Managing sustainability in urban environments

A strategic approach for the assessment of energy efficiency, carbon reduction, and circular economy initiatives within cities

by

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Submission in fulfilment of the
requirements for the degree of

Master of Science in

Environmental and Energy Management

at the

UNIVERSITY OF TWENTE.

Leeuwarden, September 2017

Title	**Managing sustainability in urban environments** *A strategic approach for the assessment of energy efficiency, carbon reduction, and circular economy initiatives within cities*
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Submission	September 15, 2017

Acknowledgment

This thesis is dedicated to all of those who have been concerned and involved in my academic, professional, and personal growth. Thanks for all the support, patience, and cooperation.

Abstract

As urbanization increases, natural resources and energy systems become more stressed in order to cope with the needs and demands for products and services stemming from cities all around the world. It is estimated that by 2050 the urban population will increase to 6.5 billion people, accounting for 66% of the world's total population (Mcdonald et al, 2008; UN, 2015b). Business-as-usual practices for the development and maintenance of urban areas are often perceived as unsustainable. Hence, management methods and building techniques, capable to withstanding the expected urban growth, are required

This research project sets to explore and analyse the current state of urban sustainability management. The aim is to provide a linkage between management strategies and urban sustainability programmes. Based on a thorough and extensive literature review, urban sustainability challenges, barriers, trends, and opportunities are analysed and categorised, in an attempt to understand and harness their complexity. The study is complimented with a strategic management tool that supports the assessment and decision-making processes, during the design, implementation, or evaluation of urban sustainability initiatives. A general framework, that compiles the key factors that support the integration of urban sustainability, was developed. This tool is presented as a guide to assess sustainability programmes through their different dimension, these include: *(i) policy and citizenship support, (ii) resources and innovation, and (iii) communication and engagement.*

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Chapter I: Introduction

Currently, more than half of the world's population reside in urban areas, and the number is expected to grow dramatically in the next decades (UN, 2015b). As urbanization increases, natural resources and energy systems become more stressed in order to cope with the needs for products and services of high-consuming cities all around the world. Issues as energy security, waste management, and emission control grow in scale and potentially affect larger population segments.

Facing these issues, citizens, organizations, and governments are undertaking actions in order to mitigate the adverse effects. Concern of communities is increased as pollution and health risks become evident in urban daily life. In response, a vast number of policy measures have been implemented across the world in order to control and improve urban environments (Kousky and Schneider, 2003). And, commercial opportunities emerge from the necessity and opportunity of saving resources and improving the quality of products.

The inevitable urbanization of the world, comes along with substantial sustainability challenges. The current and forthcoming strategies applied for urban planning, development, and management will prove to be a defining factor in the transition to a decarbonized future (Angel, 2011). Although all the growing attention towards urban sustainability continues to encourage innovation, research, and public action, it has been estimated that at the current rate, the transition to low-carbon cities will not be fast enough to have significant mitigation impact against problems such as climate change or ecosystem depletion (Kates and Parris, 2003; Cohen, 2006). More ambitious measures and actions are urgently required so a mostly urbanized Earth can be sustained (Schuetze et al, 2013).

Moreover, the rapid technological advancements, emerging business models, and constant innovative breakthroughs in the field of sustainability can result overwhelming for design and implementation of the most adequate and effective strategies. The intention of this research project is to compile available theories and empirical research to understand current urban sustainability options and develop a tool to support their strategic management. Taking from the laurate author Elinor Ostrom (2009): *frameworks are required to organize finding and cumulate knowledge*.

1.1. Background

It is estimated that by 2050 the urban population will increase to 6.5 billion people, accounting for 66% of the world's population (Mcdonald et al, 2008; UN, 2015b). Currently, hosting over half of the population of the world (54% - nearly 3 billion people), *cities* or *urban environments* (see section 2.2 for a detailed definition), directly and indirectly, contribute with about 20% of total greenhouse gas global emissions (IPCC, 2014). Current practices for the development and maintenance of urban areas are often perceived as unsustainable, due to the stress that a highly-urbanized will place on energy systems, natural resources, and ecosystems (Su et al, 2013).

Hence, management models and building techniques, capable of withstanding the expected urban growth, are required. In the past decades, the term "*sustainability*" has had a dramatic increase in popularity. Important breakthroughs and improvements across technologies, industries and policies have been attained since the term was first defined in 1987 by the United Nations as "[meeting] the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). It is common for sustainable development to consider three main aspects: environmental, social, and economic. Therefore, achieving sustainability relays on a multi-layered complex process that requires cooperation from government officials, institutions, non-governmental organizations, and citizens.

Since the second half of the last century, the sustainability movement began to gain momentum. In this new century, awareness has been raised and a major consensus towards acting to mitigate environmental issues exists. It has become increasingly common to find governments and institutions that are actively taking measures to tackle environmental and health problems. New business models, centred in the principle of sustainability, that turn a profit from resource preservation, waste avoidance, and energy savings have emerged and increasingly gain popularity. Nevertheless, important challenges reside in the integration of optimal and efficient solutions, most especially, solutions that account for all the interests and needs of communities in complex and constantly-evolving urban environments.

1.2. Research purpose and objective

This research project sets to explore and analyse current sustainability management methods and trends, focused on the improvement urban environments. The aim is to provide a linkage between management strategies and urban sustainability programmes. By developing and illustrating an assessment tool, it is

expected to help break the complexity of the rapidly increasing developments and implementation of sustainable initiatives. It is expected for the results of this study to provide a clear overview of the current urban sustainability challenges and the factors that contribute to the successful fulfilment of solutions. Consequently, the research objective is *to develop a general framework that contributes to the design, implementation, and development of sustainable urban environments.* Sustainability of cities is studied from a strategic viewpoint, with the intention to explore the common features, enabling the harness of complexity and supporting the development of sustainability programmes within urban environments.

In order to satisfactorily fulfill the research objective, this research project revolves around the question of *how can sustainable management strategies be adequately integrated and effectively optimized for urban environments?* Supporting questions that provide guidance and demarcation to the research project include: What are the main environmental impacts of an urbanized world? What are the current trends and prospects for an urban sustainable development? And, what are the management theories and methods that support sustainable development?

1.3. Research Design

To be able to develop a management tool that adequately integrates sustainability into the urban built environment, first it is important to study the environmental impacts, issues, and challenges of a majorly urbanized world. To understand the former a thorough literature review is included, covering the main environmental impacts and rising challenges of urban environments and the increasing urbanization processes (Chapter II). Then, an analysis of the techniques, measures, and initiatives that are currently being undertaken to improve the sustainability of urban environments is presented (Chapter III). Due to the extent of the subject, urban sustainability is an extensive subject, literature and initiatives to review were limited to certain characteristics relevant to the interests of this research project.

Subsequently, a framework, adapted from relevant existing theories on sustainable development, social-ecological systems, and urban governance, presents a strategic approach for the evaluation of sustainable initiatives in the built environment (Chapter IV). And finally, an assessment of selected case studies illustrates the linkage of the management strategies with urban sustainability programmes, assessing their strengths, weaknesses, and opportunities, in an attempt to illustrate the framework's functionality (Chapter V). Discussion is centred around the impact, feasibility, reach, and fulfilment of the measures studied and

their impacts on the sustainability improvement of the urban built environment. It is intended that this model can be replicated, to help ease decision making process and provide better understanding of management strategies for the urban built environment.

Chapter II: Issues and challenges of urban environments

To enable the strategic assessment of urban sustainability programmes, it is important to understand the main issues and threats that are being faced. First, key concepts and definitions are discussed, in order to clearly identify the object of this research project. Then, the most relevant problems, brought by urban environments and their expected expansion, are introduced. In order to highlight the most urging challenges for forthcoming urban sustainability management. The chapter consists of a literature review of, mainly, the environmental impacts of cities, their trends, and the risk that they represent.

2.1. The definition of urban areas

Cities are a product of their history, culture, and surroundings. Geography, society, technology, and economic development are key factors that define the urbanization process. While the evolution of the urban environment may have occurred differently in each place, common characteristics can be identified across cities worldwide (Pacione, 2009). Nevertheless, throughout literature, much has been debated on the definition and demarcations of urban areas. Reaching an agreement for a sole and clear definition of a city has become problematic due to the different considerations, purposes, and perspectives of urban studies (Parr, 2007). Defining by political demarcations may not be effective because in many cases administrative districts do not match the exact extent of a city. To define a city by its main economic activities is often ineffective as many urban developments present a wide range of occupations and even ambiguous demarcation of rural and urban activities. Population-wise, it is common to encounter high variation of density rates within small distances in urban areas.

Even though all the factors that define a city are interrelated, the perception may vary depending on the approach of each study. For the purpose of this research the definition of city is based on its territorial extent, prioritizing this perspective over geopolitical, economic, historical, or cultural approaches. The spatial definition of city was chosen due to its intrinsic link to the urbanization processes and its impact to nearby ecosystems and the environment. The next paragraph presents an attempt to find a convenient definition regardless of the size, population, or activities of urban areas.

Urban study experts have defined a *"city"*, as the *"urban land cover"* or the *"urban environment"*, which consists of an agglomeration of contiguous development, that contains building districts, industrial areas,

and mass transportation infrastructure, facilitating the centralization of services, commercial, and economic activities within a boundary (Parr, 2007; Angel, 2011; Madlener & Sunak, 2011). The urban land cover may defer of the administrative limits set by political entities. A study by Parr (2007) explores further on the spatial definition of city, proposing 4 perspectives to understand the extent of a city:

- **The built environment**; identified as the contiguous physical built-up area;
- **Consumption systems**; refers to households that consume goods and services, most of them supplied within the built environment;
- **Employment systems**; this extent of the definition of city refers to the daily movement of labour and residents to, around, and across the built environment;
- **Production systems**; considers the area required to support the employment and consumption systems within the built environment.

The employment and production systems commonly have strong dependences with outer areas of a city, additionally they may be related to labour and workforce on industrial value chains, regional energy systems, and long-distance transportation services. Meanwhile, the built environment and consumption systems are located at the core of cities, and include housing and commercial buildings, local transportation services, and open and public spaces for recreational or health purposes. *This research focuses on the later, analysing sustainability management within the core of cities, rather than examining the sustainability options for the external dependences with the city systems.* As stated by Mccormik et al (2013), focusing in building and districts (the inner scales of urban environments) is much more manageable than targeting whole city system, while they still encompass opportunities for relevant solutions across infrastructure, transportation, and open spaces.

2.2. Urbanization

In the last century, the world has witnessed an important transformation on the lifestyle of the majority of the population. In 2007 it was reported, that for the first time in history more than half of the world's population resided in cities. Furthermore, the total urban population is expected to increase by about 2.5 billion people by the half of this century. Since the 1950's the urban population in the world has increased six-fold. Current projections do not expect this trend to end soon (UN, 2015b), while the major increase of urban population is projected to happen in developing countries (see Figure 1).

