it is backed by scientific evidence. There is a higher chance of obtaining the approvals easier for that project with compared to the situation without a supporting research”. P1 added, “stronger research backed up project is a favorable reception” thereby it is easy to convince the authorities as well as general public regarding critical decisions that needs to be made affecting different parties in the society. One example P2 given was “ if this research can show that using nature based green infrastructure indicates the smartness of Port City Smart City project and mandating that from a regulatory framework is doubtful for the policy makers due to the higher cost involved, the research can supersede and they at least will tend to evaluate them with the alternatives”. Similarly, as the project is still in the planning stage, Performance Measurement System can be used in setting goals. Through the research, potential goals that were used around the world are evaluated against the Port City context and the most suitable goals in form of the smartness indicators are summarized in the detailed framework. P4 adding his views said “If the policy makers are happy to proceed, measurability of the goals is only what they need to look into thereafter”. Similarly, when the goals are established benchmarks/ baselines too can be established. Subsequently the comparison of the actuals and goals can be done so as to address the gaps and required improvements. According to P1 “this Performance Measurement System would be a good starting point, as the completion of this project is not in near future. The smart initiatives we should look at now most probably will not be suitable in another few years’ time. So, this smartness criteria might change with the time or in other words with the development of technology. Yet, with visionaries this study tries to establish certain long-term goals which goes in line with the planned city. Therefore, obviously this system as a futuristic study would be a guideline define the scope with available plans”. For the same reason, a team of smart experts and required resources needs to be in place prior planning. P1 said “While the areas of specialty are in a great variety, such areas can be identified with this study, not only to human resources, this applies to the other resources as well”.

In this case, smart features are planned to incorporate in to newly built city. The newly built city (Port City) thereby will be built having a basic idea about the smart initiatives that needs to be facilitated with the urban infrastructure. However, the making a city smart starts right with from the city planning stage. One example is green certification, for that the services installation and use of green material has to be decided in the planning stage. To decide on such procedures and construction methods in the basic city, smart features should also be agreed.

Stage 2: Case study findings

4.4 Suitability of the listed Performance Measures (from literature) to SMCPC

The comprehensive list of Performance Measures that was produced following the literature review was given to the interviewees to assess its suitability in the SMCPC context. Accordingly, expert opinion was obtained for the below key components related to Smart City Performance Measurement.

- Smart economy
- Smart People
- Smart Living
- Smart Governance
- Smart Environment
- Smart Mobility
- Propagation

There were few generic observations that were noticed from the expert opinions. One of the major observations were the approval of all the themes. Although the subthemes and indicators were added, removed and modified, no changes were done to the seven themes. Out of the main changes, obvious changes such as currency change and the population unit changes were done even before taking the list of Performance Measures to the experts. The approach including the changes taken can be illustrated as the below Figure 4.3;

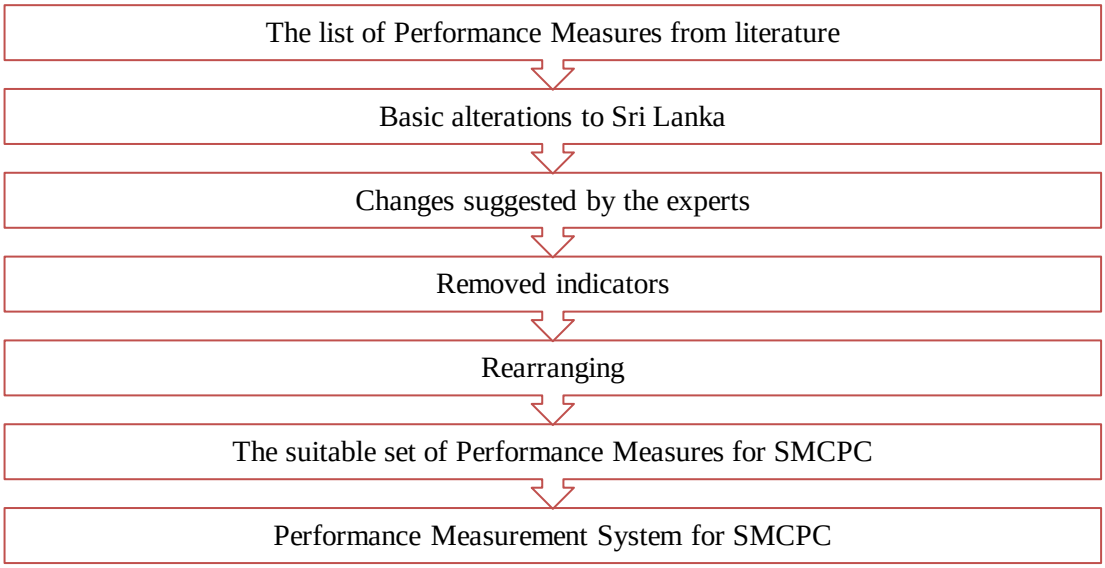

Figure 4.3: Development process of the Performance Measurement System for SMCPC

All the other modifications are shown under each of theme and categorized as changes suggested by the experts, added indicators, removed indicators and rearranging. Rearranging involved the changes suggested by experts to the order and placement of certain indicators/ subthemes. The following analysis contains cognitive maps under each theme which shows the modifications with a colour coding under the aforementioned categorisations. The themes smart economy, smart people, smart living, smart governance, smart environment and smart mobility are analysed likewise. However, as none of the experts did any modification on propagation theme, it is not included in the analysis.

4.4.1 Smart Economy

Figure 4.4 illustrated the modifications suggested by the experts to make the listed Performance Measures a suitable and applicable one for the SMCPC under the smart economy theme. An initial discussion with literature was done under 2.62 The Most Significant Themes/ Dimensions in a Performance Measurement Performance Measurement System Framework for a smart city Smart City: Smart Economy.

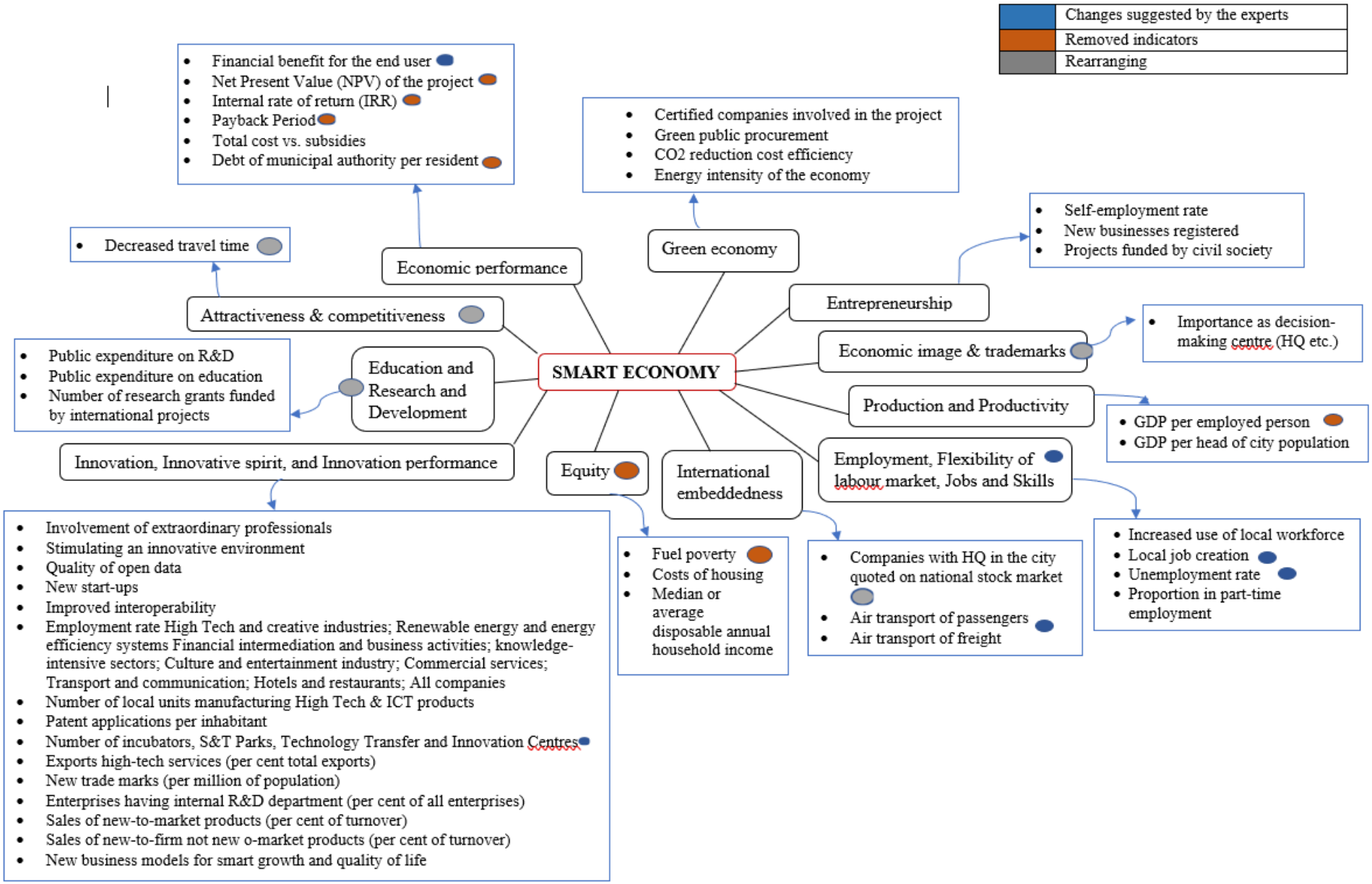

Figure 4.4: Modifications for the listed Performance Measures under Smart Economy theme

In terms of economic developments, in the process of calling Port City an international financial city, the regional rivalry, except from Singapore, is surprisingly not found. “That shows the potential of Port City to contribute to the country’s economic growth. “Sri Lanka has already become the “choice of destination” due to the increasing growth rate in Business Process Outsourcing (BPO) and Information Technology Outsourcing (ITO) sectors” I10 mentioned. According to A.T. Kearney’s Global Services Location Index (GSLI) 2019, Sri Lanka is ranked as the 25th location that can best provide business process outsourcing (BPO), information technology (IT), and voice services based on countries' financial attractiveness, business environment, skills and availability of its people, etc. This is a consecutive winning after having been ranked in many other indexes since the Outsourcing Destination of the Year 2013 title, awarded by the National Outsourcing Association (NOA), UK.

As the Smart City framework in Sri Lanka is developed by a Chinese Company, one of the Consultants working for Chinese Smart Cities (I15) has talked about how the Chinese influence can impact SC in PC; “In the Chinese framework of Smart Cities, the Government initiates and takes care of the basics, strategists from citizens’ end can contribute and develop whatever beyond the basics”. In other words, if the basic data in a city is captured and connected in real time, citizen can get the benefit of that data and explore the potentials of development in the basic Smart City network which the Government facilitate. This can contribute to the individual company growth as well as the economic growth of the country. However, this depends on the delivering of open Smart City APIs (open Application Programming Interface). Based on that most of the services can be enhanced. One example brought out by I9 is greenhouse gas emission data contributing to improve different aspects of transportation such on cycling and the related ecosystem.

Many experts have argued regarding the projects funded by the civil society. Despite, there are examples like Melbourne Smart City where an open API which contains a wide range of rich data that can instigate creative projects to emerge from public; at this moment that cannot be predicted in the CPC case. In fact, investor’s threshold is really low due to the lower population. Alternatively, the Estate Management

Company (EMC) which manages the CPC collects taxes from general public. Amidst all the objections, I8 gave a rather impartial comment on that indicator “In a situation where this company develop an app to provide city wide smart solutions, that can be termed as a project funded by the civil society”, justifying the relevance of the indicator.

While the financial benefit for the end user was commonly accepted, I8 and I13 suggested to rephrase it as ‘financial benefit for the stakeholders’ as the benefits are not only limited to the end users. One example brought in by I1 regarding this is the indirect financial benefits gained by different stakeholders due to smart waste management solutions; “smart waste management involves a systematic procedure starting from collecting waste from bins which are installed with sensors that gives alerts when they are filled. This alert should be communicated to the municipal authority which collects the waste and send the waste to categorization. The garbage truck will go in a specified routine about which the residences are aware and they get notifications when the truck is coming. While the end users find the convenience more than financial benefits, it is the government (EMC) that gets rewarded with financial benefits.”

When it comes to a SMCPC there are two aspects; one is infrastructure management and the next one is operations and smart solutions for the operations. In other words, digitalization of the operations. With that we have two layers on which these services are offered to the public. When public is known as the “Consumer”, the two layers are “Business” to “Consumer” and “Business” to “Business” to “Consumer”. For now, it is an operation specific Smart City with the Business to Consumer provisions, Command and Control Centre will manage them. The rest of the services, which is termed as “Business” to “Business” to “Consumer” is encouraged to be developed by the plot owners. As a result, the respondents raised concerns with regards to the indicators like number of incubators, Science and Technology (S&T) parks, technology transfer and innovation centres as they are not there in the initial plan but can be most likely developed by the plot owners. However, considering the futuristic use, researcher has decided to keep the potential developments that are possible to be

undertaken by plot owner, allowing the experts to remove them depending on the applicability, in the coming round.

While the CPC is said to be a transit-oriented development, international movement would definitely be there. Air transport of passengers and air transport of freight therefore are obvious indicators. However, the experts' suggestion was to combine them too as them separately doesn't give a significant result to assess.

"At a glance the jobs that might create in CPC are white collar jobs and the labour factor comes to the discussion only during the infrastructure/ building construction" said I3. In fact, in Sri Lanka the local skilled labour force is in a scarcity. Having similar views I1 mentioned "the current trend of the employers/ constructors is to export labour from India or China at a lower cost. Therefore, unless this trend discontinues having an indicator on labour might deviate the true interpretation of the smartness". Therefore, the experts suggested to remove the "labor force" from the subtheme 'Employment, Flexibility of labour market, Jobs and Skills' as it has a least relevance. By the same means, experts recommended to remove the indicator unemployment rate as it is not relevant in CPC case and add employment rate. "The online job creation in CPC is also highly possible, apart from the employers that come to the city to work in established companies; having a significant unemployment rate is long shot" said I7. However, increased use of local workforce and local job creation indicators represent a similar situation where the local workforce is employed by the jobs created by SMCPC, where local job creation is quite an obvious output. Therefore, the indicator local job creation is removed.

The objective of the proposed Smart City in PC is to build the most liveable city and the most desired travel destination; ideally a world class city in the South Asian Region. As a result, most of the interviewees commented the irrelevance of a positive NPV, IRR or a lower payback period as indicators of smartness in CPC. I14 added "The services that you need to improve the ease of doing business index even will not show any direct return. Calculating the NPV will also be a challenging. However, the utility and service (outsourced) providers will calculate for their benefit, for the project having direct and indirect returns measuring these aspects are tough. Usually

for the government/ EMC this might not be a revenue generating project, when they are doing it to increase the quality of life of people." However, as the financial performance calculated by the utility and service (outsourced) providers or any other interested party again shows the financial benefits different stakeholders achieve, those three indicators were removed.

In simple terms the indicators like 'debt of municipal authority per resident' and 'fuel poverty' are not relevant to CPC. I14 adding her views said "For the services provision, service charges are obtained from the public. In the usual case, in Sri Lanka for a person government subsidize most of the services and even for a tourist (backpacker) the burden for service provision lies with the government. However, in CPC government will not subsidize likewise and as a result service charges will be relatively high". Yet that cannot be considered as a debt. Similarly, SMCPC is designed for luxury living with compared to most of the other parts in Sri Lanka. When considering the target residential/commercial group only those who can afford for that living will come. I4 mentioned a similar view "There will be no equity issue inside the city but if compared with the Colombo city there can be differences". Therefore, equity will not be a part of SMCPC objectives and measuring it will deviate the purpose of the Performance Measurement System. Although this subtheme was removed the applicable indicators, costs of housing and median or average disposable annual household income will be included under a different theme (smart living). Similarly, attractiveness and competitiveness subtheme were mentioned under smart living as suggested by the experts.

Some experts have commented on the indicator "importance as decision-making centre (HQ etc.)" which was included under both the subthemes economic image and trademarks and international embeddedness with slightly different phrasing. However, the experts I7 and I13 said "it should have been included under productivity subtheme as having the headquarters located in the city itself contributes to productivity through fast decision making and actions". Therefore, they were included under productivity subtheme and removed from previous subthemes. Consequently, economic image and trademarks subtheme was also removed; as per

I5 “economic image and trademarks is anyway covered by smart economy theme itself”.

According to the experts it is very unlikely that any tangible manufacturing/ production in large scale would happen in the Smart City. Therefore, GDP will encompass the intangible productions, outsourced professional services, etc. Nevertheless, measuring GDP as a smartness indicator has confused the experts, as per I4 “this cannot be taken as a smartness indicator, as in Middle East there are certain countries where the GDP is high even without a Smart City”. However, I10 provided a solution, “may be what should be considered is the GDP of certain smart service sectors.” Having that as an option, the indicators were rewritten. However, as GDP per employed person and GDP per head of city population both gave similar indications only one (GDP per head of city population) is kept.

4.4.2 Smart People

Figure 4.5 illustrated the modifications suggested by the experts to make the listed Performance Measures a suitable and applicable one for the SMCPC under the smart people theme. An initial discussion with literature was done under 2.62 The Most Significant Themes/ Dimensions in a Performance Measurement Performance Measurement System for a Smart City.

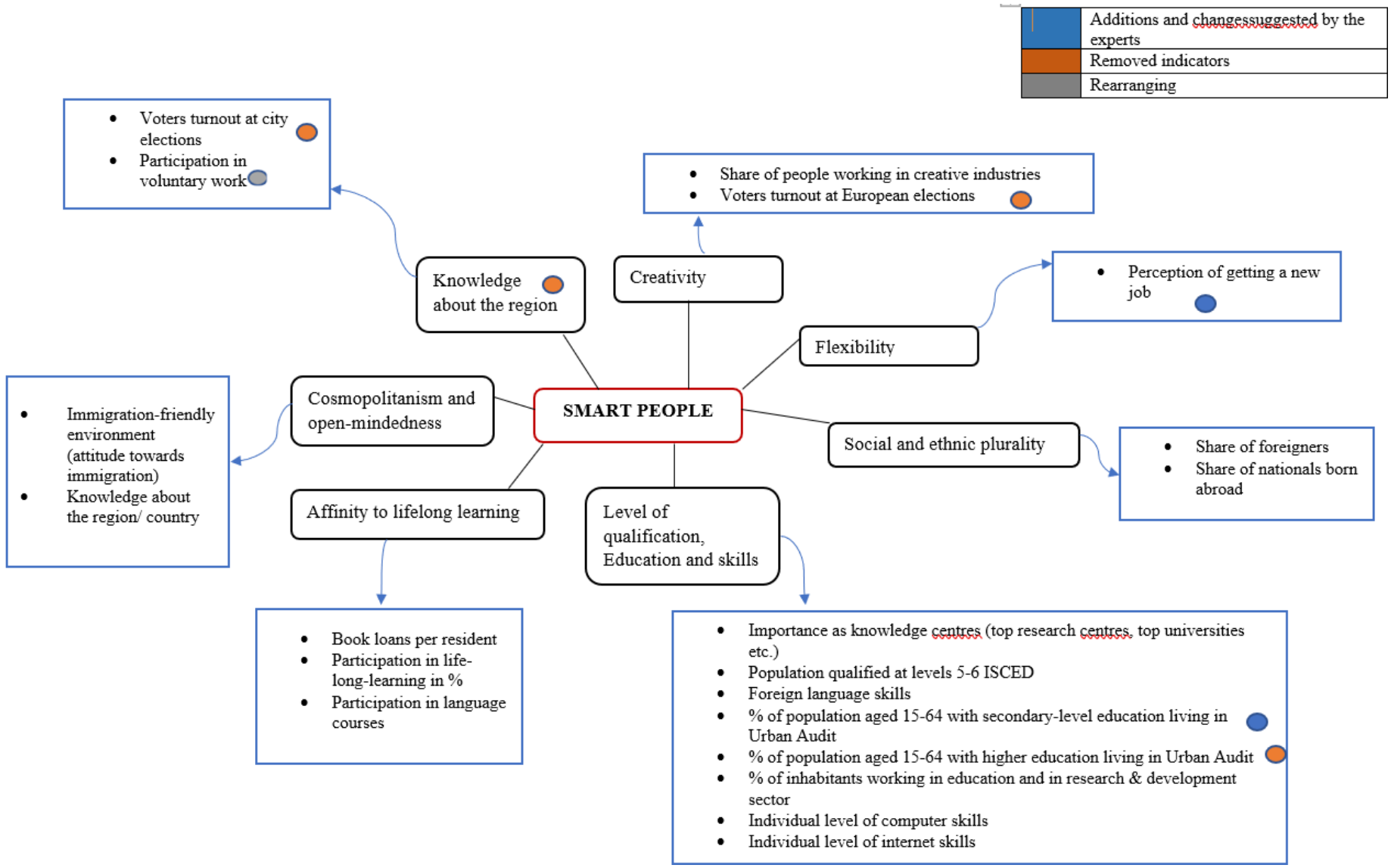

Figure 4.5: Modifications for the listed Performance Measures under Smart People theme

Despite the population, Chinese Smart Cities are known to be smarter and efficient than most of the other counterparts in the world. One of the Chinese respondents, I8, who is work in CPC says “in China we strive to cut down lines and save our time as the saved time and satisfaction are two great things you benefit from a Smart City. One strategy we use commonly is Cash-less transactions. To increase efficiency in systems mostly the systems are digitalized and integrated. Mostly in subways payments are done with face to cut down lines/ queues. Most of these can be done in Sri Lanka as well but what matters is the per square meter cost for digital infrastructure”. Assuming the evaluation turns out to be profitable this suggestion is included as an indicator. However, as cashless transactions are not very common in the Sri Lankan public service the citizens will have to be flexible enough to bear the initial inconvenience and be corporative. Therefore, the indicator is included under flexibility subtheme. In fact, flexibility of Sri Lankans as well as the foreigners who interact with Sri Lankan businesses is quite important to a SMCPC as it stands different to other cities in Sri Lanka. Voluntary work is a result of the flexibility as they will always be an option amidst the busy lives as city dwellers. Subsequently the two indicators under the knowledge about the region subtheme is removed and knowledge about the region under the subtheme cosmopolitanism and open-mindedness is kept.