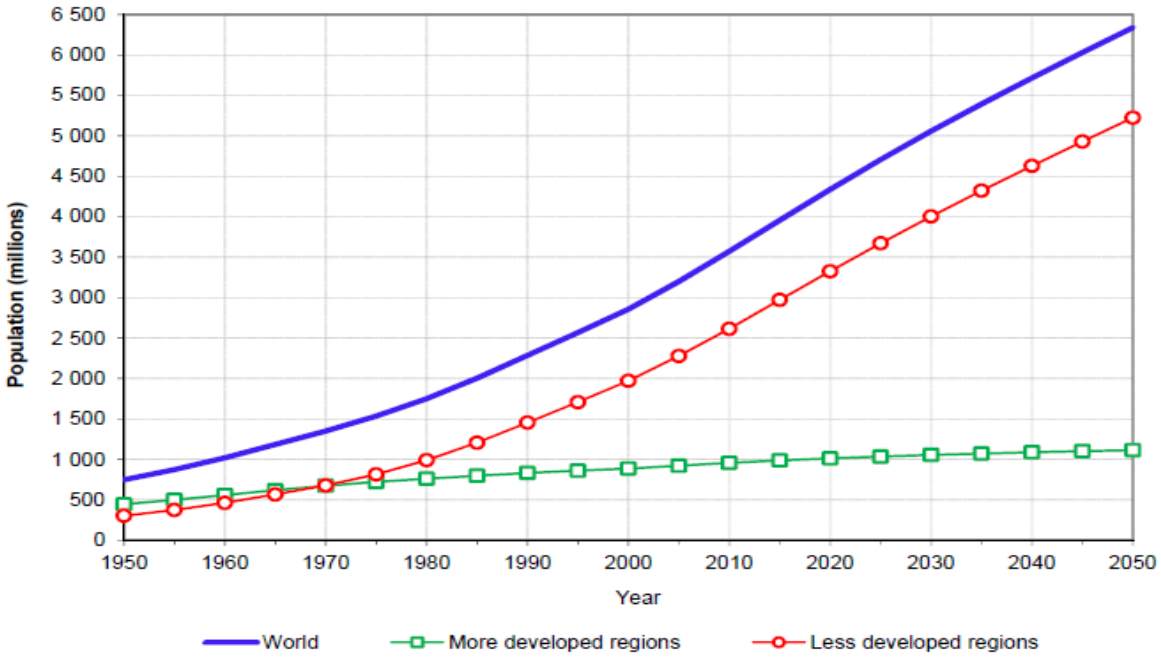

Figure 1. Estimated and projected urban population in the world. Taken from UN (2015), World Urbanization Prospects, page 25.

Urbanization, or urban sprawl, is characterized as dispersed and inefficient (Hasse and Lathrop, 2003). It can be described as a function of urban population growth and the variation of population density in a limited area (Angel, 2011). Regarding the current urban population projections, it has become clear that further urban expansion is inevitable. In addition, a study of 120 cities by Angel (2011), determined that in the last century population densities have consistently declined. In this way, future urban areas will host more people but less concentrated, leading to significantly higher expansions. A follow up study confirmed that the urbanization increase is significantly higher than the population increase rates (Angel et al, 2011), in such way that if there is an urban population increase of two-thirds by 2050 the covered land by urban areas is expected to increase three times. The former, potentializes the challenges and impacts that have been related to urban environments.

2.3. Environmental impacts of the urban built environment

Urban areas have been a key factor for human development. Since ancient history, cities have served as centres of production and consumption. Urban environments conveniently provide goods and services, functioning as facilitators for trade and economic growth. Nevertheless, modern urban life style implies

hefty environmental impacts. Impacts range from local issues such as air, water, and soil pollution to growing world-wide concerns such as global warming and climate change.

It is expected that the rapid urbanization will stress energy systems, natural resources, and ecosystems (Su et al, 2013). The unrestricted, unplanned, and inefficient growth could pose serious threats for urban sustainability (UN, 2015b). However, due to the complexity and diversity of cities, designing and deploying solutions is not an easy task. To enable the adequate assessments that lead to the development of optimal and sustainable programmes, it is important to clearly identify and understand the current challenges, impacts, and threats. In the following sub-sections, some of the main environmental impacts, identified in literature, are explored. This overview covers macro-scale factors around important concerns regarding urban sustainability: *resource consumption, energy demand, greenhouse gas emissions, and depletion of ecosystem services.*

2.3.1. Resource consumption

The European Commission defines resources as *"all inputs into the economy, these resources include raw materials such as fuels, minerals and metals but also food, soil, water, air, biomass and ecosystem"* (EEA, 2015). Much has been studied regarding the current resource consumption behaviours and the alerting projections for the future (Princen, 1999; Wackernagel et al, 2006; Putt del Pino et al, 2017). Mass production processes have resulted in over exploitation of resources, in some cases leading to their complete depletion and the deterioration of natural environments (EEA, 2015). Industrialized production processes, supported by the rapidly increasing demand and exacerbated by careless consumption practices, follow a linear economic model (acquire – use – dispose) that induces substantial waste generation.

In 1972, the Club of Rome (Meadows et al), better described the potentials risks derived from the over exploitation of resources and waste production. In their famous report, *The Limits to Growth*, they stated that the alarming rates of population increase could, at a given point, exceed the carrying capacity of earth (illustrated in Figure 2). In other words, reckless extraction and consumption trends may surpass the ecosystems' ability to produce resources and absorb waste. Overshooting the carrying capacity of ecosystems may result in severe consequences for societies and the environment, as warned by the authors of the report.

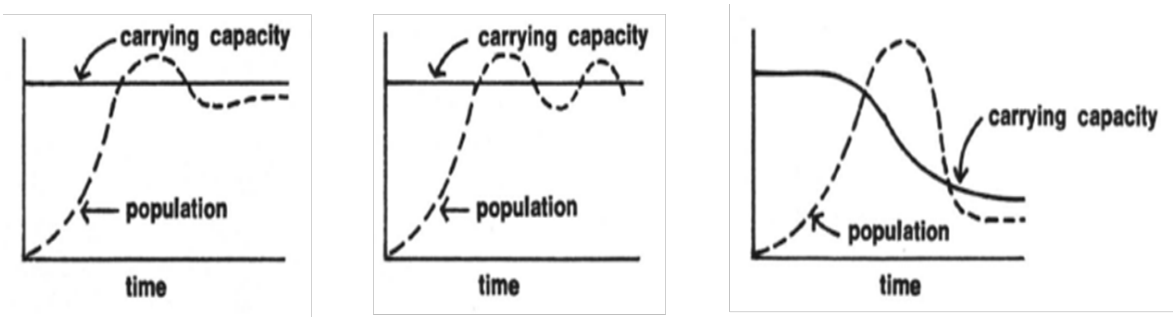

Figure 2. Behaviour models of ecosystems' carrying capacity. Taken form Meadows et al (1972), The Limits to Growth, p. 92.

Because the urban production systems fuel economic growth, cities become hotspots for consumption, attracting a major influx of resources and products. Such is the demand, that despite of only covering around 2% of the total global land, about three quarters of the total world's consumption of resources can be accounted to cities (Madlener and Sunak, 2011). The United Nations in their World Urbanization Prospects report estimated that urban residents consume around twice as more resources than people living in rural areas (UN, 2015b). As an example, the global share of water and wood demand attributed to cities add up to 60% and 76% respectively (Grimm et al, 2008). The use of materials for the construction buildings and infrastructure represents almost 50% of the world's total resource consumption (Santamouris, 2011; ARUP, 2016a). Signs of stress on resources due to the continuous urban sprawl become more evident as droughts increase, fisheries collapse, forests shrink and species disappear (Brown, 2001).

2.3.2. Energy demand

In the last century, the urban explosion, industrialization, and technological advancements have caused a global transformation of energy consumption patterns. A dominant low-energy intensive life-style, based mostly on agricultural production, has shifted to a highly energy intensive system, designed over the economy of mass production and consumption of products and services (Madlener and Sunak, 2011). Because, urbanization is highly related to energy consumption, it is not rare for developed countries, that account for the majority of the current urban population, to display above-average energy consumption indicators (Liddle, 2013).

In sight of the inevitable urbanization processes in the world, to apply the same model for growth that took place in the developed regions will most likely result unsustainable (IPCC, 2014; UN, 2015b; York et al, 2003). The former is a key issue of concern for scholars, scientists, and environmental experts, since

urbanization in developing countries is expected to dramatically increase (Madlener and Sunak, 2011; UN, 2015a). Several authors have warned that following the same urbanization patterns will result on exceeding the carrying capacity of earth, threatening ecosystems, economies, and the health of societies (Bugliarello, 2006; Cohen, 2006; Seto et al, 2012).

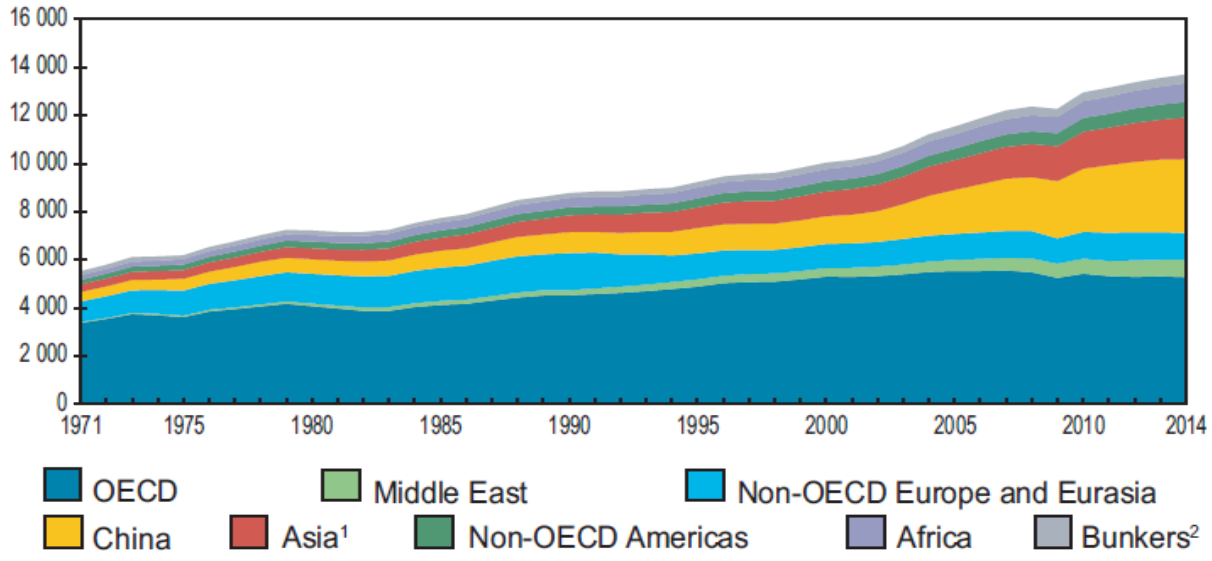

Figure 3. World total primary energy consumption (Mtoe). From IEA (2016), Key World Energy Statistics, page 8.

Energy demand is increasing and will continue to do so. As presented in Figure 3, it can be inferred that the increase on energy consumption has a direct and positive relation to urbanization (Jones, 2004; Zhao and Wang, 2015). The most energy-consuming regions correspond to the most urbanized and the regions presenting significant increase on energy demand are the same regions that are experiencing major urbanization (UN, 2015b; IEA, 2016b). According to the current trends, it has been predicted that by half of the century, energy consumption may double the average amount consumed in the first decade of the new millennia (EIA, 2016).

The close relationship between urbanization and energy consumption exacerbates the current energy challenges. However, issues such as generation capacity, grid reliability, and energy sources are commonly of national concern and require extensive infrastructure. These are rarely treated at a local or city level. Energy production systems undoubtedly have an influence on cities, which can be analyzed through the different urban dimensions. The production systems consume energy in order to cope with the demands to fulfill the needs of urban residents. The employment and consumption systems require

constant movement and transportation of products, services, and people. And the built environment involves the energy and electricity necessary for commercial and domestic activities (Jones, 2004). Even though it is complicated to break down the energy consumption of cities by sector, as the results can be influenced by the definition of city boundaries, the location of industries, local climate characteristics and/or the efficiency of transportation systems, studies have shown that the built environment accounts for around 30 – 40% of the total energy consumption in the world (IPCC, 2014). Figure 4 shows an estimate of energy consumption by sector in selected cities.

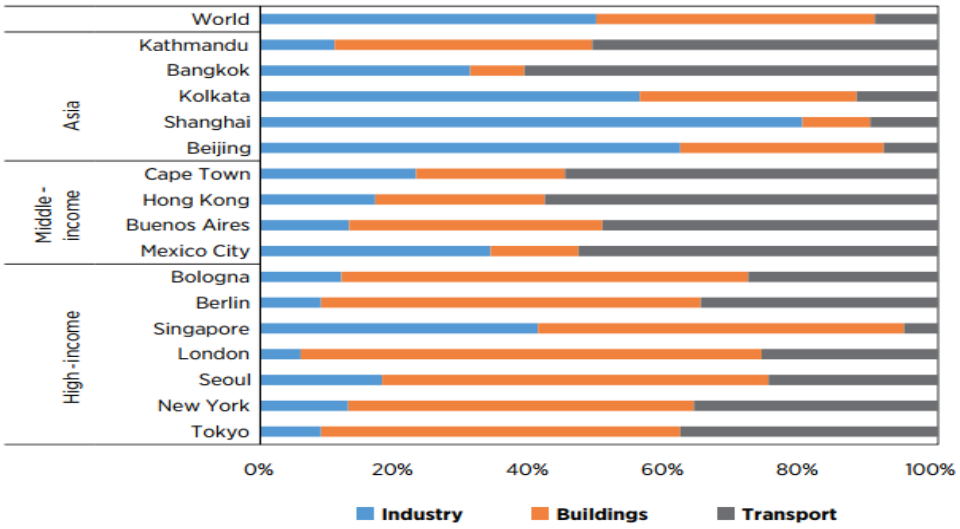

Figure 4. Estimates of the breakdown of energy use by sector in selected cities. Taken from IRENA (2016), Renewable Energy in Cities, page 12.

2.3.3. Greenhouse gas emissions

Due to the concentration of activities, it is evident that most of the greenhouse gases in the world are emitted in cities, or are related to the industrial production processes driven by their consumption. It is accounted for cities to produce nearly 70% of all greenhouse gas emissions in the world (Dahal and Niemelä, 2017). For this reason, environmental experts and organizations have called upon cities to act promptly, recognizing urban centres as key elements for the mitigation of climate change and global warming (IPCC, 2014; UN-HABITAT, 2016).

To be able to formulate strategies that effectively target the emissions of greenhouse gases accounted to cities, the sources, causes, and circumstances must be clearly understood. Nevertheless, this may be

hindered by the complexity of urban systems and the lack of reliable emission accounting methods (Dahal and Niemelä, 2017). To accurately measure greenhouse gas emissions produced in urban areas has proven to be a challenge. Urban emissions sources can be countless, appropriate technology to measure and monitor may be lacking, and boundaries (geographic / administrative) can produce ambiguity.

Fortunately, a vast amount of research has been directed to model, estimate, and establish inventories of urban greenhouse gas emissions and air pollution (IPCC, 2006; Butler et al, 2008; Kennedy et al, 2010). Additionally, practices consisting in assigning responsibility for emissions are growing in popularity among regulatory bodies, facilitating the identification and measurement of greenhouse gases. A research paper by Hoornweg et at (2011) discusses this subject, providing a clear distinction of emissions according to two perspectives, consumption-based or production-based. The consumption based approach accounts emissions to the consumers who encourage emissions production, while the production based approach accounts emissions to those directly producing them. Even though, the purpose is to facilitate the measurement and identification of greenhouse gas emission sources, much has been debated about how, when, where and why to apply each perspective (Kanemoto et al, 2012; Ramaswami et al, 2012; EEA, 2013). However, the different accounting perspectives can serve to improve the accuracy of mitigation and control strategies, increasing the precision of sector-specific restrictions, goals, and targets.

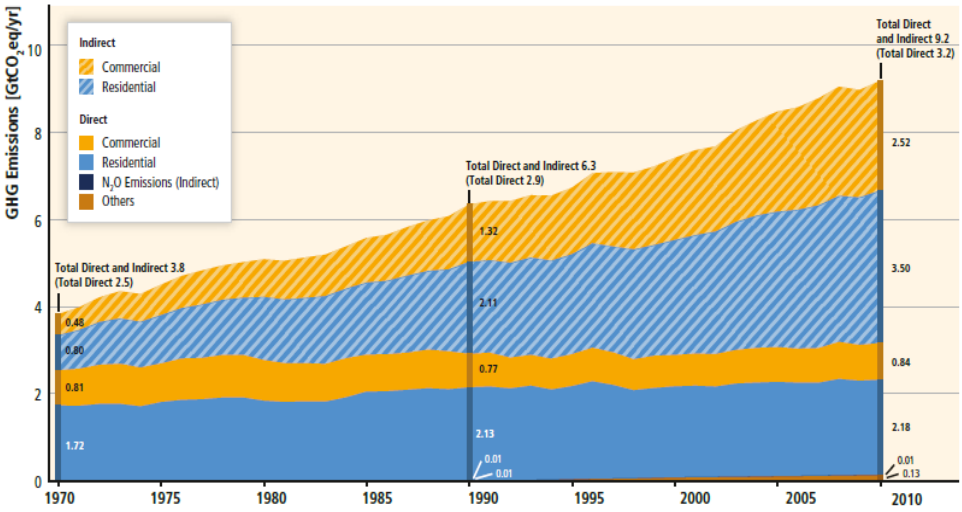

Figure 5. Direct and indirect GHG emissions of the built environment have doubled since 1970, from IPCC, 2014, p. 678

Despite of the aforementioned challenges to measure and account greenhouse gas emissions, many years of empirical research have demonstrated that the built environment's main emissions are due to building heating, transportation, and cooking. Additionally, the production processes and their involved logistics

result in an expansion of emissions that can be accounted to cities (IPCC, 2014). Figure 5 demonstrates the direct and indirect greenhouse gas emission sources of the urban built environment.

2.3.4. Degradation of ecosystem services

As it was discussed earlier, unrestrained growth of urban developments is driving major land cover changes around the world, immediate effects are noted in the loss of the surrounding ecosystems, natural resources, and arable soil (Hasse & Lathrop, 2003; Scheyer & Hipple, 2005). Consequently, higher and more distant influx of resources is required to cope with urban population's demands; as cities become larger and concentrate more inhabitants, their impacts grow in magnitude and extent, in this way global-scale biodiversity and ecosystem changes can be directly and indirectly attributed to cities (Grimm et al, 2008). Furthermore, the surroundings of urban environments have to cope with the conjoined waste production (in all of its forms: solid waste, emissions, water pollution, etcetera) that is inherent to urban production and consumption cycles. Cities require ecosystem services to provide inputs and take care of their outputs, nevertheless, the rapid urbanization has surpassed the capacity of ecosystems to generate and produce resources, absorb and regulate waste, and self-restore from disturbances (Bolund and Hunhammar, 1999; Su et al, 2013).

Ecosystems provide benefits that sustain the life of humans and other species, these benefits are known as ecosystem services. Included are natural cycles that support life, processes that regulate and maintain the local and global environment, the provision of goods and materials, and, likewise, consider the cultural and spiritual experiences that can be attained from natural environments. Several authors have categorized the ecosystem services according to the function they fulfil; Table 1 presents a summary of ecosystem service classifications commonly presented in literature (Costanza et al, 1997; Millennium Ecosystem Assessment, 2005; TEEB, 2010; Gómez-Baggethun and Barton, 2013).

Cities are highly dependent on ecosystem services and it has been proved that the conservation and restoration of ecosystems within and nearby urban areas provides social, health and economic benefits to its residents (Nesbitt et al, 2017; Mcdonald et al, 2008, Alberti, 2005). Direct benefits from ecosystem services to cities and its residents include: air purification, cooling, moderation of disturbances such as noise, heavy rainfall, and runoffs (Vejre et al, 2010; Gómez-Baggethun and Barton, 2013); and are also capable to deliver important cultural and spiritual experiences to enhance the physical and mental health of the population (Nesbitt et al, 2017; Wolch et al, 2014; Maas et al 2006).

Table 1. Summary of ecosystem services, adapted from several sources

Number	Service	Category
1	Nutrient Cycling	Supporting Services
2	Water Cycling	Supporting Services
3	Soil formation	Supporting Services
4	Habitat and refugia	Supporting Services
5	Food Production*	Provisioning Services
6	Raw Materials*	Provisioning Services
7	Fresh Water Supply*	Provisioning Services
8	Fuel*	Provisioning Services
9	Regulation of atmospheric conditions and composition*	Regulating Services
10	Water treatment and maintenance*	Regulating Services
11	Erosion prevention and soil fertility	Regulating Services
12	Pollination and seed dispersal	Regulating Services
13	Biodegradation and bioremediation	Regulating Services
14	Moderation of disturbances and impact mediation*	Regulating Services
15	Diversity	Cultural Services
16	Aesthetic appreciation	Cultural Services
17	Recreation and tourism*	Cultural Services
18	Intellectual and educational	Cultural Services
19	Spiritual and Religious	Cultural Services

**Ecosystem services that are especially relevant for urban environments*

2.4. Pressing urban sustainability challenges

To improve the livelihood, health, and quality of urban residents and their surrounding a transition to more sustainable systems is required. The IPCC (2014) identified a "window" for important mitigation actions during the next two decades to prevent devastating consequences. Responsible urban planning, bundled with adequate policy instruments may fuel and accelerate a transition to more sustainable cities. As expressed by Schuetze et al (2013), *"Growing urbanization, increasing resource consumption, and limited*

resource availability mean that urban user behavior and infrastructure systems need to be transformed to become more efficient and for a more sustainable use and management of resources, particularly for the provision of primary services such as energy, water and food". To successfully achieve an urban transformation industries, businesses, and governments must be equipped with the proper skills and resources to allow a genuine and efficient sustainable development (The Royal Academy of Engineering, 2010).

Extensive and arduous efforts are required in order to mitigate and reduce the adverse effects caused by urban environments and their inevitable growth in the following years. Policy makers, organizations, and communities must take notice of these challenges to implement adequate and effective sustainable solutions to improve the sustainability of urban developments. The built environment, being at the core of cities, presents significant opportunities to integrate sustainability into the urban livelihood. Just like issues and environmental impacts are potentialized by cities, successful strategies can be scaled-up, with the possibility of applying economies of scale, to support an urban sustainable development. In this way, cities become an ideal "hub" for the development of mitigation strategies, however, challenges reside in their effective application. Management strategies must be optimized in order to operate through the complexity of urban environments.

Chapter III: Analysing urban sustainability strategies

This chapter studies urban sustainability strategies and management methods are deeply studied in this chapter. The purpose is to present a clear outline of the current, and developing, solutions that promote sustainability in urban environments. The intertwined nature of the complex city systems and the increasing issues explored in the previous chapter, create a challenging environment for the integration of solutions in accordance with the social, environmental, and economic needs of communities, ecosystems, and businesses. Policy-makers, organizations, and civil society often interact across multi-levelled dimensions and sectors to ensure the well-being of communities and account for the interests of all the concerned parties.