The urban audit refers here to the European Commission sponsored project which is developed to provide comparable data on urban areas. For an instance, Urban Audit 2010- 2012, comprises 185 main variables and further derived figures for the UK. According to I11, “a similar database should be maintained for CPC as well, in fact, having a newly established city collecting most of the data is not difficult, therefore, there’s a greater chance of having an urban audit for SMCPC”. As a result, the indicators that refers to an urban audit are not removed.

ISCED is a mapping system that maps national education systems according to the International Standard Classification of Education (ISCED). Levels 5-6 in ISCED is equivalent to the bachelor's degree or equivalent level/ Short-cycle tertiary education (Higher National Diploma in Engineering – HNDE/ Higher National Diploma in Accountancy- HNDA/ National Diploma in Technology) which the experts accepted

in unison as a satisfactory level to measure educational qualifications. In terms of educational qualifications, the other two indicators found are the percentage of population aged 15-64 with secondary-level education living in Urban Audit and the percentage of population aged 15-64 with higher education living in Urban Audit. Without keeping the two indicators separately they were combined and formed an indicator as the percentage of population aged 15-64 with secondary-level and above education living in Urban Audit.

Voters turnout at elections is also gained attention of many respondents. As per I13, "this is not a good indicator as the level of participation not always show the level of satisfaction or level of performance of governing bodies". While the majority of analysts hold a view that the participation is an indication of the degree of interest the city dwellers have towards government this in certain cases can differ and end up as an indicator that imply that the dissatisfied population with its local government's actions and leadership. Moreover, as the voting procedure in CPC is still vague and would not be a prominent factor even if disregarded in this stage. Therefore, the indicators are removed from the Performance Measurement System.

4.4.3 Smart Living

Figure 4.6 illustrated the modifications suggested by the experts to make the listed Performance Measures a suitable and applicable one for the SMCPC under the smart living theme. An initial discussion with literature was done under 2.62 The Most Significant Themes/ Dimensions in a Performance Measurement Performance Measurement Systemfor a Smart City.

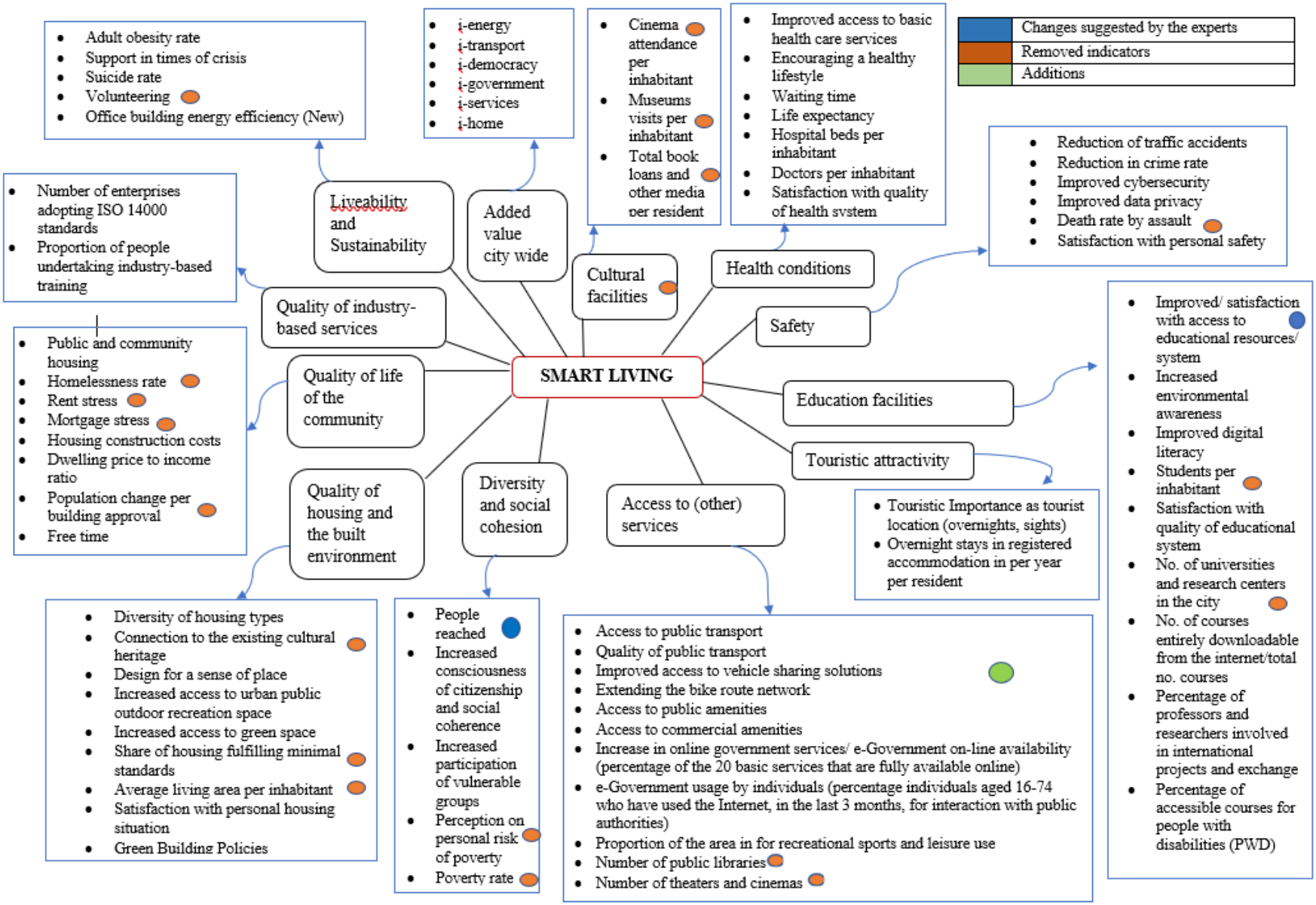

Figure 4.6: Modifications for the listed Performance Measures under Smart Living theme

The aspects in smart living are labelled as the most important criteria that pose the competitive advantage in CPC project. I4 explaining said “Most high demanding communities in the business world before investing/ migrating to the city search the other living factors like quality residential facilities, international level healthcare sector and schools, etc. for their families”. Therefore, they need to be fulfilled first in order to attract such outstanding communities. Smart living should therefore incorporate all such attributes. Therefore, smart living especially in this project needs a significant deal of attention. As a result, a number of facilities will be available. However, a museum is not there in the CPC plan so far. Therefore, the indicator museums visits per inhabitant is removed. One another indicator under the subtheme cultural facilities, total book loans and other media per resident is also removed as it is included under smart people theme. The leftover indicator cinema attendance per inhabitant was also criticized for being irrelevant for SMCPC as the nature of city will make cinema as a secondary option to its citizens more often than not. That being the situation, a comparison with another Smart City could mislead the reader with regards to city’s smartness. Therefore, that indicator was also removed.

Time saving is one of the key aspects that is looked at in making a city smart. The smart living theme in most respondents’ view is about making city life efficient and satisfying. In the process of doing that waiting time and queues is something that should be cut off from in citizens’ routines while obtaining services. Although the majority of experts suggested to include it under this subtheme reducing queues was mentioned under smart governance. Similarly decreased travel time is included as an indicator under the same subtheme.

In terms of additions, Autonomous driving is added under access to services subtheme. Explaining the new jargon I3 said “you’re going from owning an asset to sharing an asset. A trend has come to a certain level in Sri Lanka, but still there are drivers. In order to make this happen in Sri Lanka, a lot of other things needs attention. For instance, infrastructure need to be developed and so are roads and road designs”. In other words, with the introduction of futuristic provisions like use of robotics and service delivering without human conduction there should be an

integrated and strong infrastructure network. Therefore, such indicators represent a next level development as the main development needs support networks.

Safety is another key term that most of the experts have raised their concerns on. One reason for this attention was the recent "Easter attack" bomb blasting that has been taken place by holding the government and authorities in guilt and responsible. The latter investigations showed that the terrorists were nurtured due to the lack of attention paid on island wide security measures, which definitely should be prevented to take place in CPC. I7 once commented that "every context has to know what version of Smart City they need, for instance, for Sri Lanka, from my point of view, it should be more security driven or rather a safe connected city that actually help people live without fear". Adding to that I2 stated "More or less safety-oriented expectations are covered through the indicators. But there's no point mentioning the ways you can commit a crime one by one". Therefore, the indicator death rate by assault is removed.

The two indicators improved/ satisfaction with access to educational resources/ system and satisfaction with quality of educational system had similar meanings and therefore the first indicator was changed as improved access to educational resources. Under the same subtheme there were another two indicators on which the experts commented solemnly. They were students per inhabitant and number of universities and research centers in the city. While the main focus of the city is more towards commercial operations, education is considered to be an important support system especially to the city dwellers who have settled with their families and looking for an internationally standardized education for their children. Having provisions for that the initial PC plan includes an international school at its best level. This school will be an accredited and outstanding in the South Asian region where no rivalry is expected. As a result, the number of schools will be very low. Although the initial plan doesn't include any university, few private universities might be operated. However, the number of students learning in those institutions might be low when compared to the professions of other city dwellers. Commenting on such situations I12 stated that "if the number of students is significantly low or high as a proportion of total number of city occupants it would not be a good indicator". This same

applied to the number of universities and research centers, cinemas, public libraries in the city. Therefore, those indicators were removed.

Most of the experts were confused of the indicator people reached and they have specified that is should be expressed in a clearer way. Indicator refers to the participation of the entire group of a service where the project is called successful when the 100% is attended. One example I9 used was “car owners of all electrical cars join to a programme with which the energy system efficiency is planned to be improved”. Accordingly, the indicator was changed as the percentage of people in the target group that have been reached and/or are activated by 5 services in the project, where the 5 services and target group of the audience needs to be predefined as the SMCPC objectives are confirmed.

The CPC which aims a luxurious living is targeted at the group of investors who can afford that life. Therefore, the financial burden which is involved in acquiring a residence should not be a problem to the citizens and it is expected a same social class in the whole city. Therefore, the indicators like perception on personal risk of poverty, poverty rate, share of housing fulfilling minimal standards, homelessness rate, rent stress, mortgage stress will not be there and therefore are not relevant for this particular project.

Moreover, the city is built newly and will not have any type of a cultural heritage. Adding to this I10 says “as the city is attached to Colombo city there can be connected routes to existing cultural heritages yet that doesn’t seem to be case specified, there are other important indicators”. by similar means the newly built city consisted of a limited number of plots and the living area is similar in saleable lands. As per the experts, having an indicator as the average living area per inhabitant is not inessential. The other indicator that seek the attention of experts was the population change per building approval. It is no doubt that higher the number of building approvals get, higher the buildings built to occupy a higher number of building users. However, with the limited space more buildings might not be practical. Therefore, the indicator is removed due to the irrelevance.

4.4.4 Smart Governance

Figure 4.7 illustrated the modifications suggested by the experts to make the listed Performance Measures a suitable and applicable one for the SMCPC under the smart governance theme. An initial discussion with literature was done under 2.62 The Most Significant Themes/ Dimensions in a Performance Measurement Performance Measurement System for a Smart City.

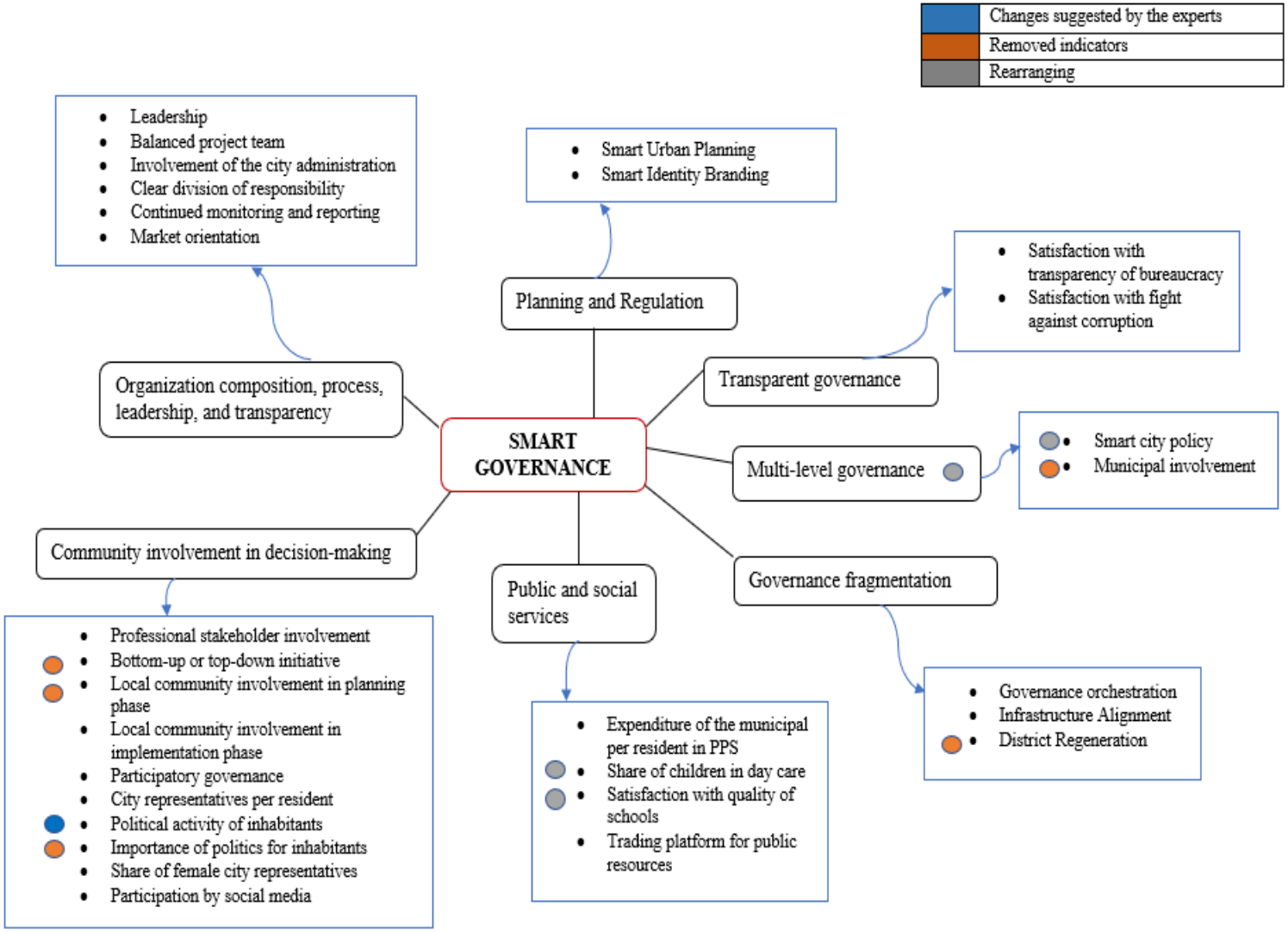

Figure 4.7: Modifications for the listed Performance Measures under Smart Governance theme

For city management purpose in the CPC, a separate entity is planned to be formed. This entity which is known as EMC includes service provision, service management and maintenance. According to the tripartite agreement between Project Company, Ministry (Government of Sri Lanka) and Urban Development Authority, EMC consisted of 51% share of Sri Lankan government and 49% share of the project company. As the Port City is being developed in order to facilitate a Smart City or in other words as the Smart City in CPC is a newly built Smart City, the planning of it doesn't involve citizens. "In the planning stage we are not aware about who will occupy this land; however, planning needs to proceed without the community involvement" says I4. Adding to that the experts agreed in unison that the community involvement is important and at least they should be involved in the implementation stage. Out of different approaches, for SMCPC it is the top down approach that is being undertaken to establish smart initiatives, as the city dwellers are not identified in the stage where smart initiative were set out. However, the needs are indirectly originated from the bottom layer meaning the general public as they demand them when buying the plots. The civic engagement in establishing the further layers of smart initiatives would be possible with open APIs, yet, that cannot be granted and therefore, the indicator is removed.

The exact fragmentation and role of politics in CPC for the time being is vague. The planned community represents the modern upper-class society and a corporate community which prefers active participation in the processes of urban governance. I11 explaining the fact said "for the corporate world and the land owners who paid a quite a significant sum of money will require to advice, question and provide feedback as community actors in city governance and therefore they will consider it is important to be politically active". Alternatively, I9 thinks that "I doubt as to whether the political activity of inhabitants and importance of politics for inhabitants are good smartness indicators, although participatory governance is". I13 who bore a similar opinion said "they should have voting rights as they symbolize the democracy as the city is based in Sri Lanka, similarly, city representatives per residents would be a good indicator up to a certain extent, but I guess having citizens who are actively involved in politics doesn't indicate the smartness a Smart City".

However, the majority of the experts held a different opinion, I14 commented representing that whole set “unlike most of the Smart Cities SMCPC is built newly for a different group of people which consisted of Sri Lankans as well as foreigners. In the due course, them as city dwellers are those who should be politically active in that particular city and not any outsider”. Therefore, the “political activity of inhabitants” indicator is not removed and encouraged to interpret emphasizing the inhabitant’s participation in politics (other than for any other outsiders’) and not as if the active politics indicated the smartness. As a result, it is changed as “Inhabitants’ satisfaction with politics”. While the inhabitants anyway hold the rights to participate and contribute in politics, it is the satisfaction which implies the true importance they give and the stability and good governance. By that means importance of politics for inhabitants is removed. According to I3 who represented the majority of the experts said “the importance will not change in making a city smart”.

There are two layers in Smart Cities that the consultant party has raised concerns. The two layers according to I13 are, “city management which is covered by the Estate Management Plan with sample cases and required procedures and the citizen involvement to which a detailed Smart City policy is yet to be set in”. The policy makers of SMCPC indeed have a long-term vision towards setting goals for SMCPC. However, since the estimated completion of the project is not in near future, vision on the future of SMCPC should be in a manner that can stimulate the environment for Smart City planning. Therefore, it is included under the “Planning and Regulation” subtheme. With that, Multi-level governance subtheme was left only with the indicator municipal involvement which gives a similar indication to what is mentioned under “organization composition, process, leadership, and transparency” subtheme. Therewith multi-level governance appeared to be similar to governance fragmentation and therefore is removed.

Similarly, share of children in day care and satisfaction with quality of schools are rearranged to be mentioned under the smart living theme. However, as far as the initial plan is concerned, there will be no government schools and day care centres maintained as part of the public services rendered. Meanwhile the expenditure of the municipal per resident for acquiring public and social services can indicate the

smartness of the governance in SMCPC. Further to that having a trading platform for public resources just like in China case is most likely to happen as specified by I15. In fact, that was appreciated by many experts.

4.4.5 Smart Environment

Figure 4.8 illustrated the modifications suggested by the experts to make the listed Performance Measures a suitable and applicable one for the SMCPC under the smart environment theme. An initial discussion with literature was done under 2.62 The Most Significant Themes/ Dimensions in a Performance Measurement Performance Measurement System for a Smart City.

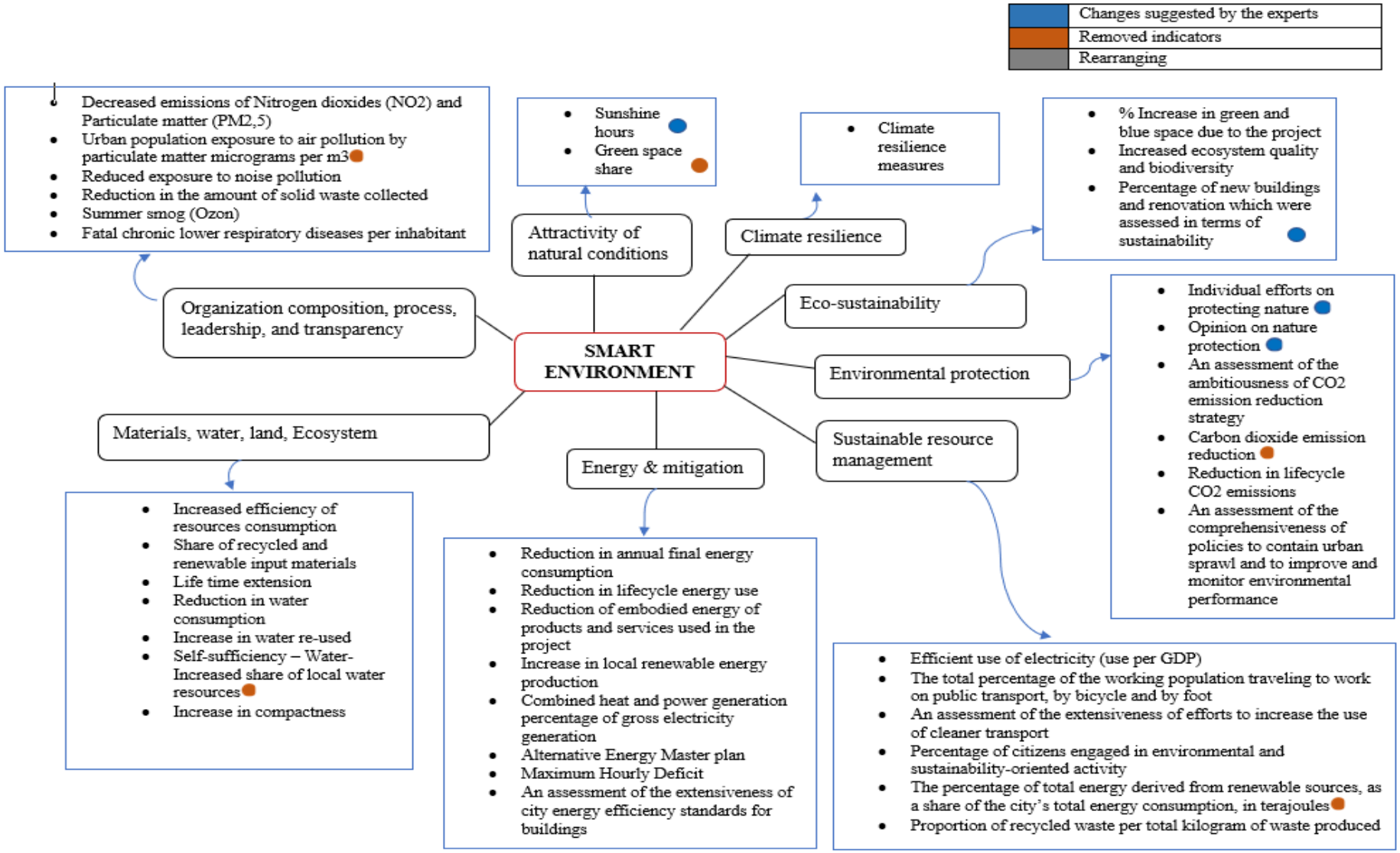

Figure 4.8: Modifications for the listed Performance Measures under Smart Environment theme

Sunshine hours as an indicator of the attractivity of natural conditions is heavily used in countries that have seasons where the sunshine duration per year sometimes is limited. Although sunlight is instrumental in terms of urban design and property values, some experts be of the opinion that it is not really a good smartness indicator. According to I7 “there are cities that have not given up on being a Smart City just because of their limited sunshine duration, what matters is how they utilize the available sources in a smart way”. Adding to that I3 mentioned “We have been to Smart Cities where the smart buildings that have automated smart blinds and shading control where the buildings are designed in a way that natural lighting is efficiently brought and therewith less energy is consumed for lighting the building throughout the day time. In that manner, sunshine hours can be a good indicator”. While for CPC the sunlight is there throughout the year except for the monsoon periods, the indicator might not be that useful and instead the space for that indicator in the Performance Measurement System can be given to a rather significant indicator. According to the regulatory framework for CPC, all public places should have provisions for solar energy use and the outdoor lighting private places are also encouraged to use solar. Therefore, smart use of the sunshine hours appears to be the indicator that should be there. However, that would be more suitable to be included under the subtheme energy and mitigation. With that the only indicator left under the attractivity of natural conditions is the green space share which is again included as an indicator under Eco-sustainability, therefore, is removed.