Navigating through this complexity, this research project identifies and focuses on urban sustainability strategies related to energy efficiency, circular economy, and the deployment of low-carbon strategies. It is not of the interest of this research to present an individual and detailed study of the technical requirements and specific methods for the development of each strategy. Instead, a review on sustainability programmes and initiatives is presented, enabling the reader to obtain a quick, but comprehensive, glance to the urban sustainability landscape. Later, management approaches to sustainable development and their success factors are discussed. And finally, urban sustainability initiatives are categorized along three axes: *the range on which environmental benefits can be perceived., the time to achieve results, and the effort and resources required for their implementation.*

3.1. Key sustainability strategies and prospects in urban environments

As it has been explored in the previous chapter, the upcoming urbanization pose as a significant threat for natural resources and ecosystems around the world. The current consumption and production practices are not fit to satisfy the needs of the increasing number of urban citizens. Despite the rough outlook for the future, there are silver linings. Sustainability has quickly escalated in the political agenda of countries around the world (see UN Sustainable Development Goals[1], Intergovernmental Panel for Climate Change[2], International Energy Agency[3], European Environmental Agency[4]), and organizations devoted to

[1] Sustainable Development Goals, http://www.un.org/sustainabledevelopment/sustainable-development-goals/ (note: hereafter, all weblinks mentioned were lastly checked and accessed on August 2017).
[2] Intergovernmental Panel on Climate Change, http://www.ipcc.ch/

the provision of knowledge, financial support, and technical expertise are strongly positioning themselves along global markets (see The World Bank[5], The World Resource Institute[6], C40 Cities[7], 100 Resilient Cities[8]). Globalization has brought cities closer to each other, along with the application of similar building, transportation, and consumption practices. Facilitating integration and collaboration through, for example, knowledge sharing platforms and large-scale technology deployment.

The following sub-sections present a quick glance to distinguished measures, techniques, and initiatives in the field urban sustainability. It is of the interest of this section to explore the relevant sustainability advancements within the urban built environment. As well as the prospects and trends that are leading the transition to more sustainable cities.

3.1.1. Energy efficiency

Energy efficiency can be defined as the minimization, or optimization, of energy inputs through design, enhancement, or modification of a system, and can be applied at all stages of the energy chain (Omer, 2008; EU, 2012). The utilization of energy efficiency techniques has been identified as one of the main strategies for the mitigation of global issues, such as climate change and global warming, due to its vast savings potential on both of the supply and demand sides of energy networks (IEA, 2014). Additionally, the inherent economic benefits that can be attained with relatively low capital investment, has quickly risen its popularity amongst sustainability options for industries, businesses, and governments.

In urban environments, an enormous potential for energy efficiency savings remains untapped. This accounts for two sectors: the construction industry and existing building stock. Combined, they contribute to the total share of energy consumption and greenhouse emissions (IPCC, 2014). Regarding new urban developments, it is estimated that about two-thirds of building constructions does not follow any energy performance codes or standards, thus, energy performance in new buildings is far from optimal (IEA, 2016a). Additionally, studies have noted that around 50% - 70% of the current building stock will be still in use by the year 2050 (Marnay et al, 2008; van der Heijden, 2016b). This means that a considerable share of the existing building in cities is (and will become) long-standing infrastructure presenting

[3] International Energy Agency, https://www.iea.org/
[4] European Environmental Agency, https://www.eea.europa.eu/themes/energy
[5] The World Bank, Sustainable Urban Development, http://www.worldbank.org/en/topic/urbandevelopment
[6] World Resource Institute, WRI Ross Center for Sustainable Cities, https://www.wri.org/our-work/topics/sustainable-cities
[7] C40 Cities, http://www.c40.org/about
[8] 100 Resilient Cities, http://www.100resilientcities.org/

substantial refurbishment and retrofitting opportunities in order to optimize their current energy consumption (IPCC, 2014; Veenstra and Kaashoek, 2016).

In the construction and building industry, energy efficiency techniques are commonly considered as the best practices (Beggs, 2009; Ma et al; 2012; Mumovic and Santamouris, 2013), and as energy prices rise, they attract more interests and become more commercially viable. Governments, business, and civil society have started to seize the benefits of energy saving that results in fewer demand and lower costs. Energy efficiency measures cover from the initial design, the building operation, and refurbishments. And benefits can be immediately noted in the reduction of fuel and electricity consumption, reducing the energy costs related to the building operations. For instance, buildings can be designed and positioned to maximize thermal performance and utilizing ideal materials to minimize energy losses (see, Passive House Institute[9], The Zero Energy Project[10]). Likewise, natural ventilation techniques can help maintain high air quality and improve heat transfer processes (see Breathing Buildings[11], Indoor Environment Group[12]). More comprehensive strategies include the creation of networks capable of providing knowledge and technology to building developers, in order to support the design and integrate sustainability into buildings (see AECB[13], Green Building Counsel[14], Whole Building Design Guide[15]).

Energy saving opportunities in already built and long-standing buildings are also being addressed. Retrofitting methodologies can range from simple and (relative) low costs with immediate benefits (IPCC, 2014), such as lighting replacement and insulation methods, to major refurbishment activities with significantly higher capital investments, these may include entire-building renovations, upgrade of building materials, and/or the modernization of energy distribution, measurement, and control systems (Ma et al., 2012). Mainly in developed countries where urban environments are mature, retrofitting initiatives have been strongly introduced (see BEEM UP[16], Build Up[17], Energy Saving Trust[18]).

3.1.2. Circular economy

[9] Passive House Institute, http://passivehouse.com/
[10] Zero Energy Project, http://zeroenergyproject.org/
[11] Breathing Buildings, http://www.breathingbuildings.com/
[12] Berkeley Lab's, Indoor Environment Group, https://indoor.lbl.gov/
[13] AECB Building Knowledge, http://www.aecb.net/
[14] World Green Building Counsel (GBC), http://www.worldgbc.org/
[15] Whole Building Design Guide (WBDG), https://www.wbdg.org/about-wbdg-whole-building-design-guide
[16] BEEM UP, Building Energy Efficiency for Massive Market Uptake, http://www.beem-up.eu/
[17] Build Up, The European Portal for Energy Efficiency in Buildings, http://www.buildup.eu/en
[18] Energy Saving Trust, http://www.energysavingtrust.org.uk/

As cities evolve and develop, physical changes on buildings and infrastructure can easily be perceived, nevertheless, their production and consumption cycles are also affected. A study on the effects of urbanization in developing countries (Jones, 1991) explored the energy-use and consumption changes regarding the transportation, household, agricultural, and industrial systems as urban environments expands. The study found that the environmental footprint considerably increased as urban lifestyle took over the traditional rural environments. Although these effects have already been analysed in section 2.3, it is worth emphasizing some of them:

- Resources, materials, and products have to be transported over greater distances to cope with urban demand;
- Industrial processes require more energy than traditional manufacturing or production methods;
- Surrounding ecosystems act as waste sinks, and are unable to process the increasingly amount of water, air, and soil pollution.

The circular economy perspective attempts to address these challenges by creating regenerative, local, and efficient production processes; while maintaining, preserving, and restoring materials to retain them as useful inputs within the same system. A circular economy aims to eliminate waste flows altogether and encourages "designing-out" harmful, toxic, or scares materials (Ellen MacArthur Foundation, official website).

Circular economy is increasingly gaining popularity within cities. Governmental programmes that resemble circular economy are usually implemented at a sectorial level. For instance, waste management strategies become more comprehensive and range from the 3R systems (reduce, reuse, recycle) to more ambitious zero waste programmes (Wilson et al, 2012; Ghisellini et al, 2016; Ferreira et al, 2017). Large-scale circular economy initiatives require a wide range of multi-sector collaboration and cooperation networks and often require legislative support in order to facilitate, encourage, and boost circular market opportunities (Ellen MacArthur Foundation, 2015). A concise example of the application of circular economy strategies at a macro-level, is the recent Circular City Deal (Staatscourant, 2017) signed by several Dutch cities, where cities commit to explore circular economy opportunities, implement tools to track and monitor material flows, and incentivise institutions and businesses to adopt circular economy practices.

At a meso-level, examples include, environmental front-runner construction companies that integrate circular economy in their building practices. The former consists on concepts such as modularity,

renovation, and repurpose of materials are incorporated in the design stages of their projects (ARUP, 2016a; European Energy Innovation, 2017). The World Economic Forum (WEF) a significant potential for economic and environmental benefits by the adoption of circular economy practices in the construction industry, the report states the following: *"[a] minimal increase in upfront costs of about 2% to support optimized design will lead on average to life-cycle savings of 20% on total costs"* (WEF, 2016, p.10).

New business models and innovative ventures that embrace the circular economy concepts are arising, creating market and employment opportunities. Increasingly popular business models include the integration of local production process, sharing and leasing platforms, and networks for the disassemble and recycle (or reuse) of materials (Ghisellini et al, 2016; Ellen MacArthur Foundation, official website). Additionally, repurposing, redesigning, or redistributing spaces within the built environment can lead to attractive circular economy initiatives, for instance, vertical urban agriculture is currently being developed and applied in major cities of the world, utilizing unused or compact spaces to farm produces at higher rates than traditional methods (see Alesca Life Technologies[19]; Edible Garden City[20]; Plant Chicago[21]). These micro-level initiatives are often limited due to the reach of their own capabilities (Lewandowski, 2016). Some of the challenges that have yet to be overcome include the creation of sound collaboration networks, induce sustainable consumer behaviours, and ensure fair competition against conventional market forces (van Buren et al, 2016).

3.1.3. Low carbon initiatives

As cities are composed of complex networks and interrelated systems, it is not easy to implement a single all-encompassing solution. High-impact sustainability programmes require the integration of several measures that usually need to be applied at different scales and different sectors. The coordination and implementation of this kind of programmes is one of the biggest challenges for cities, but several efforts are being undertaken all over the world in order to improve the sustainability of urban environments. Usually, these initiatives carry names such as green, sustainable, or smart cities. In the following paragraphs, an attempt to define and identify these measures is presented, subsequently, their relevancy and contributions towards the sustainability of the built environment are analysed.

[19] Alesca Life Technologies, http://www.alescalife.com/en/home/
[20] Edible Garden City, https://www.ediblegardencity.com/
[21] Plant Chicago, http://plantchicago.org/

There is not a general consensus on the definition of *low carbon cities.* Firstly, because not all city emissions are the same, it depends on their primary activities, population densities, geographic location, and many other factors. Second, because of the complexity of accurately measuring and accounting the emissions to individual or specific locations in the complex environment of cities. And finally, because each city has its own specific agenda, and will rarely prioritize long term sustainability actions over short term economic development (Baeumler et al, 2012; Mccormick et al, 2013; Dahal and Niemelä, 2017). Thus, to facilitate the process of this review, the definition of low carbon strategies can be a simplified as*: urban transformation programmes that integrate diverse sustainability actions to provide communities with a liveable and healthy environment.* In this way, low carbon cities comprehend initiatives that include the promotion of non-conventional energy sources and efficient mobility systems; the creation, development, or re-adaptation of open spaces, parks, and lakes to improve air quality and encourage recreational activities; and the application of technology and techniques that stimulate resource efficiency and improve waste management methods (Nielsen et al, 2013; Ryan, 2013). Low carbon strategies seek for the reduction of the overall city footprint (illustrated in Figure 6), through comprehensive sustainable solutions across city-wide systems, including food, water, fuel provision, electricity consumption, and waste management.

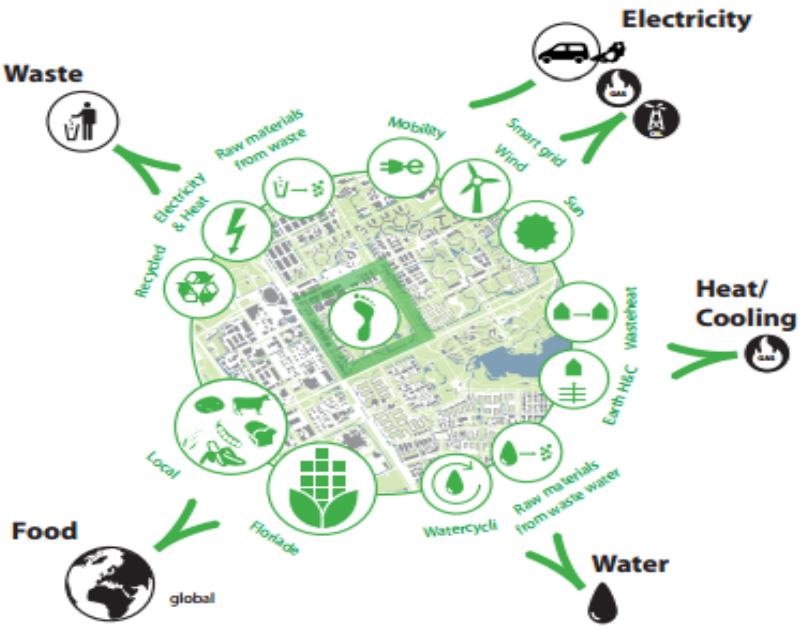

Figure 6. Environmental footprint from cities. City of Amsterdam TRANSFORM project, taken from https://amsterdamsmartcity.com/projects/transform

Because undertaking city-wide transformation programmes may result to be extremely complicated, many cities have initiated strategies focusing on single districts, precincts, or selected communities. For instance, in London and Stockholm large scale regeneration of decayed areas are currently being developed. Districts in a post-war social housing area and an old industrial port, respectively, are being redesigned and adapted to build low-energy, mobility efficient, and healthy neighbourhoods (C40 Cities, 2016). Both projects aim to considerably increase the life quality of their citizens while transforming the city landscape.

3.2. Sustainable management approaches

The focus of this section is to present an attempt to define and provide a clear understanding of the management strategies that can enable, facilitate, and accelerate a transition towards the sustainability of the built environment. It is intended to provide an introduction to the wide range of sustainability strategies that can be, or are currently being, applied in urban contexts. A broad overview of groundbreaking management solutions and methods, abstracted from available literature and several empirical studies, is presented.

For simplicity's sake, the strategies and measures analyzed are focused on the innermost dimension of cities: the urban built environment and its respective consumption system. At a macro-scale, these two perspectives, almost always, present similar characteristics despite the unique and specific conditions and contexts. Common characteristics include, for instance, energy and electricity demand for heating and cooking; basic requirements of products and services such as food, water, and healthcare; and the need for local transportation. The discussion includes (i) policy instruments and governance systems, and (ii) business innovation; research support, and catalyst, as enablers of a transition to a sustainable urban built environment.

3.2.1. Policy instruments and new governance approach

Even before the adoption of the term sustainability, policy instruments were being applied to ensure society's well-being. Protective and preventive regulations to guard communities against harsh

environmental and health effects are usually sought when risks become evident. However, in 1963, in the book Silent Spring, Rachel Carson described the adverse effects of certain pesticides on human health and the surrounding environment, in what is considered by some as the beginning of modern environmental movement. Since then, important advancements regarding citizenship awareness, sustainability, and environmental policy have been achieved. Nowadays, it would be expected to find prohibitions, bans, and regulation limits on harmful and toxic materials and substances in most countries of the world. Technology mandates and performance standards, are also regularly implemented, however, these can vary according to local or specific factors, such as the main economic activities or financial capabilities of a country or region.

Additional regulatory measures can range from taxation or penalization methods, to allowances and certification schemes. Taxes and auctioned allowances have proved to be a relevant source of governmental revenue (Goulder and Parry, 2008). Subsidies can help mitigate environmental externalities contributing to technological development and social well fare (Timilsina and Dulal, 2008). Voluntary regulation approaches evoke for the social and environmental responsibility of companies and organizations, but may offer exclusive benefits such as tax breaks, knowledge acquisition, and market positioning (Prakash and Potoski, 2007).

In practice, direct (such as standards, technology mandates, and limits) and indirect (namely subsidies, taxation, and certifications) sustainable policy instruments are applied concurrently, as one cannot replace the other. Leading examples of policy measures within the built environment include the publication of building guidelines and best practices that enable and accelerate the self-regulation processes within the construction industry (Zuo and Zhao, 2014); setting taxation and emission limits for private mobility in heavily congested areas (Timilsina and Dulal, 2008); and the development of restrictions for intensive material use and incentives for their adequate disposal (Ghisellini et al, 2016). A suitable selection, design and the appropriate implementation of policies can lead to substantial sustainability advancements (Geller et al, 2006). However, viable regulatory instruments may fall short of the increasing sustainability challenges, important gaps regarding the ambition, enforcement, and evaluation of environmental policies still have yet to be bridged (McIntosh et al, 2008).

Despite the growing attention from policy makers and organizations, studies have found that environmental policies lack effectiveness (Newig and Fritsch, 2009). Several authors have urged the use of non-conventional governing methods in order to accelerate urban sustainability (Hahn, 2000; Bai et al, 2010, van der Heijden, 2016a). It is proposed that introducing new governing approaches may support the

development of a more effective sustainable regulatory framework. Thus, the *new governance* perspective has emerged. Citing the definition provided by O'Leary et al (2006), governance refers to the process of steering and influencing decisions and actions, within the private, public, and civic sectors; and differs from the traditional top-down and hierarchical *government* methods (O'Leary et al, 2006; van Zeijl-Rozema et al, 2008). Key strategies to achieve this new approach include opening and spreading participation in decision-making processes, scaling systems and solutions to the most adequate dimensions, and the adoption of flexible and adaptable instruments.

It has been discussed that **extended public participation**, against a traditional top-down implementation approach, may improve the support and effectiveness of environmental policies. In Agenda 21 (UN, 1992), the concept was constantly listed as a key factor to foster the development of environmental and sustainable practices and policies. The participatory model is based on the integration of non-state actors, and attempts to reach a more reflexive and pro-active policy making processes (Tatenhove and Leroy, 2003). It is recognized that consulting relevant actors will likely increase their awareness and understanding of the issues and aims of policies; additionally, it provides policy-makers with distinctive local knowledge; and finally, it is argued that citizenship appreciation and commitment are increased when their ideas and perceptions are taken into account (O´Fallon and Dearry, 2002; Bulkeley and Mol, 2003; Yearley et al, 2003). Nevertheless, the execution of a participatory model is complex. The involvement of more actors hampers agreements and slows down decision making processes. As issues grow in scale, fragmentation and confrontations increase as well. Thus, the proper and efficient integration of relevant actors often presents dilemmas of participatory inclusion (or exclusion), which, if are not properly addressed, may turn to uncertainties, leading to inadequate public representation (Pellizzoni, 2003).

The many dimensions of urban systems further complicate the development of effective governance approaches. Actor's perceptions may vary regarding their relations with their surrounding environment and their interests. New governance methods must be able to incorporate instruments adaptable to **multi-level and scalable** systems (Newig and Fritsch, 2009). Thus, it is required that environmental policies are designed in a flexible manner, leaving open possibilities for rescaling and redefining the system's dynamics, such as stakeholder involvement, spatial relations, and reach of the measures. An effective environmental governance must be able to **evaluate, modify, and adapt** accordingly to the interests of the concerned parties, the systems' responses, and the public (dis-)conformity (van der Heijden, 2016a).

Table 2. Selected new governance instruments for low-carbon built environment. Taken from van der Heijden (2016b). The new governance for low-carbon buildings: Mapping, exploring, interrogating, p. 14 – 18.

Instrument	Country	Description	Source
Amsterdam Climate and Energy Fund	NL	Revolving loan fund managed by the City of Amsterdam.	http://akef.nl/
BREEAM	Global	Certification and classification instrument based on labelling.	http://www.breeam.com/
CitySwitch Green Office	AU	Technical support for and information sharing among office tenants about energy efficiency and waste efficiency.	http://www.cityswitch.net.au
Energy Leap	NL	Program to increase demand and supply of energy efficient buildings.	http://www.energiesprong.nl/
Energy Star	US	Certification and classification instrument based on rating and benchmarks for commercial buildings.	https://www.energystar.gov/buildings
Green Building Index	MY	Certification and classification instrument based on labelling.	http://new.greenbuildingindex.org/
Green Deals	NL	Covenants between the Government of the Netherlands and local businesses and households committed to reduce their greenhouse gas emissions. Strong focus on building energy efficiency.	http://www.greendeals.nl/
LEED	Global	Certification and classification instrument based on labelling.	https://www.usgbc.org/leed
Retro Fit Chicago	US	Technical support for and information on commercial and residential building retrofits.	https://www.cityofchicago.org/city/en/progs/env/retrofit_chicago.html
Small Business Improvement Fund	US	Financial assistance for building retrofits.	http://somercor.com/sbif/

3.2.2. Innovation, collaboration, and catalysis

The new governance approach strongly leverages form knowledge and technical development. Being able to test and experiment with the latest methods and technologies provides cities the opportunity to be in the forefront of sustainability and environmental management. Additionally, spreading information and successful case studies helps increase stakeholders' engagement, enabling the scalability and replication of initiatives. In this way, **innovation** can be one of the most powerful tools to support the new governance approaches and the development of new business models. For instance, driving political and economic

approaches towards the recognition of technology as an embedded part of the current social contexts (Guy, 2006; Goldthau, 2014). In other words, innovation supports the development of favourable policy instruments for the incorporation of *"smart"* techniques. In this context, smart techniques refer to the incorporation of information and communication technologies to significantly increase their resource and energy efficiency (Nielsen et al, 2013). But innovation is not only about technology implementation and digitalization, it also covers the development of new business and operating models, encouraging the interactions among governments, organizations, and society (Rogers, 1999; Paskaleva, 2011).

Working across boundaries and developing multi-sector relationships, based on continual and reciprocal cooperation, is what conforms **collaboration** networks (O'Leary et al, 2006). Recent literature on collaborative management states that complex societal and environmental problems can be efficiently talked through multi-sector collaboration (Goldsmith and Eggers, 2004; Bryson et al, 2006; Steiner et al, 2013; NCC, 2016). Collaboration enables systems to integrate, facilitates effective communication channels, and may result in the generation of value by exploiting mutual benefits or undiscovered, opportunities (Hamann and April, 2013). For example, Blue City[22] in the Netherlands assists cross-industry companies to increase their revenues by connecting output with input streams, reducing waste and cost. Furthermore, through collaboration networks, benchmarks, knowledge, and, media attention can be shared and distributed across industries and sectors, enhancing the capabilities and performance of the involved actors (van der Heijden, 2016b).