As the project is completely newly built there will be no renovation which needs to be assessed in terms of sustainability, therefore, in the indicator percentage of new buildings and renovation which were assessed in terms of sustainability, renovation term is removed. In addition to that the two indicators, individual efforts on protecting nature and opinion on nature protection are combined in to one.

According to the experts, having two separate indicators as Carbon dioxide emission reduction and Reduction in lifecycle CO2 emissions is no use. I6 says “Reduction in lifecycle CO2 includes direct operational CO2 emission. Although the operational emission reduction due to project is important as a smartness indicator, this particular project being a newly built city the comparisons with baselines/ benchmarks would

be misleading. By that means the lifecycle emission would not give any absurd sense." Therefore, only the indicator reduction in lifecycle CO2 emission is kept. Similarly, the indicator increase in local renewable energy production represents what is indicated by the percentage of total energy derived from renewable sources, as a share of the city's total energy consumption, in terajoules, as the renewable energy is anyway derived from renewable sources. Therefore, the indicator under sustainable resource management subtheme is removed.

As per I9, "the project team has not decided about the local water sources in CPC, however, there is an equal chance of using desalinated/treated seawater as well as treated ground water and surface water if the land reclamation consequences allow". Adding I3, "For the time being, water will be an expense to city dwellers with compared to other cities in Sri Lanka". Therefore, having self-sufficiency – water-increased share of local water resources as an indicator might be deceptive.

It is no doubt that a Smart City project having smart objectives towards smart environment should have provisions for preventing air pollution. However, the two indicators urban population exposure to air pollution by particulate matter micrograms per m3 and decreased emissions of particulate matter gives a similar meaning as per the experts while the indicator decreased emissions of particulate matter is more straightforward in practical use of this Performance Measurement System. Therefore, the indicator urban population exposure to air pollution by particulate matter micrograms per m3 is removed.

4.4.6 Smart Mobility

Figure 4.9 illustrated the modifications suggested by the experts to make the listed Performance Measures a suitable and applicable one for the SMCPC under the smart mobility theme. An initial discussion with literature was done under 2.62 The Most Significant Themes/ Dimensions in a Performance Measurement Performance Measurement System for a Smart City.

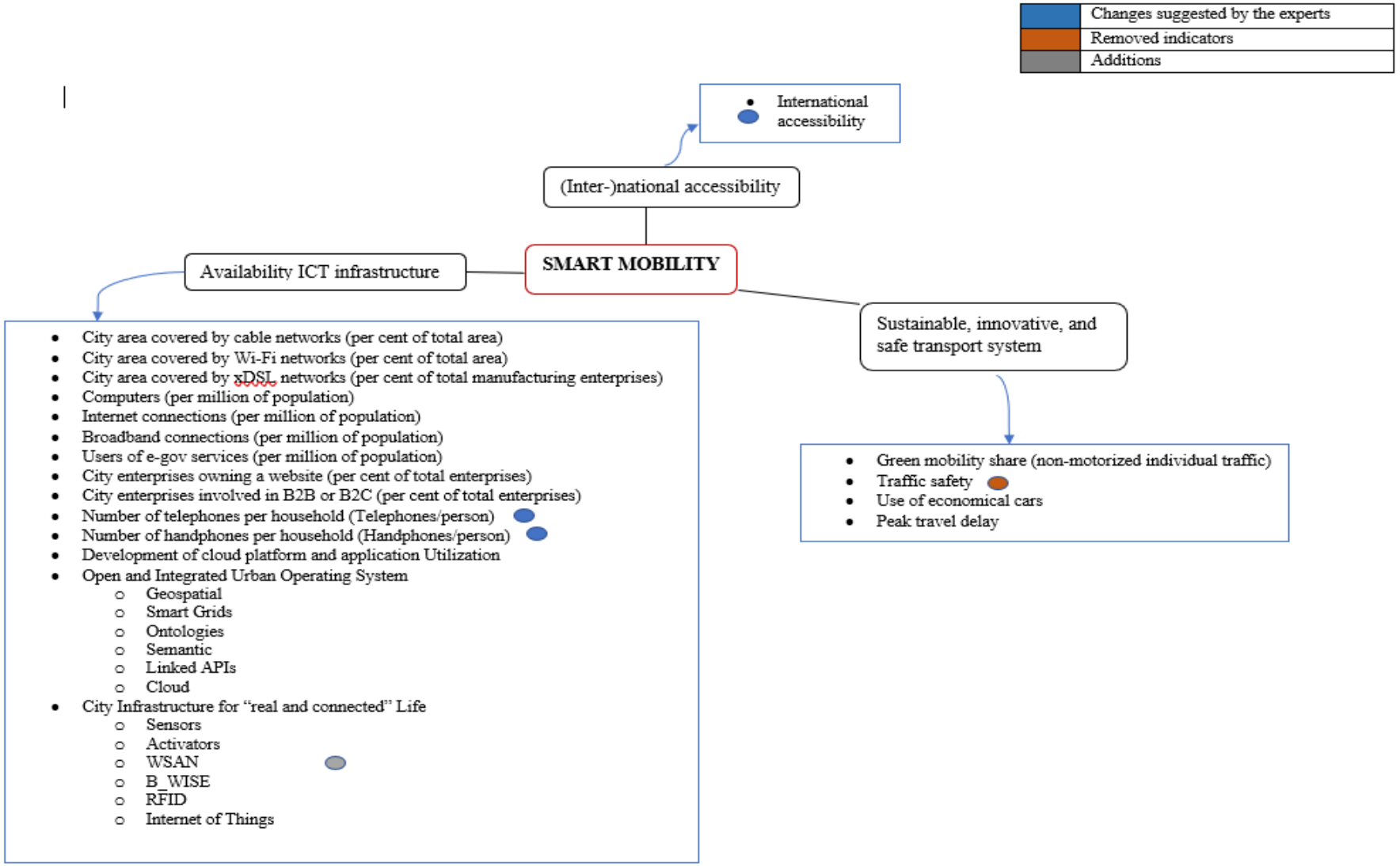

Figure 4.9: Modifications for the listed Performance Measures under Smart Mobility theme

Smart mobility theme was considered an important by many experts as the theme refers to the urban mobility as well as the technology, mobility infrastructure (vehicles, parking, signaling, charging network, etc.), mobility solutions (mobility business framework) and people. The technology component played a significant role in all other subthemes as well. According to I14 “Smart City simply is about the technology integration to increase the efficiency and sustainability of the city”. Yet the computing and telecommunications defines mobility with the use of ICT infrastructure. Hence the researcher decided to emphasize the availability and smartness requirements with regards to the ICT infrastructure under this particular theme to which none of the experts opposed.

I5 commented “Smart Cities add intelligence to existing urban system making it possible to do more with less; connected applications put real time, transparent information in to the hands of users to help them make better choices”. With that terms like artificial intelligence, edge computing, cognitive computing, IoT platforms, mobile internet, cyber security, predictive analytics, digital literacy, etc. come hand in hand. According to the experts who agreed that everything is covered under the subtheme, in designing a Smart City, the three layers; physical and social layer, application layer and adoption and usage layer needs attention. Smart City applications can improve the quality of life indicators. I19 added “for instance, SCADA system for remote monitoring of water consumption and the Bali hotel system where waste water is used for gardening and the blooming of flowers becomes an indicator of hotel occupancy. Real time solutions for urban spaces can prevent fatalities. AI can go to an extent where emotions reading can be used for decision making based on satisfaction and getting an action for security problems customers face inside UBER. In China AI is used at a massive scale together with 5G and 6G”. While discussing those provisions I3 and I11 brought in the term “social credit” which is popular in China. As per I11 “One example where it is used is when a person who owes a debt to another person tries to go in a business class when economic class option is there for him is tracked and the app isn’t allowing to book the ticket with the social credit system. This is same when face recognition is used to

issue toilet papers in public toilets so that citizens don't steal even toilet paper rolls". This new concept was added therewith.

Following that addition few changes were made by combing the two indicators number of telephones per household (telephones/person) and number of handphones per household (handphones/person) to one. Similarly, as traffic safety was previously mentioned, it was removed.

All in all, the Performance Measures listed under the 7 categorisations, Smart Economy, Smart People, Smart Living, Smart Governance, Smart Mobility, Smart Environment and Propagation are discussed in detail with regards to their suitability in the SMCPC. Having Performance Measures in place, the comments on linkages between different Performance Measures, provided a guide in developing the 'Performance Measurement System' for SMCPC. It can be illustrated in Figure 4.10. This Performance Measurement System together with the Performance Measures list represents the suitable system for emerging Smart Cities in Sri Lanka. Figure 4.10 represents only the subthemes; in order to see the indicators under each subtheme, Table 4.1 needs to be referred.

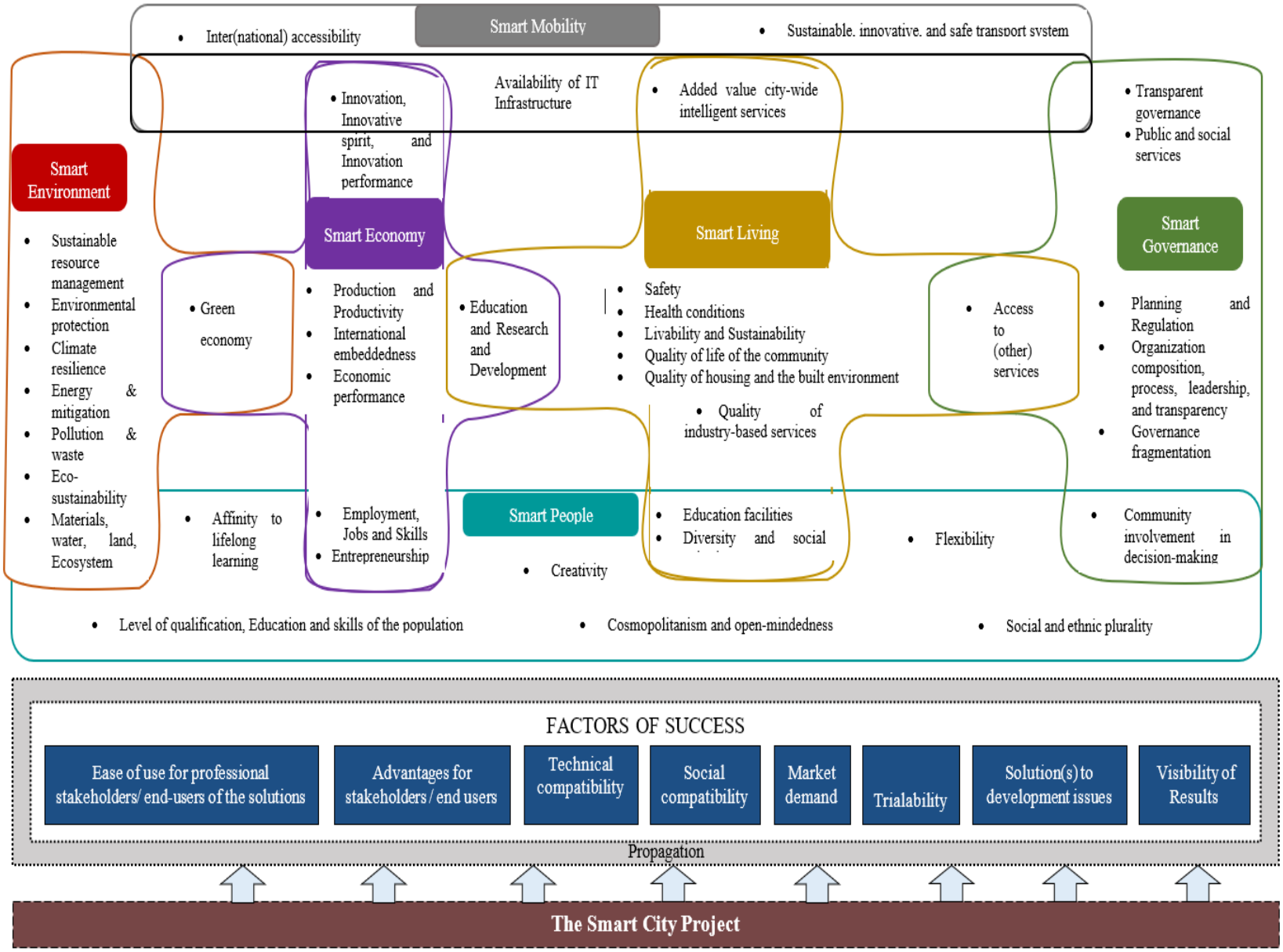

Figure 4.10: Performance Measurement System suitable for Sri Lankan Smart Cities

Table 4.1: Performance Measures suitable for Sri Lankan Smart Cities

Theme		Indicators
SMART ECONOMY	1. 12	1. Financial benefit for the stakeholder *Total cost savings in euros for a stakeholder per year*
	1. 13	2. Involvement of extraordinary professionals *The extent to which the project involved professionals normally not encountered in these type of projects- Likert scale*
		3. Stimulating an innovative environment *The extent to which the project is part of or stimulates an innovative environment- Likert*
		4. Quality of open data *The extent to which the quality of the open data produced by the project was increased -number of stars*
		5. New start-ups- *number of start-ups resulting from the project*
		6. Improved interoperability- *The extent to which the project has increased interoperability between community infrastructures*
		7. Employment rate in: High Tech and creative industries; Renewable energy and energy efficiency systems Financial intermediation and business activities; knowledge-intensive sectors; Culture and entertainment industry; Commercial services; Transport and communication; Hotels and restaurants; All companies (total number)
		8. Number of local units manufacturing high tech & ICT products
		9. Patent applications per inhabitant
		10. Number of incubators
		11. Number of Science and Technology Parks
		12. Number of Technology Transfer and Innovation Centres
		13. Exports high-tech services (as a percentage of total exports)
		14. New trade marks
		15. Enterprises having internal Research & Development Department (as a percentage

		of all enterprises)
		16. Sales of new-to-market products (as a percentage of turnover)
		17. Sales of new-to-firm not new-to-market products (as a percentage of turnover)
		18. New business models for smart growth and quality of life • Living Labs • Creative class • Web of Trust
	1. 14	19. Self-employment rate
		20. New businesses registered
		21. Percentage of projects funded by civil society
	1. 15	22. Establishment of important decision-making centres (HQ etc.)
		23. GDP (of smart services) per head of city population
	1. 16	24. Increased use of local workforce
		25. Employment rate
		26. Proportion in part-time employment
	1. 17	27. Air transport of passengers and freight
	1. 18	28. Certified companies involved in the project
		29. Green public procurement- *Percentage annual procurement using environmental criteria as share of total annual procurement of the city administration*
		30. CO2 reduction cost efficiency- *Costs per ton of CO2 saved per year*
		31. Energy intensity of the economy -gross inland consumption of energy divided by GDP
	1. 19	32. Public expenditure on R&D -percentage of GDP per head of city population
		33. Public expenditure on education -percentage of GDP per head of city population
		34. Number of research grants funded by international projects
SMART GOVERNANCE	2.8	35. Leadership- *The extent to which the leadership of the project is successful in creating support for the project. - Likert*
		36. Balanced project team - *The extent to which the project team included all relevant experts and stakeholders from the start- Likert*
		37. Involvement of the city administration- *The extent to which the local authority is involved in the development of the project,*

		other than financial, and how many departments are contributing- Likert
		38. Clear division of responsibility- *Has the responsibility for achieving the social and sustainability targets been clearly assigned to (a) specific actor(s) in the project? Yes/no*
		39. Continued monitoring and reporting - *The extent to which the progress towards project goals and compliance with requirements is being monitored and reported- Likert*
		40. Market orientation- *The extent to which the project was planned on the basis of a market analysis- Likert*
	2.9	*41.* Professional stakeholder involvement- *The extent to which professional stakeholders outside the project team have been involved in planning and execution- Likert*
		42. Local community involvement in implementation phase- *Extent to which residents/users have been involved in the implementation process- Likert*
		43. Participatory governance % *Share of population participating in online platforms*
		44. City representatives per resident
		45. Importance of politics for inhabitants
		46. Share of female city representatives
		47. Participation by social media
	2.10	48. Governance orchestration
		49. Infrastructure Alignment
		50. District Regeneration
	2.11	51. Expenditure of the municipal per resident for public and social services
		52. Trading platform for public resources
		53. Reduction in waiting time to obtain services
	2.12	54. Satisfaction with transparency of bureaucracy
		55. Satisfaction with fight against corruption
	2.13	56. Smart Urban Planning
		57. Smart Identity Branding
		58. Smart City policy - *the extent to which the project has benefitted from a governmental Smart City policy- Likert*
SMART ENVIRONMEN	3.9	59. % Increase in green and blue space due to the project
		60. Increased ecosystem quality and biodiversity- *Extent to which ecosystem quality and biodiversity aspects have been taken into account- Likert*
		61. Percentage of new buildings which were assessed in terms of sustainability

	3.10	62. Individual efforts and opinion on protecting nature
		63. An assessment of the ambitiousness of CO2 emission reduction strategy
		64. Reduction in lifecycle CO2 emissions
		65. An assessment of the comprehensiveness of policies to contain urban sprawl and to improve and monitor environmental performance
	3.11	66. Efficient use of electricity (use per GDP)
		67. The total percentage of the working population traveling to work on public transport, by bicycle and by foot
		68. An assessment of the extensiveness of efforts to increase the use of cleaner transport
		69. Percentage of citizens engaged in environmental and sustainability-oriented activity
		70. Proportion of recycled waste per total kilogram of waste produced
	3.12	71. Reduction in annual final energy consumption
		72. Reduction in lifecycle energy use
		73. Reduction of embodied energy of products and services used in the project
		74. Increase in local renewable energy production
		75. Combined heat and power generation percentage of gross electricity generation
		76. Alternative Energy Master plan
		77. Maximum Hourly Deficit
		78. An assessment of the extensiveness of city energy efficiency standards for buildings
	3.13	79. Increased efficiency of resources consumption
		80. Share of recycled and renewable input materials
		81. Life time extension-*The extent to which measures were taken to prolong the service lifetime of products - Likert*
		82. Reduction in water consumption
		83. Increase in water re-used
		84. Increase in compactness
	3.14	85. Climate resilience measures- *The extent to which adaptation options have been considered in the project*
	3.15	86. Decreased emissions of Nitrogen dioxides (NO2) and Particulate matter (PM2,5)
		87. Reduced exposure to noise pollution
		88. Reduction in the amount of solid waste collected
		89. Summer smog (Ozon)
		90. Fatal chronic lower respiratory diseases per inhabitant

SMART PEOPLE	4.8	91. Importance as knowledge centres (top research centres, top universities etc.)
		92. Population qualified at levels 5-6 ISCED
		93. Foreign language skills
		94. % of population aged 15-64 with above secondary-level education and above living in Urban Audit
		95. % of inhabitants working in education and in research & development sector
		96. Individual level of computer skills
		97. Individual level of internet skills
	4.9	98. Book loans per resident
		99. Participation in life-long-learning in %
		100. Participation in language courses
	4.10	101. Share of foreigners
		102. Share of nationals born abroad
	4.11	103. Perception of getting a new job
		104. Participation in voluntary work
		105. Increased use of cashless transactions
	4.12	106. Share of people working in creative industries
	4.13	107. Voters turnout at elections
		108. Immigration-friendly environment (attitude towards immigration)
		109. Knowledge about the region/ country
SMART LIVING	5.13	110. Improved access to basic health care services- *The extent to which the project has increased accessibility to basic health care*
		111. Encouraging a healthy lifestyle
		112. Waiting time (reduction of queues)
		113. Life expectancy
		114. Hospital beds per inhabitant
		115. Doctors per inhabitant
		116. Satisfaction with quality of health system
	5.14	117. Reduction of traffic accidents
		118. Reduction in crime rate
		119. Improved cybersecurity
		120. Improved data privacy
		121. Satisfaction with personal safety
	5.15	122. Improved access to educational resources/ system
		123. Increased environmental awareness
		124. Improved digital literacy
		125. Satisfaction with quality of educational system
		126. No. of courses entirely downloadable from the internet/total no. courses
		127. Percentage of professors and researchers involved in international projects and exchange
		128. Percentage of accessible courses for people with disabilities (PWD)