Cities are in an advantageous position to deal with sustainability issues and experiment with new approaches (Kousky and Schnider, 2003; Mccormik et al, 2013). Their concentrated nature, the possibilities of applying economies of scale, and the wide range of interconnected socioecological and political systems, captivates entrepreneurs, innovators, and researchers. Furthermore, in order to stimulate innovation and collaboration, some authors have stressed the importance of creative and disruptive entrepreneurial and political leadership (Alexander et al, 2001; Block and Paredis, 2013; Hamman and April, 2013). It is discussed that the leadership perspective must be based on values, partnerships (sharing control), collective responsibility, and trust. When combining the advantageous characteristics of cities and the emerging new leadership styles, favourable conditions that **catalyse and accelerate** the transition towards more sustainable urban environments may be enabled (see DRIFT[23], Living Labs[24], and Nevens et al, 2013).

[22] Blue City, http://www.bluecity.nl/en/
[23] DRIFT, https://www.drift.eur.nl/
[24] Open Living Labs, Smart City Living Lab, http://www.openlivinglabs.eu/livinglab/smart-city-living-lab

3.3. Conceptualization of urban sustainability strategies

As explored above, urban sustainability strategies are intertwined with many social, economic, and political factors. Additionally, urban sustainability measures incorporate more dimensions than traditional approaches, including environmental impacts, quality of life, and well-being of communities and ecosystems (Adger et al, 2005). It has been argued that to manage through the complexity and support disambiguation, urban sustainability systems should be conceptualized through assessment and measurement techniques (Pope et al, 2004; Scheirer, 2005). In this way, the best and most suitable solutions can be better understood, prioritized, and optimized, supporting the improvement of urban environments.

In the book, Sustainable Indicators: Measuring the Immeasurable, Bell and Morse (2008) open the discussion with a simple but pertinent statement: *"[W]e cannot farm or develop sustainably unless we know what this implies"*. Then, they set to explore a proper meaning to the term and its implications in the quality of a system over a time period. The authors argue that sustainability should be pursued through its spatial and time scales, while attempting to maintain (or improve) the quality of a system. Based on this notion, the current section, attempts to describe the sustainability implications of the urban challenges presented above. Conceptualizing and categorizing the different strategies can help understand the extent on which they contribute to urban sustainability.

3.3.1. Classifying urban sustainability strategies

Selecting the adequate criteria to assess sustainable strategies, has been a widely discussed subject (Bell and Morse, 2008). Conducting science based assessments to support the interpretation of urban sustainability strategies, will most likely contribute to the improvement of their credibility and legitimacy (Cash et al, 2003). Such assessments often require the application of properly selected indicators and indices that facilitate decision-making processes, enabling more efficient and effective planning, implementation, development, and evaluation of sustainable strategies (Luthra et al, 2015). There are many methods and techniques that can be adapted to measure urban sustainability, although the most suitable alternative will often depend on specific characteristics and conditions regarding the assessment context (Munda, 2005; Wang et al, 2009).

As this research project deals with several sustainability strategies, in a range of different sectors, levels, and scales, the application a single methodology to measure and operationalize them was not allowed. Nevertheless, from a higher appreciation level, strategies can be relatively assessed and compared through indicators and measures that regard to the overall sustainability of a programme. For example, a study by Scheirer (2005) analysed the constituents of health programmes sustainability, where three distinct types of measures were summarized:

"[1] measuring continued health benefits for individuals after the initial program funding ends, particularly continuing to achieve beneficial outcomes among new consumers or other intended recipients (in contrast to maintaining behavioral change among earlier clients); [2] inquiries concerning the continuation of program activities within an organization, often termed "institutionalization" or "routinization," within an organizational focus; and [3] questions about the continued capacity of a community to develop and deliver health promotion programs, particularly relevant when the initial program worked via a community coalition or other community capacity–developing process."

Although this study presented an analysis of health programmes, the measures can be adapted as they refer to basic sustainability principles. The first measure, refers to the benefits attained, their extent and reach. The second measure covers the time scale, although this specific example focuses on the continuation of programmes, the time scale can be defined as the desired period for programmes to be performed or results attained. And the third measure, stresses the importance of capacity-development, or the technical, scientific, and capital resources available for the development of programmes and initiatives. According to this study, a programme becomes sustainable when it successfully fulfils all three measures, in other words a sustainable programme is one that provides extended benefits, functions over long periods of time, and is supported by adequate capacities to be operated and maintained.

Based on the former, the sustainability of the urban strategies was conceptualized. Enabling an analysis along the three described dimensions, namely time, capacity, and benefits. First, strategies were analysed regarding the relative time required for an initiative to be developed and results to be perceived. Then, strategies where ranked according to their reliance on technological developments, infrastructure, financial mechanisms, skilled human resources, and/or stakeholder engagement. Lastly, the range and extent of the probable benefits was determined with the support of empirical studies and reviews.

Appendix 1 shows the detailed measures and analysis performed which resulted in the relative classification of the studied urban sustainability strategies. Results are schematically represented in Figure 7.

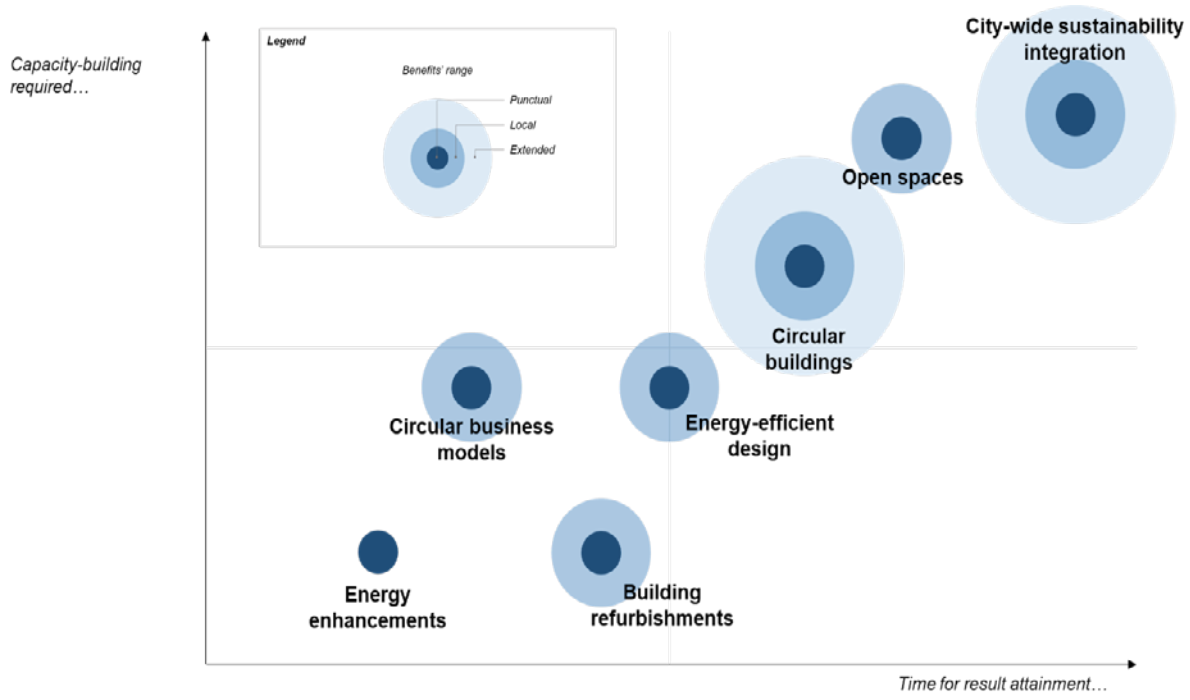

Figure 7. Relative categorization of several urban sustainability measures. Own designed based on the analysis of several initiatives, empirical sources, and case studies (see appendix 1).

3.3.2. Understanding environmental benefits

As explored in previous sections, the benefits of implementing environmentally-friendly measures within the built environment can range from cost savings and business opportunities, to quality of living and health standards improvement. It is obvious that some are more clearly perceived than others. Energy efficiency initiatives in buildings immediately produce electricity or fuel savings, that can be directly measured and appreciated by the final users. Whilst, more comprehensive strategies, such the implementation of environmental mobility zones, at first sight, may create inconveniences and generate the discomfort of citizens, but, in the long run, significant environmental and living standards improvements can be achieved. Some benefits are much harder to be measured than others, thus affecting the appreciation and awareness of the final users. For these reasons, quantifying environmental benefits is not always simple and straight forward.

With this in mind, environmental benefits were studied from a holistic perspective. Taking into account the direct and indirect advantages, mitigation potential, and precautionary measures. Direct benefits refer to those that can be easily traced and clearly attributed to a specific measure. Indirect benefits are those contributions to the improvement of general conditions, yet the programme cannot be held completely accountable for the achievements, as many other factors may interfere. Mitigation potential are identified as the actions required to stop, slow down, or reverse environmental issues. And precautionary measures include the possible benefits, avoidance of issues, and reduction of risks. Furthermore, the range of benefits can vary according to the scale and extent of a strategy, initiative, or programme. Results may only be evident at a local level, or they may extend far beyond the limits of the initiative. For instance, applying circular concepts in the construction industry directly improves the quality of buildings, by, for example, utilizing non-hazardous materials, but the reach of its benefits may extend all along the value chain, due to the integration of recycled materials and optimization of waste streams.

3.3.3. Exploring time and capacity building

In this analysis, capacity building refers to the time, resources, methods, and technologies required in order to fulfil the implementation of a sustainability strategy. The most comprehensive sustainability measures often require longer periods of time to attain returns, as stated above these results may not be as evident but support long-term strategies that produce greener and healthier urban environments. However, dominant shareholders and political entities, commonly focus on quick financial returns or notable results within communities. The former, commonly hiders more comprehensive strategies, limiting the pace of urban sustainability transitions (Dangerman and Schellnhuber, 2013). To overcome short term-solutions favoured by political agendas, and turn the attention towards long-term but more effective programmes, civil society must remain active; supporting and evaluating the performance and accountability of sustainability programmes (see Urgenda[25]).

As discussed in the previous section, the development of collaborative networks, policy frameworks, and market innovations are all key factors to enable a transformation of urban environments. Moreover, the availability of technological advancements, proper infrastructure, and adequate resources may be recognized as gaps that challenge the transition to sustainability. Therefore, capacity building and investments in technical, capital, and human resources is critical for the development of lasting and

[25] Dutch Urgenda Foundation, http://www.urgenda.nl/en/

enduring solutions. In this way, significant efforts should be directed to system innovation, the training of highly qualified human resources, the adoption of information and communication technologies, and the promotion of market opportunities for sustainable development. In the other hand, a lack capacity and resources to build it, leads to the focus on market-ready and cost-effective solutions, which, as expected, have less sustainability impacts.

3.3.4. Discussing the complexity and influencing forces

Currently, market-ready *energy efficiency strategies*, that include low-consuming lighting and modernizing electrical equipment, are really common, due to their relative low investments required, and their reasonable pay-back periods. Subsequently there is a wide range of products and schemes available within sectors and industries (Beggs, 2009; Philips, Lighting Services[26]). More comprehensive energy efficiency measures, that include, for instance, the refurbishments of buildings to improve their overall energetic performance, require larger efforts and capital investments, but provide greater and more evident benefits (IEA, 2014). Even though, instruments and incentives promote high-capacity sustainable building programmes exists (de la Rue du Can, 2014; European Commission, Energy Efficiency[27]) a great potential for upgrading existing buildings remains untapped (IEA, 2014). The lack of integration between building developers, operators, and final users is a commonly identified barrier for the implantation of these initiatives.