	5.16	129. Touristic Importance as tourist location (overnights, sights) - *overnight stys in registered accommodation in per year per resident*
	5.17	130. Access to public transport
		131. Quality of public transport
		132. Improved access to vehicle sharing solutions
		133. Extending the bike route network
		134. Decreased travel time
		135. Provision for autonomous driving
		136. Access to public amenities
		137. Access to commercial amenities
		138. Increase in online government services/ e-Government on-line availability (percentage of the 20 basic services that are fully available online)
		139. e-Government usage by individuals (percentage individuals aged 16-74 who have used the Internet, in the last 3 months, for interaction with public authorities)
		140. Proportion of the area in for recreational sports and leisure use
	5.18	141. People reached (*Percentage of people in the target group that have been reached and/or are activated by 5 services in the project)*
		142. Increased consciousness of citizenship and social coherence
		143. Increased participation of vulnerable groups
	5.19	144. Diversity of housing types
		145. Design for a sense of place
		146. Increased access to urban public outdoor recreation space
		147. Increased access to green space
		148. Satisfaction with personal housing situation
		149. Green Building Policies
	5.20	150. Public and community housing
		151. Dwelling price to income ratio
		152. Free time
	5.21	153. Adult obesity rate
		154. Support in times of crisis
		155. Suicide rate
		156. Office building energy efficiency
	5.22	157. i-energy
		158. i-transport
		159. i-democracy
		160. i-government
		161. i-services
		162. i-home
	5.23	163. Number of enterprises adopting ISO 14000 standards
		164. Proportion of people undertaking industry-

		based training
SMART MOBILITY	6.5	165. Satisfaction with international acceibility
	6.6	166. City area covered by cable networks (per cent of total area)
		167. City area covered by Wi-Fi networks (per cent of total area)
		168. City area covered by xDSL networks (per cent of total manufacturing enterprises)
		169. Computers (per million of population)
		170. Internet connections (per million of population)
		171. Broadband connections (per million of population)
		172. Users of e-gov services (per million of population)
		173. City enterprises owning a website (per cent of total enterprises)
		174. City enterprises involved in B2B or B2C (per cent of total enterprises)
		175. Number of telephones/handphone per household (Telephones or handphone /person)
		176. Availability of social credit
		177. Development of cloud platform and application Utilization
		178. Open and Integrated Urban Operating System Geospatial Smart Grids Ontologies Semantic Linked APIs Cloud
		179. City Infrastructure for "real and connected" Life Sensors Activators WSAN B_WISE RFID Internet of Things
	6.7	180. Green mobility share (non-motorized individual traffic)
		181. Use of economical cars
		182. Peak travel delay
Propagation	7.3	183. Social compatibility
		184. Technical compatibility
		185. Ease of use for end users of the solution
		186. Ease of use for professional stakeholders
		187. Trialability
		188. Advantages for end users
		189. Advantages for stakeholders

		190.Visibility of Results
		191.Solution(s) to development issues
		192.Market demand
	7.4	193.Changing professional norms
		194.Changing societal norms
		195.Diffusion to other locations
		196.Diffusion to other actors
		197.Change in rules and regulations
		198.Change in public procurement
		199.New forms of financing
		200.Smart City project visitors

This table elaborates the inclusions under each subtheme.While 6 out of the 7 themes represent different aspects in a city, namely, economy, living (services by city domains), environment, people, transportation, ICT infrastructure and governance, the other theme, propagation is more about the smart city as a project. Theme propagation therefore looks at the project in a birdseye and depicts about the project inclusions. It consists of the critical success factors of a project as well as the scalability and replicability. In Figure 4.10 the 8 measures have been selected as the basis on which the rest of the themes should be developed, which can be defined as the critical success factors for SMCPC as a project. By drawing a frame around those themes and naming the frame as the propagation, the Performance Measurement System attempts to highlight the interrelationships between the rest the of themes by showing the propagation theme separately.

Through the data collection it was identified that people factor is also important as much as the ICT infrastructure for a Smart City. Therefore, Smart Mobility, which included ICT infrastructure and Smart People were shown as two main themes which indicates their overlapping relationships with the other themes, economy, governance, environment and living. Some of the obvious relationships between Smart Mobility (ICT infrastructure) are shown with overlapping shapes in the Figure. For instance, Innovation, Innovative spirit, and Innovation performance measure in Smart Economy theme, Added value city wide intelligent services in Smart Living theme and Transparent governance and public and social services measures under Smart Governance theme are such examples. In the same way the overlapping relationships between Smart People and Smart Living, Smart Governance, Smart Environment are shown.

The measure green economy in Smart Economy theme is related to Smart Environment as well. Similarly, Education and Research, which describes about the public expenditure on research and education is important to the education measure under Smart Living theme. Access to other services measure under Smart Living depicts some of the performance measures with regards to public services which are related to Smart Governance, therefore, is shown as an overlapping relationship. These overlapping relationships shows important aspects in a city which most of the times are interrelated. Therefore, for those who are keen on Performance Measurement in a city can take an extra care on such aspects as they are significant not only to one aspect but for several. However, the developed Performance Measurement System should be applied always in connection to the List of Performance Measures to make it a complete Performance Measurement System.

While this is proven to be the suitable Performance Measurement System for SMCPC given that a suitable list of Performance Measures for SMCPC are in place, this can only be applied to similar city context with a suitable set of Performance Measures for those contexts.

All in all, the two situations this Performance Measurement System can be used in the Sri Lankan context are;

1) For SMCPC: with the Performance Measures (Themes, Subthemes, Indicators) listed under Table 4.3 – Scoring of indicators within sub-themes

2) For (other) emerging Smart Cities in Sri Lanka: with the Scoring Systems (Table 4.1 – Scoring of themes/ Table 4.2 – Scoring of sub-themes within the themes/ Table 4.3 – Scoring of indicators within sub-themes)

Stage 3: Findings of the questionnaire survey

4.5 Suitability of the listed Performance Measures of SMCPC to general Sri Lankan context

The set of Performance Measures listed out in the previous data collection phase was taken as a basis to develop a Performance Measurement System that is suitable to

any type of an emerging Smart City in Sri Lanka, based on the relative importance and current data availability. In other words, while the developed Performance Measurement System (Figure 4.10) can be applied to any type of a Sri Lankan context, the list of Performance Measures should be assessed on the suitability for the context, in this study based on the importance and data availability. The results are analysed under the topics ranking of the themes, allocation of scores to sub-themes within the main themes, allocation of scores to indicators within the sub-themes so that the scores gained by three main sectors of the table themes, subthemes and indicators are covered.

As mentioned in under Questionnaire survey template design in Chapter 3, Battelle method has been used. Figure 4.11 is a snap shot of smart people theme and how the questionnaire results were calculated.

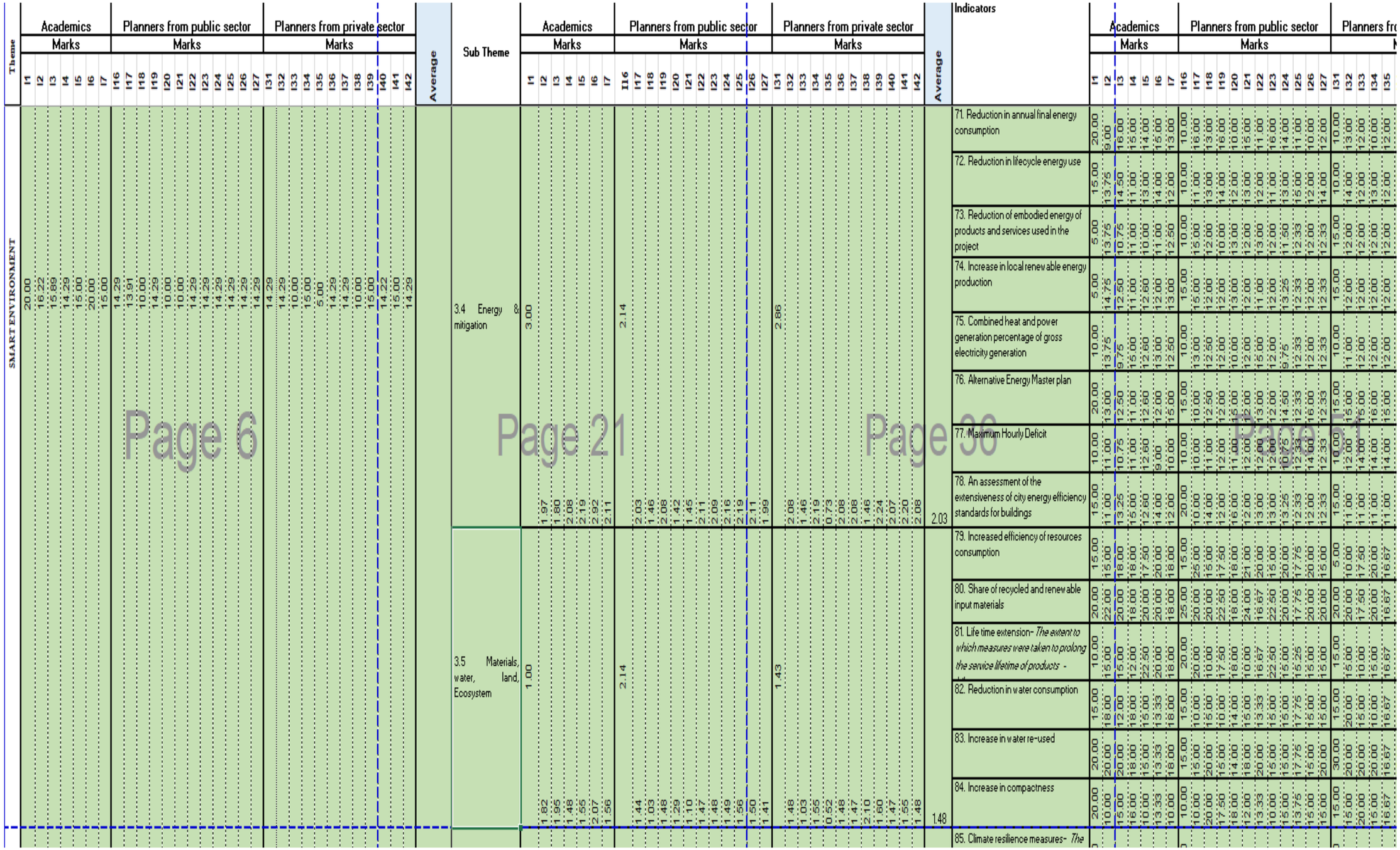

Figure 4.11: A snap shot of questionnaire survey results- mean score calculation

4.5.1 Ranking of the themes

Questionnaire survey participants were invited to allocate a total score of 100 among the 6 main themes. The scoring process can be illustrated as follows in Figure 4.12;

Figure 4.12: Development of the Scoring System to measure the performance of Sri Lankan Smart Cities

Mean scores allocated to the themes ranged from 13.42 to 15.83, all falling within 2.14 range. This suggests that the respondents have considered all the themes as equally important, albeit with minor variances (See Table 4.1).

Based on the mean scores allocated, a scoring system can be developed to measure how 'smart' a Smart City is; similar to scoring systems like Building Research Establishment Environmental Assessment Method (BREEAM) and Leadership in Energy and Environmental Design (LEED). Considering the total number of indicators, it is proposed to use a scoring system out of 1000 to make the scoring system more readable and allocation of scores to indicators more meaningful. Accordingly, the scores out of 100 were converted to out of 1000. Score allocated out of 1000 is shown in the final column in Table 4.1.

Table 4.2 – Scoring of themes

Theme	Mean score	Standard Deviation	Score out of 1000 (rounded up to the nearest whole number)
Smart Mobility	15.83	3.64	158
Smart Economy	14.78	4.36	148
Smart Living	14.59	2.93	146

Theme	Mean score	Standard Deviation	Score out of 1000 (rounded up to the nearest whole number)
Smart People	14.02	3.49	140
Smart Environment	13.88	2.87	139
Propagation	13.49	3.50	135
Smart Governance	13.42	1.93	134
Total score	100		1000

Note: This list comprised of Performance Measures (themes) suitable for SMCPC, can be applied to emerging Smart Cities in Sri Lanka based on the scores (which are given considering the data availability and their significance to the Sri Lankan context.

Smart Mobility with a mean score of 15.83 was ranked first by the participants, followed by Smart Economy (14.78) and Smart Living (14.59). Themes are ranked according to the scores allocated in Table 4.1. Smart Governance was allocated a slightly lower score than Propagation, suggesting that the respondents have viewed Propagation as an important aspect of a Smart City. Further, whilst the theme that includes ICT infrastructure (Smart Mobility) was ranked 1st, the theme including environmental considerations (Smart Environment) was ranked 5th suggesting that the respondents have placed a greater impetus on technological aspects in Smart Cities over Environmental considerations.

4.5.2 Allocation of scores to sub-themes within the main themes

As the 2nd step in the scoring process (See Figure 4.12), the participants were asked to distribute the score that they have allocated to themes among the sub-themes that comes under the particular theme. The results of this exercise are shown in Table 4.2, in which sub-themes within each theme is ranked by the mean score. Mean scores were then converted to a scoring system out of 1000, and the scores allocated to sub-themes were rounded up/down to the nearest whole number. Minor adjustments were made where required to tally the scores allocated to sub-themes with that allocated to the particular theme. Such instances are denoted with an '*' within the table.

Table 4.3 – Scoring of sub-themes within the themes

Theme	Sub-theme	Mean Score	Score out of 1000
Smart Mobility (158)	Availability of IT Infrastructure	6.79	68
	Inter(national) accessibility	5.00	50
	Sustainable, innovative, and safe transport system	4.03	40
Smart Economy (148)	Innovation, Innovative spirit, and Innovation performance	2.69	27
	Employment, Jobs and Skills	2.03	20
	Production and Productivity	1.98	20
	International embeddedness	1.78	18
	Green economy	1.77	18
	Education and Research and Development	1.72	17
	Entrepreneurship	1.51	15
	Economic performance	1.30	13
Smart Living (146)	Education facilities	1.62	16
	Safety	1.61	16
	Health conditions	1.58	16
	Access to (other) services	1.53	15
	Added value city-wide intelligent services	1.37	14
	Liveability and Sustainability	1.34	13
	Quality of life of the community	1.30	13
	Quality of housing and the built environment	1.20	12
	Touristic attractivity	1.12	11
	Diversity and social cohesion	1.05	11*
	Quality of industry-based services	0.87	9
Smart People (140)	Level of qualification, Education and skills of the population	3.04	30
	Cosmopolitanism and open-mindedness	2.45	24
	Creativity	2.36	24
	Social and ethnic plurality	2.26	23
	Flexibility	2.18	22
	Affinity to lifelong learning	1.72	17
Smart Environment	Sustainable resource management	2.29	23
	Environmental protection	2.07	21

Theme	Sub-theme	Mean Score	Score out of 1000
(139)	Climate resilience	2.06	21
	Energy & mitigation	2.03	20
	Pollution & waste	2.02	20
	Eco-sustainability	1.93	19
	Materials, water, land, Ecosystem	1.48	15
Propagation (135)	Factors of success	6.75	68
	Replicability & scalability	6.74	67
Smart Governance (134)	Planning and Regulation	2.72	27
	Organization composition, process, leadership, and transparency	2.47	25
	Transparent governance	2.41	24
	Community involvement in decision-making	2.20	22
	Public and social services	2.05	20
	Governance fragmentation	1.57	16

Note: This list comprised of Performance Measures (subthemes) suitable for SMCPC, can be applied to emerging Smart Cities in Sri Lanka based on the scores (which are given considering the data availability and their significance to the Sri Lankan context.

According to the scores allocated, availability of the ICT infrastructure emerged as the sub-theme with the highest priority. The two sub-themes within Propagation theme were the next two high-scoring sub-themes but this is explained by the fact that propagation only has 2 sub-themes, whereas all other themes had more sub-themes.

4.5.3 Allocation of scores to indicators within the sub-themes

In the third step, the participants were required to allocate scores to Smart City indicators within each sub-theme. The participants were asked to allocate scores out of 100 within each sub-theme and the scores allocated to the sub-themes in the previous stage were then distributed among the sub-themes accordingly. Within each sub-theme, indicators are ranked according to the score allocated to them. Given that some of the sub-themes consist of many indicators, scores were rounded up/down to

the nearest decimal point and minor adjustments were made to ensure that the score allocated to the sub-theme is fully distributed amongst the indicators within it / does not exceed the sub-theme score.

Table 4.4 – Scoring of indicators within sub-themes

Theme	Sub-theme	Indicator	% score in sub-theme	Score
Smart Mobility (158)	Availability of IT Infrastructure (68)	City Infrastructure for "real and connected" Life-Sensors, Activators, WSAN, B_WISE, RFID, Internet of Things	9.32%	6.30
		Open and Integrated Urban Operating System - Geospatial, Smart Grids, Ontologies, Semantic, Linked APIs, Cloud	9.31%	6.30
		City area covered by Wi-Fi networks (per cent of total area)	8.93%	6.10
		Users of e-gov services (per million of population)	8.82%	6.00
		Broadband connections (per million of population)	7.68%	5.20
		Development of cloud platform and application Utilization	7.11%	4.80
		Number of telephones/handphone per household (Telephones or handphone /person)	7.10%	4.80
		Availability of social credit	6.92%	4.70
		City area covered by cable networks (per cent of total area)	6.84%	4.70
		City enterprises owning a website (per cent of total enterprises)	6.29%	4.30
		Computers (per million of population)	5.79%	3.90
		City area covered by xDSL networks (per cent of total manufacturing enterprises)	5.44%	3.70
		Internet connections (per million of population)	5.39%	3.70
		City enterprises involved in B2B or B2C (per cent of total enterprises)	5.06%	3.50
	Inter(national) accessibility (50)	Satisfaction with international accessibility	100%	50

Theme	Sub-theme	Indicator	% score in sub-theme	Score
	Sustainable, innovative, and safe transport system (40)	Green mobility share (non-motorized individual traffic)	36.49%	14.60
		Use of economical cars	33.21%	13.30
		Peak travel delay	30.31%	12.10
Smart Economy (148)	Innovation, Innovative spirit, and Innovation performance (27)	New start-ups- number of start-ups resulting from the project	12.07%	3.30
		Stimulating an innovative environment-The extent to which the project is part of or stimulates an innovative environment	10.66%	2.90
		Quality of open data-The extent to which the quality of the open data produced by the project was increased - number of stars	9.92%	2.70
		Involvement of extraordinary professionals- The extent to which the project involved professionals normally not encountered in these type of projects	9.18%	2.50
		Employment rate in: High Tech and creative industries; Renewable energy and energy efficiency systems Financial intermediation and business activities; knowledge-intensive sectors; Culture and entertainment industry; Commercial services; Transport and communication; Hotels and restaurants; All companies (total number)	6.93%	1.90
		Number of local units manufacturing high tech & ICT products	6.10%	1.70
		Improved interoperability- The extent to which the project has increased interoperability between community infrastructures	5.73%	1.60
		Exports high-tech services (as a percentage of total exports)	5.43%	1.50
		New business models for smart growth and quality of life - Living Labs, Creative class, Web of Trust	5.37%	1.50
		Enterprises having internal Research & Development Department (as a percentage of all	5.05%	1.40

Theme	Sub-theme	Indicator	% score in sub-theme	Score
		enterprises)		
		Number of Science and Technology Parks	4.70%	1.30
		Number of Technology Transfer and Innovation Centres	4.49%	1.20
		Sales of new-to-market products (as a percentage of turnover)	3.66%	1.00
		Number of incubators	3.55%	0.90
		New trademarks	3.18%	0.90
		Patent applications per inhabitant	2.32%	0.60
		Sales of new-to-firm not new-to-market products (as a percentage of turnover)	1.39%	0.40
	Employment, Jobs and Skills (20)	Increased use of local workforce	39.84%	8.00
		Employment rate	37.76%	7.50
		Proportion in part-time employment	22.20%	4.50
	Production and Productivity (20)	GDP (of smart services) per head of city population	61.13%	12.20
		Establishment of important decision-making centres (HQ etc.)	38.87%	7.80
	International embeddedness (18)	Air transport of passengers and freight	100%	18.00
	Green economy (18)	Green public procurement- Percentage annual procurement using environmental criteria as share of total annual procurement of the city administration	29.93%	5.40
		CO2 reduction cost efficiency- Costs per ton of CO2 saved per year	25.96%	4.70
		Energy intensity of the economy--gross inland consumption of energy divided by GDP	25.80%	4.60
		Certified companies involved in the project	18.31%	3.30
	Education and Research and Development (17)	Public expenditure on education - percentage of GDP per head of city population	37.10%	6.30
		Public expenditure on R&D -percentage of GDP per head of city population	33.98%	5.80
		Number of research grants funded by international projects	29.09%	4.90

The me	Sub-theme	Indicator	% score in sub-theme	Score
	Entrepreneurship (15)	Self-employment rate	37.71%	5.70
		New businesses registered	32.00%	4.80
		Percentage of projects funded by civil society	30.29%	4.50
	Economic performance (13)	Financial benefit for the stakeholder - Total cost savings in euros for a stakeholder per year	100%	13.00
Smart Living (146)	Education facilities (16)	Improved digital literacy	17.46%	2.80
		Improved access to educational resources/ system	16.20%	2.60
		Satisfaction with quality of educational system	16.04%	2.60
		Increased environmental awareness	15.80%	2.50
		Percentage of accessible courses for people with disabilities (PWD)	13.05%	2.10
		Percentage of professors and researchers involved in international projects and exchange	11.71%	1.90
		No. of courses entirely downloadable from the internet/total no. courses	9.75%	1.50
	Safety (16)	Reduction in crime rate	20.78%	3.30
		Improved data privacy	20.49%	3.30
		Satisfaction with personal safety	20.41%	3.30
		Improved cybersecurity	20.39%	3.20
		Reduction of traffic accidents	17.93%	2.90
	Health conditions (16)	Encouraging a healthy lifestyle	16.96%	2.70
		Improved access to basic health care services- The extent to which the project has increased accessibility to basic health care	16.90%	2.70
		Life expectancy	15.51%	2.50
		Doctors per inhabitant	14.15%	2.30
		Satisfaction with quality of health system	13.05%	2.10
		Hospital beds per inhabitant	12.15%	1.90
		Waiting time (reduction of queues)	11.27%	1.80
	Access to (other) services (15)	Decreased travel time	13.85%	2.10
		Increase in online government services/ e-Government on-line availability (percentage of the 20 basic services that are fully available online)	12.31%	1.80

Theme	Sub-theme	Indicator	% score in sub-theme	Score
		e-Government usage by individuals (percentage individuals aged 16-74 who have used the Internet, in the last 3 months, for interaction with public authorities)	10.79%	1.60
		Improved access to vehicle sharing solutions	9.57%	1.40
		Access to public amenities	9.50%	1.40
		Quality of public transport	8.80%	1.30
		Access to public transport	8.17%	1.20
		Provision for autonomous driving	7.72%	1.20
		Extending the bike route network	6.98%	1.40
		Access to commercial amenities	6.50%	1.00
		Proportion of the area in for recreational sports and leisure use	5.83%	0.90
	Added value city-wide intelligent services (14)	i-energy	20.11%	2.80
		i-transport	19.75%	2.80
		i-services	15.71%	2.20
		i-democracy	15.44%	2.10
		i-government	14.90%	2.10
		i-home	14.10%	2.00
	Liveability and Sustainability (13)	Support in times of crisis	31.17%	4.10
		Office building energy efficiency	29.71%	3.90
		Suicide rate	22.08%	2.80
		Adult obesity rate	17.04%	2.20
	Quality of life of the community (13)	Dwelling price to income ratio	36.78%	4.80
		Public and community housing	36.03%	4.70
		Free time	27.22%	3.50
	Quality of housing and the built environment (12)	Increased access to green space	21.24%	2.50
		Increased access to urban public outdoor recreation space	20.26%	2.40
		Green Building Policies	16.16%	1.90
		Design for a sense of place	15.54%	1.90
		Satisfaction with personal housing situation	15.54%	1.90
		Diversity of housing types	11.25%	1.40
	Touristic attractivity (11)	Touristic Importance as tourist location (overnights, sights) - overnight stays in	100%	11.00

Theme	Sub-theme	Indicator	% score in sub-theme	Score
		registered accommodation in per year per resident		
	Diversity and social cohesion (11)	Increased consciousness of citizenship and social coherence	34.43%	3.80
		People reached (Percentage of people in the target group that have been reached and/or are activated by 5 services in the project)	34.31%	3.80
		Increased participation of vulnerable groups	31.27%	3.40
	Quality of industry-based services (9)	Number of enterprises adopting ISO 14000 standards	53.92%	4.90
		Proportion of people undertaking industry-based training	46.08%	4.10
Smart People (140)	Level of qualification, Education and skills of the population (30)	Importance as knowledge centres (top research centres, top universities etc.)	16.53%	5.00
		% of inhabitants working in education and in research & development sector	15.43%	4.60
		% of population aged 15-64 with above secondary-level education and above living in Urban Audit	14.99%	4.50
		Individual level of internet skills	14.80%	4.40
		Individual level of computer skills	14.20%	4.30
		Population qualified at levels 5-6 ISCED	12.74%	3.80
		Foreign language skills	11.32%	3.40
	Cosmopolitanism and open-mindedness (24)	Knowledge about the region/ country	34.92%	8.40
		Immigration-friendly environment (attitude towards immigration)	32.77%	7.80
		Voters turnout at elections	32.31%	7.80
	Creativity (24)	Share of people working in creative industries	100.00%	24.00
	Social and ethnic plurality (23)	Share of nationals born abroad	56.67%	13.00
		Share of foreigners	43.33%	10.00
	Flexibility (22)	Participation in voluntary work	36.23%	8.00
		Increased use of cashless transactions	35.84%	7.90
		Perception of getting a new job	27.93%	6.10
	Affinity to lifelong learning (17)	Participation in life-long-learning in %	42.83%	7.30
		Book loans per resident	28.85%	4.90

Theme	Sub-theme	Indicator	% score in sub-theme	Score
		Participation in language courses	28.32%	4.80
Smart Environment (139)	Sustainable resource management (23)	The total percentage of the working population traveling to work on public transport, by bicycle and by foot	23.19%	5.30
		Efficient use of electricity (use per GDP)	21.07%	4.90
		Proportion of recycled waste per total kilogram of waste produced	20.35%	4.70
		Percentage of citizens engaged in environmental and sustainability-oriented activity	17.91%	4.10
		An assessment of the extensiveness of efforts to increase the use of cleaner transport	17.48%	4.00
	Environmental protection (21)	Reduction in lifecycle CO2 emissions	28.51%	6.00
		An assessment of the comprehensiveness of policies to contain urban sprawl and to improve and monitor environmental performance	26.74%	5.60
		Individual efforts and opinion on protecting nature	24.16%	5.10
		An assessment of the ambitiousness of CO2 emission reduction strategy	20.59%	4.30
	Climate resilience (21)	Climate resilience measures- The extent to which adaptation options have been considered in the project	100.00%	21.00
	Energy & mitigation (20)	Alternative Energy Master plan	13.64%	2.70
		Reduction in annual final energy consumption	13.23%	2.60
		An assessment of the extensiveness of city energy efficiency standards for buildings	12.91%	2.60
		Reduction in lifecycle energy use	12.69%	2.50
		Increase in local renewable energy production	12.35%	2.50
		Combined heat and power generation percentage of gross electricity generation	11.86%	2.40
		Reduction of embodied energy of products and services used in the project	11.76%	2.40
		Maximum Hourly Deficit	11.57%	2.30
	Pollution & waste (20)	Decreased emissions of Nitrogen dioxides (NO2) and Particulate matter (PM2,5)	21.99%	4.40

The me	Sub-theme	Indicator	% score in sub-theme	Score
		Reduction in the amount of solid waste collected	20.32%	4.10
		Fatal chronic lower respiratory diseases per inhabitant	19.45%	3.90
		Summer smog (Ozon)	19.21%	3.80
		Reduced exposure to noise pollution	19.03%	3.80
	Eco-sustainability (19)	% Increase in green and blue space due to the project	35.73%	6.80
		Increased ecosystem quality and biodiversity-Extent to which ecosystem quality and biodiversity aspects have been taken into account	32.73%	6.20
		Percentage of new buildings which were assessed in terms of sustainability	31.86%	6.00
	Materials, water, land, Ecosystem (15)	Share of recycled and renewable input materials	19.94%	3.00
		Increase in water re-used	18.01%	2.70
		Increased efficiency of resources consumption	17.53%	2.60
		Life time extension-The extent to which measures were taken to prolong the service lifetime of products	15.38%	2.30
		Reduction in water consumption	15.15%	2.30
		Increase in compactness	13.98%	2.10
Propagation (135)	Factors of success (68)	Change in public procurement	16.01%	10.90
		Change in rules and regulations	15.67%	10.70
		New forms of financing	13.84%	9.40
		Changing societal norms	12.95%	8.80
		Diffusion to other locations	11.43%	7.80
		Diffusion to other actors	10.51%	7.10
		Smart City project visitors	10.27%	7.00
		Changing professional norms	9.31%	6.30
	Replicability & scalability (67)	Ease of use for end-users of the solution	12.21%	8.20
		Advantages for stakeholders	11.10%	7.40
		Advantages for end-users	11.05%	7.40
		Market demand	11.04%	7.40
		Social compatibility	10.63%	7.10

Theme	Sub-theme	Indicator	% score in sub-theme	Score
		Solution(s) to development issues	10.39%	7.00
		Technical compatibility	9.83%	6.60
		Ease of use for professional stakeholders	8.82%	5.90
		Trialability	7.69%	5.10
		Visibility of Results	7.25%	4.90
Smart Governance (134)	Planning and Regulation (27)	Smart Urban Planning	44.35%	12.00
		Smart City policy - the extent to which the project has benefitted from a governmental Smart City policy	34.13%	9.20
		Smart Identity Branding	21.52%	5.80
	Organization composition, process, leadership, and transparency (25)	Continued monitoring and reporting - The extent to which the progress towards project goals and compliance with requirements is being monitored and reported	19.27%	4.80
		Balanced project team - The extent to which the project team included all relevant experts and stakeholders from the start	17.53%	4.40
		Leadership- The extent to which the leadership of the project is successful in creating support for the project	17.16%	4.30
		Market orientation- The extent to which the project was planned on the basis of a market analysis	16.42%	4.10
		Clear division of responsibility- Has the responsibility for achieving the social and sustainability targets been clearly assigned to (a) specific actor(s) in the project	15.43%	3.90
		Involvement of the city administration- The extent to which the local authority is involved in the development of the project, other than financial, and how many departments are contributing	14.19%	3.50
	Transparent governance (24)	Satisfaction with transparency of bureaucracy	53.77%	12.90
		Satisfaction with fight against corruption	46.23%	11.10
	Community	Local community involvement in	21.16%	4.70

The me	Sub-theme	Indicator	% score in sub-theme	Score
	involvement in decision-making (22)	implementation phase- Extent to which residents/users have been involved in the implementation process		
		Participatory governance % Share of population participating in online platforms	16.37%	3.60
		Professional stakeholder involvement- The extent to which professional stakeholders outside the project team have been involved in planning and execution	15.96%	3.50
		Participation by social media	13.69%	3.00
		Share of female city representatives	12.60%	2.80
		Importance of politics for inhabitants	11.17%	2.40
		City representatives per resident	9.04%	2.00
	Public and social services (20)	Reduction in waiting time to obtain services	38.15%	7.60
		Trading platform for public resources	32.40%	6.50
		Expenditure of the municipal per resident for public and social services	29.45%	5.90
	Governance fragmentation (16)	Infrastructure Alignment	35.97%	5.80
		District Regeneration	32.80%	5.20
		Governance orchestration	31.23%	5.00

Note: This list comprised of Performance Measures (indicators) suitable for SMCPC, can be applied to emerging Smart Cities in Sri Lanka based on the scores (which are given considering the data availability and their significance to the Sri Lankan

In construing the results, the researcher recommends to evaluate the score horizontally, under the respective subthemes. The reason for this can be explained with the climate resilience measures- the extent to which adaptation options have been considered in the project, under smart environment which yielded 21 score as the it was the only indicator under its subtheme. So, if the scores of indicators are compared against the indicators in different subthemes/ themes, an incorrect impression is expressed. Therefore, the indicators should be compared only under the same subtheme, just like it was marked by the survey respondents.

With the mean scores for each theme, subtheme and indicator the scoring system was developed for the Performance Measures. It can be argued that higher the scores the Performance Measures obtain with regards to indicators belonging to subthemes under each theme, higher significance of Performance Measures and a higher chance of the availability of data is indicated. The comparisons can be done between themes but not between subthemes/ indicators under different themes. The scores of indicators and subthemes should always be compared within each subtheme, each theme, respectively. The scored list of the Performance Measures should be referred whenever the Performance Measurement System is applied to Sri Lankan Smart Cities. It is recommended to review the scoring system against the availability of data prior application, as with the need the data may become available for certain applications in the future. However, for the time being the scores are allocated considering the current data availability and therefore the system can cater immediate application need.

4.6 Barriers to implement a Performance Measurement System to SMCPC: Findings from preliminary interviews (Stage 1)

Implementation of the Performance Measurement System to SMCPC comes with several challenges. They were reviewed to a certain extent linking literature evidences by relating common barriers of Performance Measurement implementation to the Smart City context. Subsequently, the identified barriers were given to the experts in preliminary interview round to add more of the barriers they would think of. Following an analysis on a combined set of barriers list, the experts were requested to provide suggestions to those barriers in the case study interview round. The barriers identified in the preliminary round can be illustrated through a cognitive map as follows in Figure 4.13;

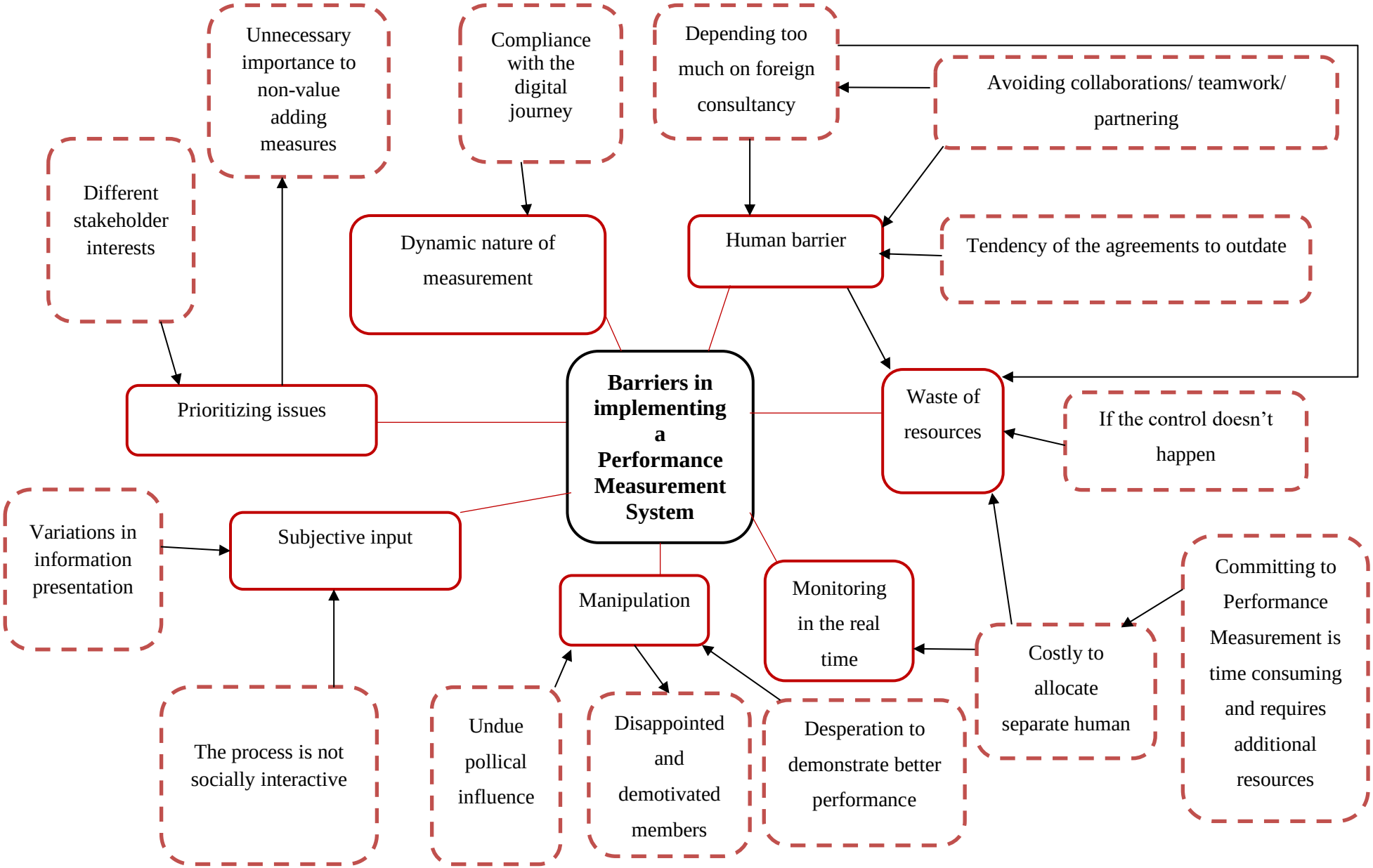

Figure 4.13: Cognitive map on barriers to implement a Performance Measurement System to Sri Lankan Smart Cities

One of the most important steps in Performance Measurement procedure is the monitoring of performance measures. The established measures will be compared with the monitored results so that actions can be taken. I8 raised concerns over this monitoring task “who is going to monitor the results in real time should be clarified”. According to I10 who had similar concerns said “it shouldn’t be an additional cost to the EMC”.

The term monitoring often goes hand in hand with controlling. “I have experienced certain situations where all costly resources were assigned for the measuring performance and the feedforward didn’t happen” said I8 who mentioned about the likelihood of a resource wastage when the true benefits of Performance Measurement were not considered. Therefore, the risk of resource waste would be there as a result of not having strategic objectives tied to the performance management process.

As Smart Cities involved a digital ecosystem, it needs to be a collaborative work. However, as per the experts, collaborations are not long lasting in Sri Lanka due to various reasons in the usual conduct of work. Adding to the issue I3 mentioned “Mostly the distinct parties have trust issues and they are not flexible as much as they should be”. This leads to settling with agreements which are rigid and bureaucratic. I2 added “agreements can outdate quickly which becomes a major problem as this involves technology which develops rapidly”. I9 describing this human barrier brought in the google maps example. According to her “even when dynamic personalities are there having knowledge about the roads in our own country, it was the Google who mapped out the road network. Google did as a teamwork giving small tasks to small teams which would have been harder for a Sri Lankan company.”.

Similarly, the local consultants seemed to be a bit disappointed about the current trend of recruiting foreign consultancy other than locals working together getting use of their knowledge and expertise. “the same existing resources are what the them experts combine, only thing we don’t trust on the combining part done by our resources. I believe our collective effort can do a lot than what an outsider does”

added I5 highlighting the harm the human barrier could do ultimately leading to costly acquiring of resources that doesn't add value than the existing resources.

In the actual application of the Performance Measurement System in SMCPC context, results manipulations may take place. As the SMCPC is a center of public interest as well as global attention, Performance Measurement would be an ideal source that provides evidences about the developments and gaps between expected and actual performance. In order to prove that the city is well performing, the responsible parties of even ill performing aspects might try to manipulate data and pretend. This can affect negatively to the improvements as actions cannot be taken to the actually ill performing sectors when they are hidden. Further one of the mostly mentioned comment was the possible influence from politicians. I10 representing most of the experts' opinion said "there's no guarantee that corrupted politicians do not unduly influence the Performance Measurement too, just like it happens everywhere in the public sector". Adding to that matter I13 said "There is a higher chance for the members of such sectors to feel disappointed and lose trust." Apart from the manipulated results, another way that correct results do not get exposed is because of the human errors in reporting and data feeding.

It is no doubt that each indicator in the Performance Measurement System can be interpreted differently. However, the indicators are developed in a way that it allows efficient and effective conversion of data into meaningful information which is supposed to be transformed into knowledge and ultimately provide the basis for real wisdom. For that everyone should be directed on the correct path so that biasness from policy makers' end does not happen. "I find the lack of social interaction in forming indicators is the main reason that gives the chance for the subjectivity component to affect the final results. When a transparent process makes all the policy makers aware about the true needs of the indicators, purposely or mistakenly the reviewers cannot interpret things in their own way" added I2. The variations in the final conclusions and reports therefore is a major barrier.

In Smart City related Performance Measurement System which takes a holistic view, prioritizing can be considered mandatory by looking at the trend. "Most of the

successful Smart Cities prioritize their underlying requirements and purpose to have a Smart City" specified I14, in describing the issues which may encounter in prioritizing the interests of different stakeholders and dimensions of a Smart City. If the prioritization is ignored non value adding indicators may also get the similar importance, the value adding indicators receive. Although this study provides a generic Performance Measurement System at some point in the actual application the themes will need to be prioritized so that the most suited indicators will be given an emphasis and thereby the resources can be utilized. Yet this prioritization can be a tedious task as several groups of stakeholders having conflicting interests/ comforts/ benefits get affected differently positively or negatively with the prioritization. Therewith the decisions are critical and challenging.

As Smart City development involves a digital journey and rapidly developing technology there's a higher chance that the indicators getting outdated and thereby the Performance Measurement System. Therefore, the dynamic nature of performance measures needs to be taken in to the account and they should always be in long term plans. This becomes quite challenging in certain contexts specially in the SMCPC where the measures largely depend on the long-term vision of the smart experts who are engaged in the city.

4.7 Solutions to the identified barriers: Findings from Case Study (Stage 2)

Through the obtained opinions as solutions to the identified challenges, it can be seen that the solutions are generic and interrelated. In other words, the solutions stipulate on improving the Performance Measurement in SMCPC without making it a burden. Therefore, the solutions are analysed as a whole and presented under the following topics.

4.7.1 Making Performance Measurement relevant

The performance measures should be first aligned with the Smart City's strategy. Therefore, the Performance Measurement System developed for SMCPC has been checked against the SMCPC's objectives and the same needs to be done for the generic Performance Measurement System as well. Further the process should be

made relevant to all the involved individuals as well. I7 added “there should be responsible parties who manage the individuals in digital ecosystem who are involved in various aspects of the Smart City, these individuals should be clear on how their work is related to measurement and how their actions affect the results”. In order to do this a systematic and integrated approach should be taken aiming great advantages by creating a synergy. I1 suggested a practical way of doing it through “initiating meaningful discussion to educate all the policy makers and team players in the digital ecosystem in the city regarding performance measures”.

4.7.2 Prioritizing

In the Smart City context Performance Measurement is mostly about learning and improvement. While the performance measuring in SMCPC is possible to be a responsibility of one organization (possibly EMC), the organization can facilitate the Smart City to be smarter but facilitating would not be measured as a performance in the Smart City. The smartness would be the basis for the Performance Measurement in the Smart City, which cannot be done overnight by the individual of the organization. Making a city smarter would be a responsibility of the policy makers in the initiation and thereafter by the organization that administer and manages the city while facilitating other smart features to branch out with the interests of different external organizations. Therefore, the stakeholders majorly involved would be the policy makers, individuals in the digital and urban ecosystem that manages/ administer the city. Managing conflicting interests put forward by the them stakeholders need effective stakeholder management. “Prioritizing the stakeholders’ interests should be done in the initial stage and should be appropriately communicated too” added I6.

4.7.3 Using right performance measures

Emphasizing another important aspect which requires prioritizing I1 added “most importantly, if the comprehensive Performance Measurement System is to be used, the themes should be prioritized so that the optimal resource allocation can happen”. By means of having the right mix, accurate targets can be set and the resource wastages can be avoided. The solution to the barrier of monitoring in the real time as

supposed by the experts was also to predetermine the right set of leading and lagging indicators to measure and monitor performance so that repetitions do not occur. “The lengthy nature of the process can also be reduced by avoiding repetitions” said I1. One way to identify the right indicators as per I5 is by looking at the required resource and energy consumption. Adding to 15’s comments I4 said “the right performance measures will be efficient in themselves will not consume energy and resources unnecessarily in measuring performance”.