New urban development offers the opportunity to incorporate efficient energy use, as well as circular economy principles, from design. The sustainable building construction require interdisciplinary approaches, during the entire process of development. Buildings must be engineered to make the most of the physical environment characteristics, while being accommodated to the final users' behaviours and requirements (The Royal Academy of Engineering, 2010). Even though, energy efficiency and circular economy buildings are based under similar principles (resource efficiency) the analysis suggests that circular economy initiatives require significantly more collaboration across the building supply chain (ARUP, 2016a; Carra and Magdani, 2017).

Regarding the the integration of circular principles into the urban built environment, there currently are many available and viable options, however, it is common that techniques, infrastructure, and behaviours must be adapted or developed to perceive an economic and environmental value (Lewandowski, 2016).

[26] Philips, Lighting Services, http://www.lighting.philips.com/main/services
[27] European Commission, Energy Efficiency http://ec.europa.eu/energy/en/topics/energy-efficiency

These initiatives usually require significant commitment from business and communities so a profitable business model can be achieved. Benefits are hard to measure, since circular economy practices take part of comprehensive systems that require integration and cooperation to maximize the advantages.

Open and green spaces within cities can potentially offer important environmental services that are lost in the traditional urban "grey" city scene. The main social and environmental benefits include the improvement of air quality, the notable change of the city landscape, and the raise of health and living standards of the surrounding communities. Nevertheless, the reclaim of urban land to develop urban open spaces, the infrastructure challenges, and capital investments required at a municipality or city level are some of the reasons that impede further developments. Additionally, although significant benefits have been demonstrated (Jansson, 2013), the greater benefits are mostly perceived only in the adjacent neighbourhoods.

It was found that the most beneficial urban sustainability programmes are the most complex and strenuous initiatives. The development of city-wide collaborative networks vastly depends on public sponsorship and active community involvement to push forward the political sustainable agenda. There are still many technical, infrastructure, and financial challenges in order to achieve a complete transformation of urban environments. Despite the challenges, empirical studies have demonstrated the viability and success of local and small-scale solutions (Yearley et al, 2003; Hamman and April, 2013; Uyarra and Gee, 2013), subsequently exploring the barriers and opportunities for their expansion and scalability (Kousky and Schnider, 2003).

3.4. Summary and final observations

Through this chapter, the main trends, initiatives, and measures that are currently seeking to transition to more sustainable urban environments were explored. The success factors, relying in governance, regulations, innovation, and collaboration were also discussed. In addition, sustainability initiatives were categorized accordingly to their relative complexity, in an attempt to provide a better understanding of their extent and reach. In this way, more impactful and effective sustainability strategies can be pursued.

All the intertwined factors involved in the design and implementation of sustainability strategies, along with the increasingly complex urban contexts, further increase the complexity of urban sustainability

attainment. Community requirements, stakeholders' interests, and political agendas must be aligned in order to converge in the most suitable solutions. Additionally, the capabilities, resources, and technologies available have to be considered in order to ensure the proper development and ambition of sustainable initiatives. A strategic management approach is essential for the development of adequate programmes, able to balance all the involved factors, and account for the interests and necessities of the involved parties.

Sustainability transition programmes must be coherent with the resources and capabilities within a specific context. It is expected that a strategic approach for the management and assessment of sustainability solutions enables and optimizes effective solutions. Failing to do so could damage the perception of sustainable initiatives. For instance, aiming for easily accessible sustainability solutions may result counterproductive in environmentally active societies. While failing to achieve over-ambitious targets and goals may diminish the reputation of sustainability programmes, increasing the resistance for further developments and initiatives. The next chapter addressed the management challenge, exploring the methods and tools that support the assessment and decision-making process for the optimization of sustainability strategies.

Chapter IV: General framework for sustainable management in urban environments

Strategies to improve the sustainability of the urban built environment are comprised of complex systems, sub-systems, and variable factors that may affect their development. Understanding the complexity on which these strategies unfold supports the process of developing more efficient and effective solutions. Utilizing a strategic approach to study and analyse the common features of city systems around the world enables the development of macro-scale models that facilitate the assessment of measures and initiatives. City leaders, politicians, businesses, and organizations can leverage form these tools to appropriately design, plan, and implement adequate sustainability programmes, whilst maximizing the potential benefits. Strategic planning processes must adapt to local conditions and specific contexts, requiring for careful and comprehensive assessments to determine the optimal solutions. A general framework can help provide the guidelines for such assessments.

This chapter explores the main factors that contribute to sustainability, by compiling previously identified elements in theoretical and empirical studies. Subsequently, a conceptual framework that extracted suitable assessment methods was adapted for its application in urban sustainability initiatives. It is presented only a general overview, analyzing the first-level factors that contribute to the development of sustainability strategies, however, setting the foundations for further in-depth study. The final discussion derives from a brief assessment performed on several initiatives, in order to illustrate and test the framework's functionalities.

4.1. Dynamics of social-ecological systems

Much has been studied in order to better understand the relations of humans with their natural surroundings, conceptualized by some authors as the study of "*social-ecological systems*" (Moffat and Kohler, 2008; Ostrom, 2011). The detailed analysis of theoretical frameworks (Hohn and Neuer, 2006; van-Zeijl-Rozema et al, 2008; Ostrom, 2009; Ramaswami et al, 2012; Mccormick et al, 2013; Ryan, 2013), and empirical sources (UNEP, 2013; Koehler et al, 2015; ARUP, 2016b; Veenstra and Kaashoek, 2016) related to study of sustainability management, lead to the extraction of common characteristics, and their further adaptation to create a framework for sustainability strategies within the urban built environment.

Most studies on sustainability management revolve around common factors that encompass, the natural and human systems and their relations. To understand its complexity, these factors have been incorporated into layers, defined as *actors, actions, and outcomes (depicted in* Figure 8*)*. The layers encompass the influences and interrelations of a social-ecological system.

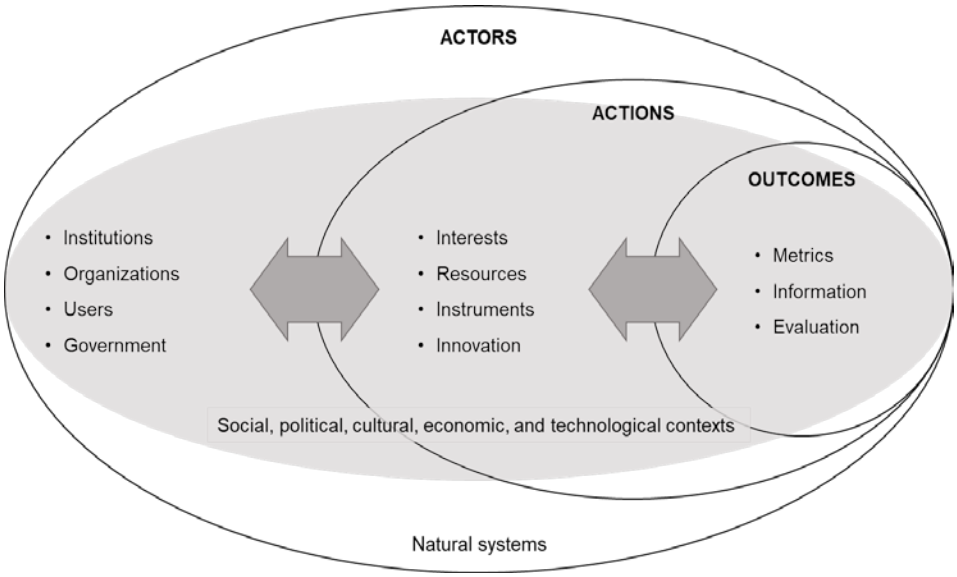

Figure 8. Common features of Social-Ecological System. Own design, based on previously developed theoretical frameworks for sustainability management.

4.1.1. Actors

Actors are the main forces influencing the transition or change processes. Within the highly complex urban built environment, actors range according to the sector, scale, or stage of urban development. Usually it encompasses city-planers, policy-makers, building developers, governmental institutions, and building occupants, such as commercial companies or dwellers. Additionally, actors can also be identified as those entities that are being affected by the adverse effects of the urban built environment, for instance specific communities (located inside, nearby, or distant from cities) or the surrounding ecosystems (usually represented by groups of interested citizens, organizations, or native communities). Regarding the growing sustainability awareness, it is common that actors arise as a response to pressing challenges, environmental problems, or discomfort with conventional practices.

Defining the relevant actors may be one of the most crucial and difficult processes for the assessment or implementation of a project or initiative (DRIFT; 2011). Actors vary according to the scale, extent, ad reach of an issue or measure that often requires cross-sector and multi-level collaboration. To facilitate

actors' involvement, it is important to ensure the availability of tools, methods and proper regulatory frameworks that enable a transition to more sustainable cities. The engagement of actors will highly influence the support, promotion, and success of sustainability measures and initiatives (Rohracher and Späth, 2014). The former stresses the importance of incentivizing and promoting knowledge as a fundamental factor on actors' involvement.

4.1.2. Actions

Actions cover the methods, resources, and tools utilized in order to develop a project or attain the goals of a programme. Sustainability actions are those that seek to provide a more liveable and healthy built environment in an affordable and enduring manner. Some examples include the grant of subsidies or incentives, the incorporation of self-regulation schemes, or seizing market opportunities that encourage the improvement of urban sustainability. This layer also considers the technical and financial resources available to facilitate the implementation and development of measures and initiatives.

Collaborative networks may support the optimization of programme developments and maximization of their potential benefits. It is here where actors must provide leadership attributes to promote and foster innovative and ground-breaking methods, operating models, and business opportunities. Furthermore, cities provide favourable characteristics to explore scientific breakthroughs, test modern technologies, and experiment with new management strategies. All in all, to achieve the integration of cleaner and more sustainable practices and systems within the built environment.

4.1.3. Outcomes

The outcomes include the final results and the monitoring, evaluation, and communication of the achievements and expectations. Outcomes should be accompanied by previously set goals or targets, so they can be measured and assessed correctly. Additionally, actors and action should balance the desired and attainable outcomes, integrating effective communication strategies to ensure the understanding and engagement to a programme. In this way, outcomes are not an isolated event that occur at the end of a process; outcomes must be incorporated since the definition of an initiative, adapted during its operation, and evaluated at the closure of a project.

Since an issue is identified the expected results can be delineated. The clear definition outcomes help maintain the direction and scope of a project. However, during the process of design, relevant actors may influence and change these expectations, and the unfolding of certain actions may affect (or enhance) the extent on which these outcomes may be achieved. Integrating continuous check-and-review processes in regard with the defined outcomes enables designers and implementers to adequately manage expectations (accordingly to the resource availability, technical feasibility, and financial possibilities) and incorporate feedback loops into the process to improve the result attainment. Consequently, enabling the evaluation of a programme and the identification of further improvement opportunities.

4.2. Setting a framework

Visualizing of the urban built environment as a social-ecological system, a framework to enable the assessment of sustainable initiatives and measures is proposed, represented in Figure 9 The framework integrates the three layers discussed in the former section and highlights the interactions between every step of the process. Interactions act as the holding forces that dive the system processes. As much other societal process, sustainability within the built environment is mostly triggered by an environmental or health issue that has become evident amongst communities. The final aim of the framework is to provide guidance in the management processes of sustainability programmes.