4.7.4 Taking an integrated approach

An integrated approach provides means for policy makers with different perspectives to come to a single platform and present multiple views, eventually resulting in obtaining the bigger picture. “The integrated approach in decision making regarding the appropriateness of different indicators in the Performance Measurement Systems developed from this study to a particular Smart City context would be the one ideal way with which it allows you to develop targets rigorously or independently” said I3 emphasizing the importance of working together. According to most of the experts, this further ensures setting city wide objectives and maintaining the consistency

4.7.5 Improving transparency

According to I3 who represented the opinion of I11, I12 and I7, “the degree of openness of measurement is one measure that demonstrate the maturity of a Performance Measurement System”. Having measurement data available to those who needs it, increases the accountability and credibility of the effort. That way the human errors and human barriers can be kept limited and the increased transparency gives motivation to the involved parties of the Performance Measurement procedure.

4.7.6 Adhering to appropriate codes of ethics

This was suggested to overcome the risk of results manipulation. Other than the solution to use targets and measures that are equally valuable and important to all stakeholders another suggestion given was to introduce random monitoring processes. However, it was seen that manipulation becomes a result of reward system and so that experts’ bear an opinion that the responsible partied before everything

should make sure such systems doesn't lead to manipulation. However, almost all the experts suggested an attitudinal change as a solution to achieve the true benefits which can lead to overcome the human barriers and dislike towards collaborations.

4.7.7 Adopting agile practices

Experts borne an opinion that this would be a solution to the dynamic nature and easily outdating performance measures. According to I2, agile practices include features like rapid obtaining of feedback, setting value-based priorities, working as small teams, engaging users to refine requirement. The most important feature is that this allows engaging the policy makers and the rest of the team including the city dwellers to come together and closely work through every few weeks for progress reviews and mainly to address the issues encountered. "The frequent interactions allow implementing modifications quicker so that faster revisions and relaunches take place" added I8.

4.8 Discussion on the case study and preliminary interview findings

The research outcomes so far can simply be put in a nutshell in terms of the suitability of the Performance Measurement System to the SMCPC and the enablers, barriers and solutions for the barriers in implementing Performance Measurement Systems to Smart Cities. The following analysis involves discussing the obtained findings with the use of literature mentioned in Chapter 2 as well as the literature from outside that could support the findings.

4.8.1 Importance of implementing a Performance Measurement System to Sri Lankan Smart Cities

Performance Measurement is not so new to Sri Lanka or more specifically to the public sector in Sri Lanka. The nature of responses from the experts who were involved throughout the data collection procedure proves the fact. The evidences were found Sri Lanka regarding a comprehensive Performance Measurement System which has been piloted in 2006/7 with 4 key line Ministries (Education, Health, Agriculture, Highways) (Putu, Jan van Helden, & Tillema, 2007; Sivagnanasothy, 2010). Furthermore there were evidences that several industries practicing

Performance Measurement in their operations. Some of which includes, apparel industry (Malmadana Kapuge & Smith, 2007; Perera & Perera, 2013), banking sector (Nimalathasan, 2009), manufacturing industry (Dilanthi, 2013), smart parking sensor network (Bandara, et al., 2016), smart disaster risk management approach (Ibrahim, 2010). However, there has been no clue with regards to the use of Performance Measurement in Smart Cities sector in Sri Lanka. Although the Smart Cities concept being an emerging one, logical reasoning to proceed with a research on Performance Measurement was not hard to find.

According to Neely (2005), the key contributors in Performance Measurement are now entering a phase where theoretical verification and empirical investigation of core concepts are largely appreaciated. Even in the Smart Cities scenario it can be seen that research projects being carried out alongside or prior to the implementation of performance measurement. One famous example is the Giffinger, et al.'s (2007) study. Knowledge that could transfer from the research, as a reliable scientific basis, to the actual application of that study is known as the most valuable source that a researcher would provide to a policy maker (Fothergill, 2000). Therefore the knowledge that is transferred from this research could help the practitioners in the Smart City discipline also to make informed decisions.

In addition to the support this study as a research renders, in convincing parties and obtaining approvals, the information produced as a result of Performance Measurement would also equip the policy makers and other parties in Smart City ecosystem with information with which solid evidence-based decisions can be made. This nature of performance data was described in 2.51 Improved decision making and 2.52 Supported strategic planning and target setting as well. They were presented as facts under 4.5 enablers to implement a Performance Measurement System to Sri Lankan Smart Cities. It can be seen that the most of the facts under 4.5 subsection are particularly to the Sri Lankan context where the initiation is the foremost stage in the Smart City case as all of the Smart Cities are just emerging and are in the feasibility stage. Therefore, the reasons that the respondents identified that could be enablers are mostly about the tasks that come in the feasibility and planning stage. For instance, the enablers like better convince, selecting and directing the team,

usefulness in defining scope, usefulness in setting goals. Apart from 2.52 these aspects were discussed under 2.51 City benchmarking as well. In Caird & Hallett's (2019) study the describes the vitality of having a "logical" system that links activities and their direct/indirect effects, outcomes, outputs and impacts with recognition of contextual factors in the initial stage of Smart City development which involves setting objectives, grouping stakeholder interests, articulating key questions, setting up the evaluation logistics and clarifying impact dimensions, the same which are brought in by the respondents in preliminary interviews.

4.8.2 Barriers to implement a Performance Measurement System to SMCPC

It is no wonder when the locally available experts who have gained experience working in foreign Smart Cities, conducted/ participated international workshops on Smart Cities, being confident about their knowledge. The experts believe that they have the know-how and therefore are quite not happy about the unnecessary dependency on foreign consultancy/ expertise. In Li, Easterby-Smith, Lyles, & Clark's (2016) study describes how absurd it is to not tap the locally available knowledge which is less expensive when compared to foreign expertise. However, findings of Markusen & Trofimenko's (2009) study says that foreign consultancy generates long-term productivity effects and not just offering a "temporary help" when domestic skills are not up to the satisfactory level. Therefore, the professionals in Smart City development projects could rethink specifying this as a barrier and should rather seek for foreign expertise for the aspects where local expertise is absent so that the optimal results can be ensured both in short term as well as long term.

The phrase "Inter organisational collaboration and networking" is often found in elaborating the Smart City concept and known challenging to sustain (Errichiello & Marasco, 2014). It is these operational and institutional collaborations that foster the development of Smart Cities by influencing the innovation ecosystem through the teamwork of main stakeholders alongside sharing resources, governing co-developments and safeguarding knowledge flow (Bakici, Almirall, & Wareham, 2013).

In barriers identified from literature under 2.82 point it was discussed that Performance Measurement procedure is costly and acquire resources largely. Resource demanding nature and demotivation the individuals feel after not making correct use of the efforts they have made on Performance Measurement was discussed under the study on "Performance Measurement in nonprofits: much to be gained or a waste of resources?" (Larsson & Kinnunen, 2008). In several sectors Performance Measurement criticized for evaluating only the measures the organizations can control (Hervani, Helms, & Sarkis, 2005). On the other hand, making no use of feedback on Performance Measurement data for betterment has also been criticized (Cavalluzzo & Ittner, 2004).

When performance measures are connected to an entire government jurisdiction, for instance, in a city, the particular measurement system tracks the performance over a number of services, departments, etc. such as cities' health system, transportation system, etc. which makes performance monitoring a complex task and requires people assigned for regular basis monitoring (Newcomer, Hatry, & Wholey, 2015). The time and cost of performance can be therefore higher owing to the effort spent on monitoring (Chan, 2003). Being a city, this applies to Smart City context as well.

The need of a dynamic Performance Measurement System for high tech industries is described in Lee & Lai (2007) 's research. Smart Cities encompassing new types of innovations developments (Schaffers, Komninos, & Pallot, 2012), require the Performance Measurement System also to be regularly updated and act comprehensively in the dynamic environment. This would require somewhat of an effort which is challenging as per the experts. According to Bititci et al. (2000), absence of a structured Performance Measurement System, lack of flexibility in the platform to allows organisations to efficiently and effectively manage the dynamics and inability in quantifying the relationships between measures within the system are the main barriers for an organization to adopt a dynamic approach in performance measurement. However, as this Performance Measurement System ensures that Performance Measurement course remains integrated, updated and sensitive to external changes at all times, the challenge will be limited. In fact, Ankrah & Proverbs's (2005) study implied it is mostly up to party that measure performance

and appropriately refine the criteria when the Performance Measurement System includes dynamic measures.

Large number of studies discuss methods to prioritise key performance indicators in a Performance Measurement System alongside effectively managing different stakeholder interests due to the largely raised concerns on that in the journey of successful performance measuring (Vachnadze, 2016). Moreover, the vital issue of understanding the most critical stakeholder needs that comply with smartness objectives in the Smart City is commonly discussed as a general challenge in Performance Measurement regardless the industry (Arena, Azzone, & Bengo, 2015). Similarly, manipulation of results and subjective content are that common and the possible manipulation are to a certain extent accepted and provided measures to minimize (Arya & Glover, 2008).

4.8.3 Solutions to the identified barriers

According to Amaratunga, Baldry, & Sarshar (2001), an instrumental Performance Measurement System should essentially reflect the objectives and strategy of the organization to which it is applied. However, one reason even carefully outlined Performance Measurement Systems to go wrong is when they assume the existence of clearly stated objectives and strategy of the organization to where it is applied (Li & Tang, 2009). Further the inconsistency of the stated strategy and undertaken strategy leads the Performance Measurement System to fail (Parker, 2000). While the experts mentioned that performance measures should be in line with the organisational objectives, the literature emphasised the importance of having a firmly established strategy and objective before outlining performance measures. Therefore, formulating the organisation's strategy and objectives should be the starting point in matching the performance measures with that (Johnsen, 1999). Further the importance of the clarity of performance measures and making all the parties aware about the impact of different performance measures is widely discussed (Ittner & Larcker, 2003; Lau, 2011; Wang, Law, & Chen, 2008). Working together as a team having roles and tasks understood is is difficult yet an effective way of designing

effective team-based Performance Measurement Systems (Mendibil & MacBryde, 2005), which can be mostly relevant to SMCPC.

Moreover, in Tung, Baird, & Schoch's (2011) research the importance of collaborative approach in improving performance as well as measuring performance is specified. With an integrated approach Performance Measurement can be made productive in terms of joint planning and decision making, process integration, enhancing each other's capacity for mutual benefits and to focus on the common purpose and share resources (Pekkola & Ukko, 2016).

Kostakis, Bauwens, & Niaros (2015) in their study promotes having social enterprises established within Smart Cities aiming long term development and sustainability instead of seeking easy financial gains. In fact social enterprises have similar characteristics that Smart Cities have, like, principle aim having to serve the community to upgrade wellbeing, participative management, involvement of heterogeneous set of stakeholders, etc. (Defourny & Nyssens, 2007). In addition, social enterprises are diversified as they operate in various fields such as commercial and financial services, health and social services having different organizational structures and relationships with different sectors (Alter, 2007), just like in the case of Smart Cities. Arena, Azzone, & Bengo (2015) identified the need of managing and prioritising different information needs, different metrics for evaluating performance and basically all expectations from stakeholders resulted in due to the aforementioned diversification.

According to Behn (2003) appraising the most significant performance measures is such a complicated task as some measures which are particularly suitable for one purpose may not be useless at all for another purpose. One suggestion given is to identify key processes in the organization, value adding areas and indicators that can influence these processes and areas so as to select an appropriate set of performance measures directly linked with the organisational performance (Gunasekaran & Kobu, 2007). In translating theory in to practice the measurement practitioner has to carefully decide the right mix of performance measures including how each measure

should be specified, to which level of details should be look for, how often they ought to be measured, etc. (Tangen, 2004).

Performance Measurement indeed is one way which can bring transparency to public sector (Bruijn, 2002). Strengthening accountability of an organisation's operations through the transparency maintained in Performance Measurement process is known as an important part which measurement practitioners shouldn't missed (Melitski & Manoharan, 2014). However, measuring performance create negative consequences no matter the control extended and general remedies mentioned in Grizzle (2002) study were related to The American Society for Public Administration's Code of Ethics, The International City/County Management Association's Code of Ethics and the Government Finance Officers Association's Code of Ethics, demonstrates the importance of adhering to measurement practitioners' own set of code of ethics. Experts suggested a best practice so as to adopt characteristic of agile practices and the features of agile practice are described related to Performance Measurement in several studies. For example, rapid obtaining of feedback (Mausolff, 2004), setting value-based priorities (Gunasekaran & Kobu, 2007), working as small teams (Laitinen, 2002), engaging users to refine requirement (Taticchi, Cocca, & Alberti, 2010).

4.8.4 The Suitable List of Performance Measures for the SMCPC

The Performance Measurement System (see Figure 4.10) is referred together with the list of Performance Measures (see Table 4.3). The Performance Measurement System comprised of 7 themes, namely, Smart Economy, Smart People, Smart Living, Smart Governance, Smart Mobility, Smart Environment and Propagation, with a special emphasis on people factor (Smart People), technology factor (Smart Mobility: ICT infrastructure) and the critical success factors as mentioned in Propagation theme. The interrelationships between the themes are shown. The list was prepared mainly based on Giffinger et. al.'s (2007) Performance Measures although several Performance Measurement Systems were referred (see 2.6 Evaluation of Performance Measurement Systems in Chapter 2).

Hamza (2015) who has done a study on Smart Cities in developing countries used the Performance Measurement System developed by Giffinger et. al. (2007) as a base to develop a Performance Measurement System to Egypt. He has included smart economy, smart people, smart governance, smart mobility and connectivity, smart environment, smart quality of life, smart institutions, smart infrastructure while emphasising the four development processes: community development, economic development, political development, and ecological development and specified that weight and description of each of these themes may differ depending on the economy, political, and social condition of a country/ city/ society. Similarly, Vu & Hartley (2018) who have studied about Smart Cities in developing coutries have considered smart economy, smart human capital development, smart governance, smart environment and smart infrastructure as suitable to Vietnam. One another study on Smart Cities in developing economies, highlighted the underdeveloped community needs in India and came up with themes energy management, health hazard management, urban mobility, water supply sanitation, solid waste management, storm and rain water harvesting, electricity, internet and telephone, urban development, education, entertainment and good sports facilities and social media (Chatterjee & Kar, 2015). Another study which was done based on developing countries where the case was Brazil mentioned the themes under political and governance, technological and sociocultural aspects (De Mello Miranda, da Cunha, & Pugas Filho, 2016). In Kono, Suwa, & Ahmad's (2016) study which studied ways of adopting SC principles in developing country cities considered energy, water, transportation and waste under various economic conditions. It can be seen that all the themes the aforementioned researchers have considered in their studies, have been covered in thein the list of Performance Measures for SMCPC which is the most important component in the developed Performance Measurement System for SMCPC. In addition to that, considering the fact that proposed Smart City is emerging not just from a developing economy/ country but aiming a world class city the Performance Measurement System incorporated possible future developments as well. In fact, according to Peris-Ortiz, Bennett, & Yábar (2017) developing countries sometimes embrace possible Smart City innovations faster and successfully than developed countries.

The experts talked about “an open API which contains a wide range of rich data that can instigate creative projects to emerge from public”, when discussing projects funded by civil society. In Hamilton & Zhu’s (2017) study which was about funding and financing Smart Cities, this was further explained as financing though data monetizing where the third-party developers who are willing to develop applications using city data are charged for data access. Hamilton & Zhu (2017) brought in the parking space app as an example. Further, Paskaleva (2011) mentioned that open ‘digital citizen-developer’ communities are important in Smart Cities to trigger open innovation in urban development.

As discussed in 4.4 Suitability of the listed Performance Measures : 4.41 Smart Economy, the modifications on certain Performance Measures can be discussed relating to the literature. Both problems and solutions in the Smart Cities have an impact on all stakeholder groups directly or indirectly, although to differing extents; and so are the financial benefits (Marrone & Hammerle, 2018). In understanding the financial performance of Smart Cities, it is important to look at the economic benefits main stakeholder groups get in return for their investment and hope (Babar, 2016).

Although incubators, Science and Technology (S&T) parks, technology transfer and innovation centres were not a part of the initial CPC plan, they were kept when raised as indicators since they have a development potential. Santos (2018) names them as knowledge intensive structures which should be placed in a Smart City to capitalise the knowledge stock which is a productive and cost-effective way to conduct research, develop technology, and encourage new businesses.

Business and job creation are two of the economic outcomes of Smart City initiatives while fostering economic growth and attracting skilled workforce (Alawadhi et. al., 2012). Further, the jobs created due to Smart Cities are more towards white and collar jobs while the usual blue-collar jobs that are in demand for city services remain (Bronstein, 2009).

The profitability of a Smart City project can be important for the investors of that project, yet, does not indicate the smartness of that city (Cosgrave, Tryfonas, &

Crick, 2014). Although Net Present Value (NPV) and the Internal Rate of Return (IRR) are suitable tools to evaluate the profitability of a project (Perrone, 2014), as per the experts they may not indicate the smartness. Further, just as experts mentioned, GDP can be a measure of sector strength of smart services (Barrionuevo, Berrone, & Ricart, 2012).

Some of the modifications on certain Performance Measures in Smart Living theme as discussed in 4.4 Suitability of the listed Performance Measures: 4.43 Smart Living can be related to the literature. According to Harrison (2017), the assumed users of the Smart City can be expecting and willing for a luxurious living or longing for a one step above the existing poverty, regardless the both situations, the understanding of the citizen–technology relationships must be reached. However, even in the luxury living condition, the housing costs and disposable annual household income may reflect the smartness of a Smart City as the smart features should have the affordability along with their beneficial use (Gascó-Hernandez, 2018).

Emerging Smart Cities have a tendency to use of “smart cards” for payment as a convenient way to the customers as the transactions become “cash less” (Singh, Mathur, Das, Sinha, & Singh, 2017). People in a Smart City with their flexibility can achieve greater efficiencies with the laissez faire growth for which any country should also do a cost benefit analysis beforehand (Batty, et al., 2012).

Factors that upgrade the lives of Smart Cities’ citizen is one reason that can leverage the society's potential to appeal talented employment (Stratigea, 2012). Some researchers look at Smart Cities as a combination of facilities (Marcus & Koch, 2016). Reducing waiting time, service delays and lengthy queues have been a trend adopted by Smart Cities and mostly been discussed with reference to smart mobility (Munir, Abedin, Alam, Tran, & Hong, 2018). While Intelligent Transportation Systems and related technologies are deployed globally in Smart Cities, connected and autonomous vehicles and fully automated transportation systems are under wide field testing (Menouar, et al., 2017). When a Smart City is activated with its safe city applications theft and crime would no longer take place; a recent example is Barcelona (Bakıcı, Almirall, & Wareham, 2013). Further, the citizens in the Smart

City will hold their right to contribute or actively participate in the political arena and at the same time more importantly they should be satisfied with the practice (Vázquez & Vicente, 2019)

4.9 Summary

The collected data are analysed until it forms two lists of performance measures; 1) to be used in the performance measurement in SMCPC and 2) to be used in the performance measurement in emerging Smart Cities in Sri Lanka. The Performance Measurement System formed could be used in both the situations and the suitable list should be referred in each respective case. Further the importance of implementing a Performance Measuremet System can be used to convince any related party in the Smart Cities scenario. The provided solutions can be used in the case where barriers are encountered during Performance Measurement in Smart Cities.

CHAPTER 05

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The chapter purposes to conclude the research findings by providing shrewd recommendations farsightedly. The limitations to achieve the research objectives are mentioned as well. Additionally, the suggestions to carry out further studies and the unearthed and barely researched concept are also specified.

5.2 Conclusions under the research objectives

Under each research objective as mentioned in aim and objectives (Section 1.3), their conclusions and followed methodology are presented described as follows;

5.2.1 Objective 1: To investigate the characteristics of Smart Cities globally and with particular reference to Sri Lanka.

This objective was achieved through several step as it consisted two main parts; a general study on smart characteristics through Section 2.3 Characteristics of Smart Cities and Section 2.7 A Comprehensive list of Performance Measures for Smart Cities and specific smart characteristics applicable to Sri Lanka through Section 4.4 Suitability of the listed Performance Measures (from literature) to SMCPC, Section 4.5 Suitability of the listed Performance Measures of SMCPC to general Sri Lankan context and Section 4.8.4 The Suitable List of Performance Measures for the SMCPC. As there were no literature evidence found regarding the Sri Lankan case, only the general study was done with the literature review. Alternatively, for the Sri Lankan case the smart characteristics were identified from the case study (Section 4.4 Suitability of the listed Performance Measures (from literature) to SMCPC) and questionnaire survey (Section 4.5 Suitability of the listed Performance Measures of SMCPC to general Sri Lankan context). While there was no consensus reached regarding the characteristics of Smart City, this study has taken three approaches to investigate smart characteristics. That was to explore the literature evidences through studying elements that formed Smart City definitions (Section 2.3.1 Elements of

recent Smart City definitions), by reviewing similar city conceptualisations (Section 2.3.2 Comparison of city conceptualisations with Smart City initiatives) and by examining Performance Measurement Systems for Smart Cities (Section 2.7 A Comprehensive list of Performance Measures for Smart Cities). In studying Smart City definitional elements ten Smart City definitions that were put forward in year 2019 were selected. As the concept was said to be an evolving one only the most recent definitions were selected. In essence two mainstreams ICT and technology-oriented approach and people-oriented approach were identified under which the characteristics like aims to upgrade the quality of life of its citizens and sustain the urban system development; urban innovations; critical infrastructure and information management; modern advanced and intelligent ICT applications; sustainable urban environment, satisfaction and well-being of citizen, encouraged community participation, optimum utilization of resource, well-performing governance, sustainable economic growth, etc. were presented. Thereafter, similar city conceptualisations like digital city, intelligent city, ubiquitous city (U-city), global city and sustainable cities were compared with Smart City concept to identify the unique Smart City characteristics. Similarly, the Performance Measurement Systems for Smart Cities contained smart characteristics in the form of performance measures/ indicators. Therefore, they were identified with the thorough review of existing Performance Measurement Systems which was done as a part of achieving objective three. Consequently, this approach was the ideal to identify the characteristics of a Sri Lankan Smart City as well. Therefore, at the end of Objective 4 the smart characteristics for the Sri Lankan context will also be represented in the form of the Performance Measures in the Performance Measurement System for Sri Lankan Smart Cities.

5.2.2 Objective 2: To investigate the importance of Performance Measurement in Smart City development.

The first objective was accomplished with the literature review (Section 2.5 Importance of Performance Measurement in Smart City Development) where it was identified that Performance Measurement is important to Smart Cities context as well, just like it is in all other industries. The importance was discussed under several

topics namely, performance management, monitoring and control, improved decision making, accountability, strengthened local democratic institutions, supported strategic planning and target setting, improved communication, continuous improvement, overall success of the organisation, funding purpose, city benchmarking, politically valuable outcomes in contested environments and civic support for public efforts. Performance Measurement is important as it gives the basis for performance management in a Smart City. With Performance Measurement better monitoring coupled with a controlling procedure and better communication among individuals is facilitated. A Performance Measurement System could be used as a guidance tool in determining the benchmarks, strategic planning and target setting. Further to the literature findings, in preliminary interviews the respondents were asked the reasons for this study to proceed. Their reasoning also added new facts to the discussion on the importance of Performance Measurement to Smart Cities with particular reference to the Sri Lankan case, and therefore highlighting the benefits of Performance Measurement in the initial stage of emerging Smart Cities. The respondents highlighted the scientific backup an evidence based study could bring in the Smart City development stage which involves obtaining approvals/ funds, making parties understand, etc most of which can be easily done with better convicing through a research done before the practical application of the Performance Measurement System. In addion to that the other benefits include the ease in selecting and directing the team, usefulness in defining scope, usefulness in setting goals, guidance and motivation to the team and monitoring and control.

5.2.3 Objective 3: To synthesize different Performance Measurement Systems for Smart Cities.

This was purely done by the literature synthesis (Section 2.6 Evaluation of Performance Measurement System for Smart Cities) and provided a base to achieve Objective 4. Out of several Performance Measurement Systems for Smart Cities, 8 were selected. The basis for the selection was the holistic nature of the Performance Measurement System and its ability to cover all Smart City dimensions and not one/few. The selected Performance Measurement Systems were from the studies carried out under Bosch et al. (2016), Giffinger et al. (2007), Lombardi et al. (2012),

Komninos (2008), Merli and Bonollo (2014), Shen et al. (2018), Australian Government (2017) and Ambrosetti, (2012). From the existing Performance Measurement Systems seven themes were identified to be the most significant and they are smart economy, smart people, smart living, smart governance, smart environment, smart mobility and propagation. The existing Performance Measurement Systems were more or less looked alike containing three parts themes, subthemes under themes and Performance Measurement indicators. With the identified themes a list of Performance Measures for Smart Cities was produced which contained 256 Performance Measurement indicators. This was given to the experts to evaluate the applicability for SMCPC in the case study interview round.

5.2.4 Objective 4: To identify the barriers to implement a Performance Measurement System to Sri Lanka and recommended solutions to overcome the barriers.

Barriers were searched in a similar way the enablers were searched. It started with the literature review (Section 2.8 Barriers for Performance Measurement in Smart Cities) and thereafter in preliminary interview round again asked about (Section 4.6 Barriers to implement a Performance Measurement System to SMCPC: Findings from preliminary interviews (Stage 1)), together with the enablers (Section 4.3 Importance of implementing a Performance Measurement System to Sri Lankan Smart Cities). The listed-out barriers from literature review were Performance Measurement System implementation problems, increased cost over benefits, multiple interests of different parties engaged in a Smart City project, limitations and unavailability of technological implications that cause delays in information and automation issues in the process of Performance Measurement, difficulties in obtaining information including the lack of accessibility for databases, data availability and data management issues, privacy issues, increased workload to the individuals in the Smart City management organisation that intents to measure performance, problems due to the human involvement; for example, political undue interventions and influences, lack of integration and the internal resistance from the parties that are affected differently from Performance Measurement. Similar facts and some additional facts were obtained from preliminary interviews. The facts that

were not repeated in the literature review and were found from preliminary interview include, human barrier due to lack of trust on local expertise and dislike towards collaboration, waste of resources due to lack of control, problems with monitoring in real time, dynamic nature of measurement, prioritizing issues, subjective input and manipulation of results.

The experts in the case study round were requested to provide solutions to overcome the identified barriers. By looking at the barriers the experts have provided a set of solutions which can be also called as expert suggestions to improve the successful implementation of Performance Measurement or the best practices in implementing a Performance Measurement System in Smart City context. The suggestions are to making Performance Measurement relevant by ensuring the relevance of performance measures to Smart Cities' objectives and strategy and also by making sure the measuring practitioners and other involved parties are clear about the measures and individual impact on measures; prioritizing most appropriate measures, distinct stakeholder interests and information needs; using right performance measures and the right mix of lagging and leading indicators; taking an integrated approach by involving all parties for the process; improving transparency by making performance data available to the parties that need them; adhering to appropriate codes of ethics and adopting agile practices (described in Section 4.7 Solutions to the identified barriers: Findings from Case Study (Stage 2)).

All in all, the first Performance Measurement System developed is supposed to provide a guidance in refining objectives, measuring performance and overall decision making in developing the SMCPC whist the second Performance Measurement System which is having a scoring system will be useful in immediate use for emerging Smart Cities in Sri Lanka.

5.2.5 Objective 5: To develop a Performance Measurement System for Smart Cities in Sri Lanka.

The study consisted two development phases in producing a Performance Measurement System for Smart Cities in Sri Lanka. The first phase was specific to a unique case study in Sri Lanka and the second phase was generic and for an

immediate application. The first Performance Measurement System (Figure 4.10: Performance Measurement System suitable for Sri Lankan Smart Cities) which was produced aiming the SMCPC provided a base for the generic Performance Measurement System. The difference lies with the listed Performance Measures in the two scenarios. The first Performance Measurement System contained Performance Measures considering potential technological and social developments (Section 4.4 Suitability of the listed Performance Measures (from literature) to SMCPC and list without scores as per Section 4.5.3 Allocation of scores to indicators within the sub-themes), while the second Performance Measurement System (the generic Performance Measurement System with the scoring system) given less marks for the Performance Measures specific to SMCPC case and Performance Measures to which data weren't available in the current Sri Lankan scenario. However, even the second Performance Measurement System (list of Performance Measures) had provisions for customizing yet covered all dimensions in an emerging Smart City.

5.3 Recommendations

In terms of Smart Cities and Performance Measurement Sri Lanka is in a naïve stage and therefore, there is a room for improvement in technical aspects as well as attitudinal changes. While most of the solutions for barriers were presented in the form of recommendations, some of the generic recommendations are as follows;

5.3.1 Develop a Smart City policy

In the current stage Sri Lanka is lacking a Smart City policy. Having a Smart City policy Smart City laws and policies can be enforced so that they can detail on providing consent for data gathering, data protecting, how that data can be used / shared, privacy and personal information protection.

5.3.2 Maintaining databases

It is obvious that data plays the most vital role in Smart Cities. However, in Sri Lanka one of the challenges to work on Smart City initiatives and then Smart Cities, is the data unavailability. In most of the times the developments planned on the

infrastructure or services as an initiative to implement Smart Cities halt when the data required for development are lacking to proceed. One example was the cease of planned improvements on plumbing services as part of a smart initiative of a municipal council. Although this will not be a challenge for SMCPC being newly building city, for other cities in Sri Lanka, data should be in place and databases should be available.

5.3.3 Infrastructure development

Mostly the available infrastructures are not in a position to facilitate the smart initiatives/ smart services in Sri Lanka. SMCPC on the other hand has the competitive advantage of building the infrastructure completely from the beginning. Basic infrastructure network should therefore be improved prior planning Smart Cities.

5.3.4 University and organisational level awareness programs

The practices on Performance Measurement as well as knowledge on Smart Cities should be communicated to the lowest and most critical level in means of education. Therewith costly training can be avoided and the interested parties can further study and learn so that experienced professionals on these areas would be there, which is lacking in the current context.

5.3.5 Focus on nature based/ green infrastructure and provisions for disaster resilience

It can be seen that the developed Performance Measurement System doesn't consist anything related to the above two areas. However, it is obvious that Smart Cities having a higher initial cost should be sustainable. Therefore, disasters resilience needs consideration for other emerging cities as it is there in the SMCPC.

5.4 Limitations

The depth of knowledge on Smart Cities was almost untouched and barely known in the Sri Lanka which resulted in create of different interpretations on the themes/ subthemes and indicators. However, this was avoided by providing clarifications for

each and every indicator and by researcher attending to the interviews/ survey data collection, face to face as much as possible. Yet, the Performance Measurement Systems being lengthy as a result of making them comprehensive, given the limited time, surveys were limited to a small sample size. Similarly, most of the interviews were conducted for two days. Moreover, most of the information that are helpful in the study were not provided as they are confidential and the Smart City objectives and potential smart experts have changed from time to time since the start of this study. Therefore, the researcher while trying to update the information as much as possible had to collect data from all the smart experts. Further the experts were not familiar with the Battelle method and as a result some of the respondents have given marks without complying to the method. Most importantly, the impact of performance measurement is not longitudinal, therefore with the given period of one year of the study the results cannot be obtained and therefore the researcher is unable to do get benefits of a learning curve.

5.5 Further research

- Developing criteria to assess the smartness based on the scores

The scoring system developed through this study can be applied to any type of an emerging Smart City in Sri Lanka and it is supposed to define the smartness of such an emerging Smart City in Sri Lanka. However, there can be certain requirements some cities demand through Smart Cities and to cater the requirement several other smartness requirements may be overlooked, due to reasons like cost restrictions. As a result, the scoring system will not produce the full score. In such situations, those Smart Cities, will need an indication on their smartness for the scores they achieved. This needs to be studied further based on the case studies and past studies.

- Developing definitions and measurement criteria for the indicators

Indicators in the developed Performance Measurement System/ scoring system needs definitions for what exact aspects to look in to make the measurement standardized, so that the outcome can be compared with the other projects which

used these tools achieved from this research. For an instance; the indicator "An assessment of the ambitiousness of CO2 emission reduction strategy", needs further explainations on how to conduct this assessments, which data to be used and the measurement criteria relating to the Sri Lankan scenario through a further study.

A study which can provide a reliable scientific justification and generate the above two criteria will be essential for the practical applications of the Performance Measurement System/ scoring system for emerging Smart Cities in Sri Lanka.

- Developing Performance Measurement Systems weighting different themes particularly for certain cities

Even though the research outcomes define the smartness requirements for a Smart City in Sri Lanka, not having a shared definition entertains different suggestions by the Smart City experts. One such important suggestions the experts involved in this study mentioned is, every city need to find their suitable Smart City theme. In other words, cities should identify and prioritise the solutions that they need through Smart Cities and their competitive advantages that can be facilitated through Smart Cities for the development and sustainability of that urban ecosystem. Therefore, this study can be further developed based on the different themes that different cities emphasise on (for example: Performance Measurement System to develop a smart agriculture city in Anuradhapura).

- Developing a Smart City policy for Sri Lanka

This would be the most important study that is recommended from this research as it is the Smart City policy that can be termed as the heart in the development of Smart Cities.

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ANNEXURES

APPENDIX A -PRELIMINARY INTRVIEW GUIDELINE

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Dear Sir/Madam,

Research Dissertation – Interview Guideline (M.Sc. (by Research)

I am a postgraduate student of University of Moratuwa, reading for Master of Science (by Research). I am conducting a research titled "A Performance Measurement System for Smart Cities in Sri Lanka". This research is conducted under the supervision of Dr. Udayangani Kulatunga and Dr Dilum Bandara, Senior Lecturers at the Department of Building Economics and Department of Computer Science and Engineering respectively.

I have selected the proposed Smart City project in Colombo Port City as the case study and I am conducting interviews with key participants engaged in this project. The objectives of this study and the interview guideline are attached herewith.

I have identified yourself as a potential participant who could provide me valuable information to this research. Therefore, I would like to interview you for **approximately 60 minutes** in this regard. The medium of collecting data will be **note taking and audio recording (with the permission of the interviewee)** in order to collect data more accurately.

I strongly believe that you would support to my research by providing your views related to my research topic. **The information collected through this interview will be kept strictly confidential and should be used only for the purpose of the dissertation. Any of your personnel information will not be disclosed within the research.**

Thank you.

Aravindi Samarakkody

Postgraduate Student

Department of Building Economics

University of Moratuwa.

Tel: 077-5557666

Email: aravindilavanya5@gmail.com

EXPERT INTERVIEW GUIDELINE FOR PRELIMINARY INTRVIEWS

SECTION I - GENERAL INTRODUCTION TO THE RESEARCH

Research Title

"Performance Measurement for the Development of Emerging Smart Cities: The Case of Sri Lanka"

Research Aim

The aim of this research is to enhance the emerging Smart City development projects in Sri Lanka through an appropriate and holistic Smart City Performance Measurement Systems.

Research Objectives

Following objectives will be achieved to reach the above research aim.

1. To investigate the characteristics of Smart Cities globally and with particular reference to Sri Lanka.
2. To investigate the importance of Performance Measurement in Smart City development.
3. To synthesise different Performance Measurement Systems for Smart Cities.
4. To identify the barriers to implement a Performance Measurement System to Sri Lanka and solutions to overcome the barriers.
5. To develop a Performance Measurement System for Smart Cities in Sri Lanka.

SECTION II - BACKGROUND INFORMATION OF THE INTERVIEWEE

1. Profession:

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2. Designation:

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3. How long is your industry experience?

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SECTION III – PROJECT DETAILS

Please mention the basic project details you are aware which can be needful for this research project

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SECTION IV – ENABLERS AND BARRIERS TO IMPLEMENT A PERFORMANCE MEASUREMENT SYSTEM TO SMCPC

Please mention the reasons to proceed this research project (enablers to implement a Performance Measurement System to the SMCPC) and the potential barriers to implement a Performance Measurement System to the SMCPC

ENABLERS	**BARRIERS**

Following list includes some of the barriers identified through the literature review;

Implementation issues – implementation procedure is complicated and lengthy

Cost Vs Benefits - higher cost of implementation and introduction of Performance Measurement Systems with compared to its potential benefits

"Beauty is in the eye of the beholder" - complicated and diversified interests of different stakeholders, make the performance appraisal stage complicated and therefore detain the Performance Measurement implementation by requiring to make the critical decision with regards to prioritizing the stakeholders.

Technology aspects - developing countries have their limitations and unavailability of technologies which cause delays in information and automation issues in the process of performance measurement

Difficulties in obtaining information - difficulties to access different sources involves extra work and therefore either inaccuracies occur or the Performance Measurement System becomes completely useless without required information timely

Privacy issues - until the reliable application of new technologies, obtaining data without putting citizen's privacy endanger remains a problem

Workload - Performance Measurement usually becomes an additional effort which requires a proper training in respect to data collection, meaningful data management and reporting

Human involvement - subjectivity and human errors

Lack of integration – problems in linking organizational objectives to performance objectives

Internal resistance - when creating the conduct transparent in an organization, the members feel uncomfortable and in danger which then result in an internal resistance

APPENDIX B –CASE STUDY INTRVIEW GUIDELINE

COVERING LETTER FOR INTERVIEW GUIDELINE

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Dear Sir/Madam,

Research Dissertation – Interview Guideline (M.Sc. (by Research)

I am a postgraduate student of University of Moratuwa, reading for Master of Science (by Research). I am conducting a research titled "A Performance Measurement System for Smart Cities in Sri Lanka". This research is conducted under the supervision of Dr. Udayangani Kulatunga and Dr Dilum Bandara, Senior Lecturers at the Department of Building Economics and Department of Computer Science and Engineering respectively.

I have selected the proposed Smart City project in Colombo Port City as the case study and I am conducting interviews with key participants engaged in this project. The objectives of this study and the interview guideline are attached herewith.

I have identified yourself as a potential participant who could provide me valuable information to this research. Therefore, I would like to interview you for **approximately 90 minutes** in this regard. The medium of collecting data will be **note taking and audio recording (with the permission of the interviewee)** in order to collect data more accurately.

I strongly believe that you would support to my research by providing your views related to my research topic. **The information collected through this interview will be kept strictly confidential and should be used only for the purpose of the dissertation. Any of your personnel information will not be disclosed within the research.**

Thank you.

Aravindi Samarakkody

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EXPERT INTERVIEW GUIDELINE FOR ROUND ONE

SECTION I - GENERAL INTRODUCTION TO THE RESEARCH

Research Title

"Performance Measurement for the Development of Emerging Smart Cities: The Case of Sri Lanka"

Research Aim

The aim of this research is to enhance the emerging Smart City development projects in Sri Lanka through an appropriate and holistic Smart City Performance Measurement Systems.

Research Objectives

Following objectives will be achieved to reach the above research aim.

1. To investigate the characteristics of Smart Cities globally and with particular reference to Sri Lanka.
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3. To synthesise different Performance Measurement Systems for Smart Cities.
4. To identify the barriers to implement a Performance Measurement System to Sri Lanka and solutions to overcome the barriers.
5. To develop a Performance Measurement System for Smart Cities in Sri Lanka.

SECTION II - BACKGROUND INFORMATION OF THE INTERVIEWEE

1. Profession:

   ……

2. Designation:

   …..…….....

3. How long is your industry experience?

……..…….....

SECTION III – SUITABILITY OF THE SUMMARY PERFORMANCE MEASURES FROM LITERATURE TO SRI LANKA

(Please mark the suitability of each theme, sub theme, indicator and provide reasons for the unsuitability)

Theme	Suitability	Sub Theme	Suitability	Indicators	Suitability
SMART ECONOMY		Economic performance		Financial benefit for the end user	
				Net Present Value (NPV)	
				Internal rate of return (IRR)	
				Payback Period	
				Total cost vs. subsidies	
				Debt of municipal authority per resident	
		Innovation, Innovative spirit, and Innovation performance		Involvement of extraordinary professionals	
				Quality of open data	
				New start-ups	
				Improved interoperability	
				Employment rate in: High Tech and creative industries; Renewable energy and energy efficiency systems Financial intermediation and business activities; knowledge-intensive sectors; Culture and entertainment industry; Commercial services; Transport and communication; Hotels and restaurants; All companies (total number)	
				Number of local units manufacturing High Tech & ICT products	
				Patent applications per inhabitant	
				Number of incubators (per million of population)	
				Number of S&T Parks per million of population)	
				Number of Technology Transfer and Innovation Centres (per million of population)	
				Exports high-tech services per cent total exports)	

				New trade marks (per million of population)	
				Enterprises having internal R&D department (per cent of all enterprises)	
				Sales of new-to-market products (per cent of turnover)	
				Sales of new-to-firm not new o-market products (per cent of turnover)	
				New business models for smart growth and quality of life • New business models • Living Labs • Creative class • Web of Trust	
		Entrepreneurship		Self-employment rate	
				New businesses registered	
				Percentage of projects funded by civil society	
		Economic image & trademarks		Importance as decision-making centre (HQ etc.)	
		Production and Productivity		GDP per employed person	
				GDP per head of city population	
		Employment, Flexibility of labour market, Jobs and Skills		Increased use of local workforce	
				Local job creation	
				Unemployment rate	
				Proportion in part-time employment	
		International embeddedness		Companies with HQ in the city quoted on national stock market	
				Air transport of passengers	
				Air transport of freight	
		Equity		Fuel poverty	
				Costs of housing	
				Median or average disposable annual household income	
		Green economy		Certified companies involved in the project	
				Green public procurement	
				CO2 reduction cost efficiency	
				Energy intensity of the economy -gross inland consumption of energy divided by GDP	

		Attractiveness & competitiveness		Decreased travel time	
		Education and Research and Development		Public expenditure on R&D -percentage of GDP per head of city population	
				Public expenditure on education -percentage of GDP per head of city population	
				Number of research grants funded by international projects	
SMART GOVERNANCE		Organization composition, process, leadership, and transparency		Leadership	
				Balanced project team	
				Involvement of the city administration	
				Clear division of responsibility	
				Continued monitoring and reporting	
				Market orientation	
		Community involvement in decision-making		Professional stakeholder involvement	
				Bottom-up or top-down initiative	
				Local community involvement in planning phase	
				Local community involvement in implementation phase	
				Participatory governance	
				City representatives per resident	
				Political activity of inhabitants	
				Importance of politics for inhabitants	
				Share of female city representatives	
				Participation by social media	
		Multi-level governance		Smart City policy	
				Municipal involvement - Financial support	
		Governance fragmentation		Governance orchestration	
				Infrastructure Alignment	
				District Regeneration	
		Public and social services		Expenditure of the municipal per resident in PPS	
				Share of children in day care	
				Satisfaction with quality of schools	
				Trading platform for public resources	
		Transparent governance		Satisfaction with transparency of bureaucracy	
				Satisfaction with fight against corruption	

		Planning and Regulation		Smart Urban Planning	
				Smart Identity Branding	
SMART ENVIRONMENT		Attractivity of natural conditions		Sunshine hours	
				Green space share	
		Eco-sustainability		Increase in green and blue space	
				Increased ecosystem quality and biodiversity	
				Percentage of new buildings and renovation which were assessed in terms of sustainability	
		Environmental protection		Individual efforts on protecting nature	
				Opinion on nature protection	
				An assessment of the ambitiousness of CO2 emission reduction strategy	
				Carbon dioxide emission reduction	
				Reduction in lifecycle CO2 emissions	
				An assessment of the comprehensiveness of policies to contain urban sprawl and to improve and monitor environmental performance	
		Sustainable resource management		Efficient use of electricity (use per GDP)	
				The total percentage of the working population traveling to work on public transport, by bicycle and by foot	
				An assessment of the extensiveness of efforts to increase the use of cleaner transport	
				Percentage of citizens engaged in environmental and sustainability-oriented activity	
				The percentage of total energy derived from renewable sources, as a share of the city's total energy consumption, in terajoules	
				Proportion of recycled waste per total kilogram of waste produced	
		Energy & mitigation		Reduction in annual final energy consumption	
				Reduction in lifecycle energy use	
				Reduction of embodied energy of products and services used in the project	
				Increase in local renewable energy production	
				Combined heat and power generation percentage of gross electricity generation	

				Alternative Energy Master plan	
				Maximum Hourly Deficit	
				An assessment of the extensiveness of city energy efficiency standards for buildings	
		Materials, water, *land*, Ecosystem		Increased efficiency of resources consumption	
				Share of recycled input materials	
				Share of renewable materials	
				Share of renewable materials	
				Life time extension	
				Reduction in water consumption	
				Increase in water re-used	
				Self-sufficiency - Water	
				Increase in compactness	
		Climate resilience		Climate resilience measures	
		Pollution & waste		Decreased emissions of Nitrogen dioxides (NO2)	
				Urban population exposure to air pollution by particulate matter micrograms per m3	
				Decreased emissions of Particulate matter (PM2,5)	
				Reduced exposure to noise pollution	
				Reduction in the amount of solid waste collected	
				Summer smog (Ozon)	
				Fatal chronic lower respiratory diseases per inhabitant	
SMART PEOPLE		Level of qualification, Education and skills of the population		Importance as knowledge centre (top research centres, top universities etc.)	
				Population qualified at levels 5-6 ISCED	
				Foreign language skills	
				% of population aged 15-64 with secondary-level education living in Urban Audit	
				% of population aged 15-64 with higher education living in Urban Audit	
				% of inhabitants working in education and in research & development sector	
				Individual level of computer skills	
				Individual level of internet skills	
		Affinity to lifelong learning		Book loans per resident	
				Participation in life-long-learning in %	

				Participation in language courses	
		Social and ethnic plurality		Share of foreigners	
				Share of nationals born abroad	
		Flexibility		Perception of getting a new job	
		Creativity		Share of people working in creative industries	
		Cosmopolitanism and open-mindedness		Voters turnout at European elections	
				Immigration-friendly environment (attitude towards immigration)	
				Knowledge about the region/ country	
		Knowledge about the region		Voters turnout at city elections	
				Participation in voluntary work	
SMART LIVING		Cultural facilities		Cinema attendance per inhabitant	
				Museums visits per inhabitant	
				Total book loans and other media per resident	
		Health conditions		Improved access to basic health care services	
				Encouraging a healthy lifestyle	
				Waiting time	
				Life expectancy	
				Hospital beds per inhabitant	
				Doctors per inhabitant	
				Satisfaction with quality of health system	
		Safety		Reduction of traffic accidents	
				Reduction in crime rate	
				Improved cybersecurity	
				Improved data privacy	
				Crime rate	
				Death rate by assault	
				Satisfaction with personal safety	
		Education facilities		Improved/ satisfaction with access to educational resources/ system	
				Increased environmental awareness	
				Improved digital literacy	
				Students per inhabitant	
				Satisfaction with quality of educational system	
				No. of universities and research centers in the city	
				No. of courses entirely downloadable from the internet/total no. courses	

				Percentage of professors and researchers involved in international projects and exchange	
				Percentage of accessible courses for people with disabilities (PWD)	
		Touristic attractivity		Touristic Importance as tourist location (overnights, sights)	
				overnight stays in registered accommodation in per year per resident	
		Access to (other) services		Access to public transport	
				Quality of public transport	
				Improved access to vehicle sharing solutions	
				Extending the bike route network	
				Access to public amenities	
				Access to commercial amenities	
				Increase in online government services/ e-Government on-line availability (percentage of the 20 basic services that are fully available online)	
				e-Government usage by individuals (percentage individuals aged 16-74 who have used the Internet, in the last 3 months, for interaction with public authorities)	
				Proportion of the area in for recreational sports and leisure use	
				Number of public libraries	
				Number of theaters and cinemas	
		Diversity and social cohesion		People reached	
				Increased consciousness of citizenship and social coherence	
				Increased participation of vulnerable groups	
				Perception on personal risk of poverty	
				Poverty rate	
		Quality of housing and the built environment		Diversity of housing types	
				Connection to the existing cultural heritage	
				Design for a sense of place	
				Increased access to urban public outdoor recreation space	
				Increased access to green space	

				Share of housing fulfilling minimal standards	
				Average living area per inhabitant	
				Satisfaction with personal housing situation	
				Green Building Policies	
		Quality of life of the community		Public and community housing	
				Homelessness rate	
				Rent stress	
				Mortgage stress	
				Housing construction costs	
				Dwelling price to income ratio	
				Population change per building approval	
				Free time	
		Liveability and Sustainability		Adult obesity rate	
				Support in times of crisis	
				Suicide rate	
				Volunteering	
				Office building energy efficiency (New)	
				Access to public transport (New)	
		Added value city wide intelligent services		i-energy	
				i-transport	
				i-democracy	
				i-government	
				i-services	
				i-home	
		Quality of industry-based services		Number of enterprises adopting ISO 14000 standards	
				Proportion of people undertaking industry-based training	
SMART MOBILITY		Local accessibility		Public transport network per inhabitant	
				Satisfaction with access to public transport	
				Satisfaction with quality of public transport	
		(Inter-)national accessibility		International accessibility	
		Availability ICT infrastructure		City area covered by cable networks (per cent of total area)	
				City area covered by Wi-Fi networks (per cent of total area)	

				City area covered by xDSL networks (per cent of total manufacturing enterprises)	
				Computers (per million of population)	
				Internet connections (per million of population)	
				Broadband connections (per million of population)	
				Users of e-gov services (per million of population)	
				City enterprises owning a website (per cent of total enterprises)	
				City enterprises involved in B2B or B2C (per cent of total enterprises)	
				Number of telephones per household (Telephones/person)	
				Number of handphones per household (Handphones/person)	
				Development of cloud platform and application Utilization	
				Open and Integrated Urban Operating System • Urban OS • Geospatial • Smart Grids • Ontologies • Semantic • Linked APIs • Cloud	
				City Infrastructure for "real and connected" Life • Sensors • Activators • WSAN • B_WISE • RFID • Internet of Things	
		Sustainable, innovative, and safe transport system		Green mobility share (non-motorized individual traffic)	
				Traffic safety	
				Use of economical cars	
				Peak travel delay	
Propagation		Replicability & scalability		Social compatibility	
				Technical compatibility	
				Ease of use for end users of the solution	
				Ease of use for professional stakeholders	

				Trialability	
				Advantages for end users	
				Advantages for stakeholders	
				Visibility of Results	
				Solution(s) to development issues	
				Market demand	
		Factors of success		Changing professional norms	
				Changing societal norms	
				Diffusion to other locations	
				Diffusion to other actors	
				Change in rules and regulations	
				Change in public procurement	
				New forms of financing	
				Smart City project visitors	

SECTION IV – BARRIERS TO IMPLEMENT PERFORMANCE MEASUREMENT SYSTEM TO SRI LANKA AND RECOMMENDED SOLUTIONS TO OVERCOME THE BARRIERS

(Please provide recommended solutions for the given barriers in the following table)

BARRIERS	**SOLUTIONS**

- Implementation problems
- Increased cost over benefits
- Multiple interests of different parties engaged in a Smart City project
- Limitations and unavailability of technological implications that cause delays in information and automation issues in the process of Performance Measurement
- Difficulties in obtaining information including the lack of accessibility for databases
- Data availability and data management issues
- Privacy issues
- Increased workload to the individuals in the Smart City management organisation that intents to measure performance
- Problems due to the human involvement; for example, political undue interventions and influences, lack of integration and the internal resistance from the parties that are affected differently from Performance Measurement
- Human barrier due to lack of trust on local expertise and dislike towards collaboration
- Waste of resources due to lack of control
- Problems with monitoring in real time
- Dynamic nature of measurement
- Prioritizing issues
- Subjective input
- Manipulation of results.

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Thank you for your contribution

APPENDIX C – QUESTIONNAIRE

COVERING LETTER FOR THE QUESTIONNAIRE SURVEY

……

Dear Sir/Madam,

Research Dissertation – Questionnaire (M.Sc. by Research)

I am a postgraduate student of University of Moratuwa, reading for Master of Science (by Research). I am conducting a research titled "A Performance Measurement System for Smart Cities in Sri Lanka". This research is conducted under the supervision of Dr. Udayangani Kulatunga and Dr Dilum Bandara, Senior Lecturers at the Department of Building Economics and Department of Computer Science and Engineering respectively.

I have selected the proposed Smart City project in Colombo Port City as the case study and initially conducted interviews with the key participants engaged in that project. As the next round I'm conducting a questionnaire survey with the experts who are having a vision for Smart Cities in "Sri Lanka". The objectives of this study and the interview guideline are attached herewith.

I have identified yourself as a potential participant who could provide me valuable information to this research. Therefore, I would like to interview you for **approximately 90 minutes** in this regard. The medium of collecting data will be **note taking and audio recording (with the permission of the interviewee)** in order to collect data more accurately.

I strongly believe that you would support to my research by providing your views related to my research topic. **The information collected through this interview will be kept strictly confidential and should be used only for the purpose of the dissertation. Any of your personnel information will not be disclosed within the research.**

Thank you.

Aravindi Samarakkody

Postgraduate Student

Department of Building Economics

University of Moratuwa.

Tel: 077-5557666

Email: aravindilavanya5@gmail.com

QUESTIONNAIRE

SECTION I - GENERAL INTRODUCTION TO THE RESEARCH

Research Title

"Performance Measurement for the Development of Emerging Smart Cities: The Case of Sri Lanka"

Research Aim

The aim of this research is to enhance the emerging Smart City development projects in Sri Lanka through an appropriate and holistic Smart City Performance Measurement Systems.

Research Objectives

Following objectives will be achieved to reach the above research aim.

1. To investigate the characteristics of Smart Cities globally and with particular reference to Sri Lanka.
2. To investigate the importance of Performance Measurement in Smart City development.
3. To synthesise different Performance Measurement Systems for Smart Cities.
4. To identify the barriers to implement a Performance Measurement System to Sri Lanka and solutions to overcome the barriers.
5. To develop a Performance Measurement System for Smart Cities in Sri Lanka.

SECTION II - BACKGROUND INFORMATION OF THE INTERVIEWEE

1. Profession:

   ……

2. Designation:

   …..…….....

3. How long is your industry experience?

   ……..…….....

SECTION III – SUITABILITY OF THE PERFORMANCE MEASURES TO SRI LANKA

Instructions for the respondents:

1) The following System is developed based on the experts' opinions with regards to the suitability of different smartness indicators to the proposed Smart City project in Colombo Port City

2) In this round it is supposed to be generalized to a similar city context in Sri Lanka

3) Accordingly, as the first step, you are required to assess the importance of "Themes" (First Column) and provide marks out of 100 for each theme.

4) Under each theme are the subthemes; as your next step you should provide marks for the set of subthemes under each theme, out of 100 marks.

5) Under each subtheme are the indicators; as your final step you should provide marks for the set of indicators under each subtheme, out of 100 marks.

Theme	Marks (Out of 100)	Sub Theme	Marks	Indicators	Marks
1. SMART ECONOMY		1. 20 Economic performance		201. Financial benefit for the stakeholder *Total cost savings in euros for a stakeholder per year*	
		1. 21 Innovation, Innovative spirit, and Innovation performance		202. Involvement of extraordinary professionals *The extent to which the project involved professionals normally not encountered in these type of projects- Likert scale*	
				203. Stimulating an innovative environment *The extent to which the project*	

				is part of or stimulates an innovative environment- Likert	
				204. Quality of open data *The extent to which the quality of the open data produced by the project was increased - number of stars*	
				205. New start-ups- *number of start-ups resulting from the project*	
				206. Improved interoperability- *The extent to which the project has increased interoperability between community infrastructures*	
				207. Employment rate in: High Tech and creative industries; Renewable energy and energy efficiency systems Financial intermediation and business activities; knowledge-intensive sectors; Culture and entertainment industry; Commercial services; Transport and communication; Hotels and restaurants; All companies (total number)	
				208. Number of local units manufacturing high tech & ICT products	
				209. Patent applications per inhabitant	
				210. Number of incubators	
				211. Number of Science and Technology Parks	
				212. Number of Technology Transfer and Innovation Centres	
				213. Exports high-tech services (as a percentage of total exports)	
				214. New trade marks	
				215. Enterprises having internal Research & Development Department (as a percentage of all enterprises)	
				216. Sales of new-to-market products (as a percentage of turnover)	
				217. Sales of new-to-firm not new-	

				to-market products (as a percentage of turnover)	
				218. New business models for smart growth and quality of life • Living Labs • Creative class • Web of Trust	
		1. 22 Entrepreneurship		219. Self-employment rate	
				220. New businesses registered	
				221. Percentage of projects funded by civil society	
		1. 23 Production and Productivity		222. Establishment of important decision-making centres (HQ etc.)	
				223. GDP (of smart services) per head of city population	
		1. 24 Employment, Jobs and Skills		224. Increased use of local workforce	
				225. Employment rate	
				226. Proportion in part-time employment	
		1. 25 International embeddedness		227. Air transport of passengers and freight	
		1. 26 Green economy		228. Certified companies involved in the project	
				229. Green public procurement- *Percentage annual procurement using environmental criteria as share of total annual procurement of the city administration*	
				230. CO2 reduction cost efficiency- *Costs per ton of CO2 saved per year*	-
				231. Energy intensity of the economy -gross inland consumption of energy divided by GDP	
		1. 27 Education and Research and Development		232. Public expenditure on R&D -percentage of GDP per head of city population	
				233. Public expenditure on education -percentage of GDP per head of city population	
				234. Number of research grants funded by international	

				projects	
2. SMART GOVERNANCE		2.14Organization composition, process, leadership, and transparency		235. Leadership- *The extent to which the leadership of the project is successful in creating support for the project. - Likert*	
				236. Balanced project team - *The extent to which the project team included all relevant experts and stakeholders from the start- Likert*	
				237. Involvement of the city administration- *The extent to which the local authority is involved in the development of the project, other than financial, and how many departments are contributing- Likert*	
				238. Clear division of responsibility- *Has the responsibility for achieving the social and sustainability targets been clearly assigned to (a) specific actor(s) in the project? Yes/no*	
				239. Continued monitoring and reporting - *The extent to which the progress towards project goals and compliance with requirements is being monitored and reported- Likert*	
				240. Market orientation- *The extent to which the project was planned on the basis of a market analysis- Likert*	
		2.15Community involvement in decision-making		*241.* Professional stakeholder involvement- *The extent to which professional stakeholders outside the project team have been involved in planning and execution- Likert*	
				242. Local community involvement in implementation phase- *Extent to which residents/users have been involved in the implementation process- Likert*	
				243. Participatory governance % *Share of population participating in online platforms*	
				244. City representatives per resident	

				245. Importance of politics for inhabitants	
				246. Share of female city representatives	
				247. Participation by social media	
		2.16 Governance fragmentation		248. Governance orchestration	
				249. Infrastructure Alignment	
				250. District Regeneration	
		2.17 Public and social services		251. Expenditure of the municipal per resident for public and social services	
				252. Trading platform for public resources	
				253. Reduction in waiting time to obtain services	
		2.18 Transparent governance		254. Satisfaction with transparency of bureaucracy	
				255. Satisfaction with fight against corruption	
		2.19 Planning and Regulation		256. Smart Urban Planning	
				257. Smart Identity Branding	
				258. Smart City policy - *the extent to which the project has benefitted from a governmental Smart City policy- Likert*	
SMART ENVIRONMENT		3.16 Eco-sustainability		259. % Increase in green and blue space due to the project	
				260. Increased ecosystem quality and biodiversity- *Extent to which ecosystem quality and biodiversity aspects have been taken into account- Likert*	
				261. Percentage of new buildings which were assessed in terms of sustainability	
		3.17 Environmental protection		262. Individual efforts and opinion on protecting nature	
				263. An assessment of the ambitiousness of CO2 emission reduction strategy	
				264. Reduction in lifecycle CO2 emissions	
				265. An assessment of the comprehensiveness of policies to contain urban sprawl and to improve and monitor environmental performance	
		3.18 Sustainable resource management		266. Efficient use of electricity (use per GDP)	
				267. The total percentage of the working population traveling to work on public transport, by	

				bicycle and by foot	
				268. An assessment of the extensiveness of efforts to increase the use of cleaner transport	
				269. Percentage of citizens engaged in environmental and sustainability-oriented activity	
				270. Proportion of recycled waste per total kilogram of waste produced	
		3.19Energy & mitigation		271. Reduction in annual final energy consumption	
				272. Reduction in lifecycle energy use	
				273. Reduction of embodied energy of products and services used in the project	
				274. Increase in local renewable energy production	
				275. Combined heat and power generation percentage of gross electricity generation	
				276. Alternative Energy Master plan	
				277. Maximum Hourly Deficit	
				278. An assessment of the extensiveness of city energy efficiency standards for buildings	
		3.20Materials, water, *land*, Ecosystem		279. Increased efficiency of resources consumption	
				280. Share of recycled and renewable input materials	
				281. Life time extension-*The extent to which measures were taken to prolong the service lifetime of products - Likert*	
				282. Reduction in water consumption	
				283. Increase in water re-used	
				284. Increase in compactness	
		3.21Climate resilience		285. Climate resilience measures-*The extent to which adaptation options have been considered in the project*	
		3.22Pollution & waste		286. Decreased emissions of Nitrogen dioxides (NO2) and Particulate matter (PM2,5)	
				287. Reduced exposure to noise pollution	
				288. Reduction in the amount of solid waste collected	

				289. Summer smog (Ozon)	
				290. Fatal chronic lower respiratory diseases per inhabitant	
SMART PEOPLE		4.14 Level of qualification, Education and skills of the population		291. Importance as knowledge centres (top research centres, top universities etc.)	
				292. Population qualified at levels 5-6 ISCED	
				293. Foreign language skills	
				294. % of population aged 15-64 with above secondary-level education and above living in Urban Audit	
				295. % of inhabitants working in education and in research & development sector	
				296. Individual level of computer skills	
				297. Individual level of internet skills	
		4.15 Affinity to lifelong learning		298. Book loans per resident	
				299. Participation in life-long-learning in %	
				300. Participation in language courses	
		4.16 Social and ethnic plurality		301. Share of foreigners	
				302. Share of nationals born abroad	
		4.17 Flexibility		303. Perception of getting a new job	
				304. Participation in voluntary work	
				305. Increased use of cashless transactions	
		4.18 Creativity		306. Share of people working in creative industries	
		4.19 Cosmopolitanism and open-mindedness		307. Voters turnout at elections	
				308. Immigration-friendly environment (attitude towards immigration)	
				309. Knowledge about the region/ country	
SMART LIVING		5.24 Health conditions		310. Improved access to basic health care services- *The extent to which the project has increased accessibility to basic health care*	
				311. Encouraging a healthy lifestyle	
				312. Waiting time (reduction of queues)	
				313. Life expectancy	
				314. Hospital beds per inhabitant	

				315. Doctors per inhabitant	
				316. Satisfaction with quality of health system	
		5.25 Safety		317. Reduction of traffic accidents	
				318. Reduction in crime rate	
				319. Improved cybersecurity	
				320. Improved data privacy	
				321. Satisfaction with personal safety	
		5.26 Education facilities		322. Improved access to educational resources/ system	
				323. Increased environmental awareness	
				324. Improved digital literacy	
				325. Satisfaction with quality of educational system	
				326. No. of courses entirely downloadable from the internet/total no. courses	
				327. Percentage of professors and researchers involved in international projects and exchange	
				328. Percentage of accessible courses for people with disabilities (PWD)	
		5.27 Touristic attractivity		329. Touristic Importance as tourist location (overnights, sights) - *overnight stays in registered accommodation in per year per resident*	
		5.28 Access to (other) services		330. Access to public transport	
				331. Quality of public transport	
				332. Improved access to vehicle sharing solutions	
				333. Extending the bike route network	
				334. Decreased travel time	
				335. Provision for autonomous driving	
				336. Access to public amenities	
				337. Access to commercial amenities	
				338. Increase in online government services/ e-Government on-line availability (percentage of the 20 basic services that are fully available online)	
				339. e-Government usage by individuals (percentage individuals aged 16-74 who	

				have used the Internet, in the last 3 months, for interaction with public authorities)	
				340. Proportion of the area in for recreational sports and leisure use	
		5.29 Diversity and social cohesion		341. People reached (*Percentage of people in the target group that have been reached and/or are activated by 5 services in the project)*	
				342. Increased consciousness of citizenship and social coherence	
				343. Increased participation of vulnerable groups	
		5.30 Quality of housing and the built environment		344. Diversity of housing types	
				345. Design for a sense of place	
				346. Increased access to urban public outdoor recreation space	
				347. Increased access to green space	
				348. Satisfaction with personal housing situation	
				349. Green Building Policies	
		5.31 Quality of life of the community		350. Public and community housing	
				351. Dwelling price to income ratio	
				352. Free time	
		5.32 Liveability and Sustainability		353. Adult obesity rate	
				354. Support in times of crisis	
				355. Suicide rate	
				356. Office building energy efficiency	
		5.33 Added value city wide intelligent services		357. i-energy	
				358. i-transport	
				359. i-democracy	
				360. i-government	
				361. i-services	
				362. i-home	
		5.34 Quality of industry-based services		363. Number of enterprises adopting ISO 14000 standards	
				364. Proportion of people undertaking industry-based training	
S 2		6.8 (Inter-)national accessibility		365. Satisfaction with international accessibility	

		6.9 Availability ICT infrastructure		366. City area covered by cable networks (per cent of total area)	
				367. City area covered by Wi-Fi networks (per cent of total area)	
				368. City area covered by xDSL networks (per cent of total manufacturing enterprises)	
				369. Computers (per million of population)	
				370. Internet connections (per million of population)	
				371. Broadband connections (per million of population)	
				372. Users of e-gov services (per million of population)	
				373. City enterprises owning a website (per cent of total enterprises)	
				374. City enterprises involved in B2B or B2C (per cent of total enterprises)	
				375. Number of telephones/handphone per household (Telephones or handphone /person)	
				376. Availability of social credit	
				377. Development of cloud platform and application Utilization	
				378. Open and Integrated Urban Operating System Geospatial Smart Grids Ontologies Semantic Linked APIs Cloud	
				379. City Infrastructure for "real and connected" Life Sensors Activators WSAN B_WISE RFID Internet of Things	
		6.10 Sustainable, innovative, and safe transport system		380. Green mobility share (non-motorized individual traffic)	
				381. Use of economical cars	
				382. Peak travel delay	

Propagation		7.5 Replicability & scalability		383. Social compatibility	
				384. Technical compatibility	
				385. Ease of use for end users of the solution	
				386. Ease of use for professional stakeholders	
				387. Trialability	
				388. Advantages for end users	
				389. Advantages for stakeholders	
				390. Visibility of Results	
				391. Solution(s) to development issues	
				392. Market demand	
		7.6 Factors of success		393. Changing professional norms	
				394. Changing societal norms	
				395. Diffusion to other locations	
				396. Diffusion to other actors	
				397. Change in rules and regulations	
				398. Change in public procurement	
				399. New forms of financing	
				400. Smart City project visitors	

-Thank you very much for your contribution-