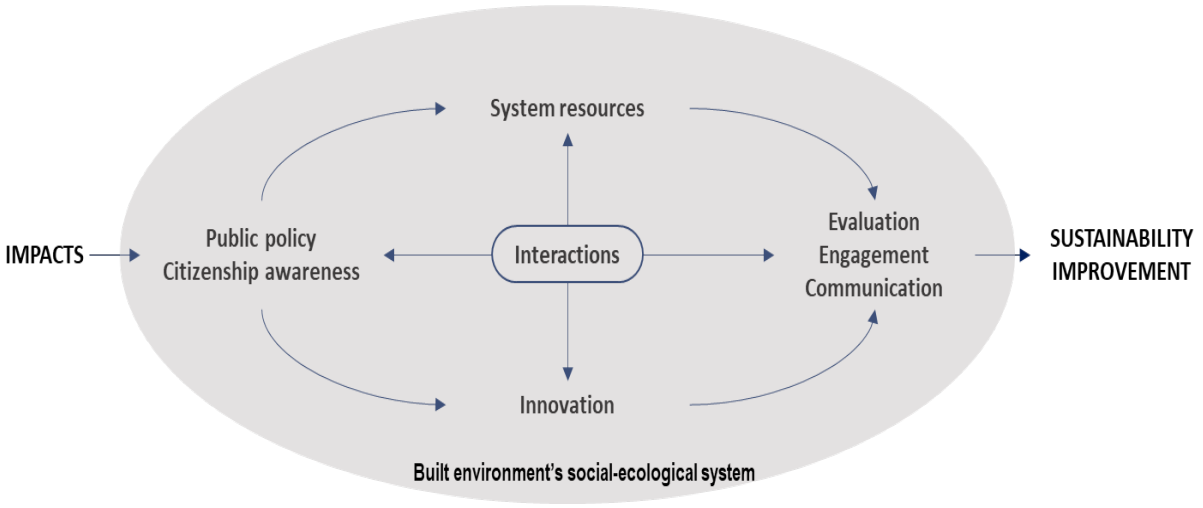

Figure 9. General framework for the assessment of sustainability strategies, measures, and initiatives. Own design

4.2.1. Awareness and support

It is key to first determine relevant actors and identify their stance concerning the issues and challenges faced. This first step can help create strategic partnerships or focused awareness campaigns in order to strengthen the **support** towards certain initiatives or measures. However, it has been studied that raising support in complex social systems may be hindered by the individual interests of the actors involved (Ostrom, 1990), as the dominant strategy for one group or organization may differ from what other actors consider as the most sustainable or ideal solution. Thus, it is advised to maintain close collaboration with those directly affected and promote the inclusion of local knowledge when possible (Cox et al, 2013).

With an increased **citizenship awareness** and involvement, it will be more likely to find, or push for, an adequate regulatory framework that facilitates the implementation of sustainability measures. Relying in supportive **public policy** schemes can greatly advantage the development of sustainable ventures. In the other hand, the absence of adequate policies might require the development of instruments that reinforce and regulate the concerning issues. The governance approach and openness of policy-makers and governmental institutions to collaborate will greatly influence the course and expectations of a project. Actors must analyse, explore, and identify the barriers and opportunities stemming from local or regional legislation.

4.2.2. Availability and capabilities

Subsequently, the **systems resources** must be analysed. This includes the materials and/or technologies, as well as the human and capital resources, required to develop and operate a project. Standards and technical limitations that must be considered (if any) accordingly to the previously identified regulatory framework. Additionally, opportunities may exist for obtaining financial incentives or non-financial incentives from governmental agencies or international organizations, such as subsidies, tax breaks, loans, knowledge provision and/or consultancy contributions.

Additionally, **market opportunities** may be exploitable with the potential of generating profits. Leadership and entrepreneurism may lead towards attractive emerging market sectors that demand for sustainable alternatives. Another interesting option resides in the integration of public-private partnerships, that can help facilitate the delivery of services or development of new business models within the complex urban systems.

4.2.3. Engagement and commitment

Furthermore, assessing the probable or attained success encourages continuous **evaluation** and improvement of on-going processes. Here communication and **information strategies** should be considered to promote the potential benefits and outcomes of an initiative. Managing the expected outcomes, and scaling them to the adequate dimensions, accordingly to the reach, extent, resource availability, and own capabilities of a programme is essential to avoid the disengagement of relevant actors (Hagbert and Femenías, 2016). However, more ambitious goals that result in significant and evident environmental and health improvements may increase the interest and **commitment** of communities, facilitating the support for further sustainability programmes.

4.2.4. Interactions

Finally, interactions are found at the core of the system. They define the **relations** between and amongst the relevant actors, their respective actions, and the effects on the social and natural systems. Within the complex nature of cities interactions can be found at every level and stage of an issue, measure, or initiative. At the end, interactions may determine the success or failure of an initiative, as describe by Bressers (2004): *"the course and outcomes of the policy process depend not only on inputs […], but more crucially on the characteristics of the actors involved, particularly their motivation, information, and power"*. All the frameworks studied stressed the significance of the specific contexts around the social-ecological systems. Political, economic, and social interactions are factors that highly influence the actors' interests and their capabilities to undertake actions, ultimately affecting the engagement, ambition, and development of sustainability initiatives.

Chapter V: Assessing sustainability strategies

The framework objective is to provide support to policy-makers, knowledge-oriented organizations, sustainability managers, or entrepreneurs in the assessment, analysis, and identification of barriers, opportunities, and limitations of sustainability measures, initiatives, or ventures within the urban built environment. It is expected to serve as guidance for strategic planning processes and incite further, and more effective, analyses. This chapter presents a brief but detailed assessment of urban sustainability initiatives implemented in different contexts. It aims to provide insight and illustrate the framework's (illustrated in Figure 9) functionalities through real case scenarios.

The assessment method is tested utilizing several brief case studies reviews presented in Table 3. Relevant case studies, that include a range of initiatives covering from energy efficiency to the decarbonisation of cities, were selected to complement the theories reviewed. The analysis is based on information gathered from first and second-hand data sources, stemming from interviews, seminars, conferences, workshops, and official reports available on project websites. More detail on the data sources can be seen in table below.

Table 3. Case study review selection

Location	Initiative	Type	Sector	Data Collection
Netherlands	Green Deal	Circular Buildings	Public & Private	• Green Deals Circular Buildings Workshop • Interview with sector specialist • Green Deals official website and publications (http://www.greendeals.nl/)
Netherlands	Sustainable Amsterdam	Low-carbon city	Public	• Amsterdam's municipality official website, reports, and publications (https://www.amsterdam.nl/) • TRANSOFRM project official website, reports, and project deliverables (http://urbantransform.eu/)
Mexico	Public Building Refurbishment	Energy Efficiency	Public	• Mexico City official reports • Interview with programme staff
Mexico	NAMA Housing	Sustainable building	Public	• Official reports and publications • Interview with programme staff

This exercise expects to illustrate a general pathway towards the assessment of solutions. And hopefully serves to facilitate the decision-making processes of policy makers, government officials, and organizations interested in the development of urban sustainability programmes. This assessment consists of an evaluation of several initiatives in different contexts, with the aim of highlighting their main achievements, challenges, and barriers and positioning them within a single framework. For this, the advice of professionals and scholars was requested; several relevant conferences, seminars and workshops were attended; and second-hand sources of information were consulted when available.

5.1. Case studies presentation

The assessment was performed by analysing relevant initiatives being developed in two countries. The selected initiatives cover different sectors, levels, and scales. It was ensured that sufficient information was publicly available, otherwise information was gathered by attending seminars or performing interviews to programme staff or sector experts. Data was collected from on-going projects aimed to improve the sustainability of the built environment in Mexico and the Netherlands.

5.1.1. Green Deal – Circular Buildings

Green Deal is a collaborative based initiative, coordinated by the governmental agencies of the Netherlands, which aim is to stimulate sustainable innovation. The Green Deals bring together organizations, companies, and civil society with local and central governments to help accelerate and remove the barriers for a sustainable growth (Green Deal, official website). Under this approach, a three-stage programme, that promotes the application of circular economy principles in buildings, is being developed. The programme consists on maximizing sustainable building features, such as extended material usage, recycling of raw materials, and installing adaptive operation and maintenance technique. The second, consist in identifying key indicators for circularity in buildings to create a “green building passport”, where best practices, performance metrics, and evaluation guidelines are defined. And finally, the project aims for the distribution of knowledge to encourage standardization and optimization of buildings. The pilot programme for Green Deal Circular Buildings started with the renovation of six buildings, from the public and private sectors. This assessment focuses on the renovation of the National

Library of the Netherlands, which underwent a retrofitting process to improve the building's energy performance, quality of materials, and user experience.

5.1.2. Sustainable Amsterdam

Sustainable Amsterdam is city's agenda for renewable energy, clear air, a circular economy, and a climate-resilient city. It includes the ambitions, measures, and targets to improve the sustainability, urban environment, and citizens quality of living, the goals include:

- Generate 20% more renewable energy and consume 20% less per citizen by 2020 compared to 2013 levels;
- Raise air quality standards, establish stringent environmental zones, and achieve a near emission free traffic;
- Stimulate research and innovation, and boost domestic waste separation and recycling;
- Adaptation of urban areas for more intense weather conditions, as more intense rains are and longer droughts are expected.

The project utilizes an integrative approach across sectors, industries, and stakeholders to enable collaboration and facilitate change. It also includes the definition of clear targets, actions, and goals, identifies the financial support options, and defines indicators to overview, monitor and adjust processes.

5.1.3. Public building refurbishment in Mexico City

This is a publicly funded initiative for the improvement of energy consumption in governmental buildings across the city. The programme aims to implement basic energy efficiency measures, such as the upgrade of electrical and computing equipment, installation of energy saving light bulbs, and re-design of office spaces to maximize the use of natural light and ventilation systems. The programme is coordinated by the city's Environmental Council and it is implemented in collaboration with the dependencies that occupy or are responsible for the buildings, including administrative buildings, public schools, state-owned hospitals, among others.

5.1.4. Mexican NAMA for Sustainable Housing

NAMA stands for Nationally Appropriate Mitigation Actions, a 2012 report funded jointly by the Mexican and German government promoted the application of mechanisms to enhance the sustainability of the Mexican housing situation. The Mexican NAMA for sustainable housing present an integrative approach for energy and resource efficiency in dwellings, based in the "overall building performance". It aims to reduce emissions and resource consumption by implementing environmental-friendly techniques during the design, construction, and occupation of the buildings (CONAVI and SEMARNAT, 2012).

5.2. Analysis and results

The framework was used as a guide to analyse each initiative along the same parameters. The results obtained are largely based on the amount of information available and the point of view of involved staff or experts, it is important to note that, given the time and resource constraints of this project, there is not a robust informational baseline. However, the purpose of this assessment is to present a supporting methodology, applicable to different contexts, to improve understanding and enable decision-making processes or sustainable strategies. The results can be applied during the appraisal or evaluation of sustainability initiatives.

Information and data gathered allowed the evaluation of each initiative along the framework components, for instance it was reviewed the political and citizenship support, the accessibility and availability of resources, and the communication and evaluation techniques being applied (see more details for the data gathering process in Appendix 2). As described in previous chapters, the analysis enabled a general perspective, providing a scan of the upper-tier factors that play a role in urban sustainability management. In this way, key factors are highlighted for further analysis and attention.

5.2.1. Public policy, governance, and citizenship awareness

It was found that, although important, a supporting regulatory framework does not ensure the overall success or support of the sustainable strategies. For instance, in the specific context of the circular building industry in the Netherlands, previous studies had noted the importance of an adequate regulatory

framework for successful building retrofitting (Climate KIC, 2017). However, the Dutch Green Deal focuses on removing legislative barriers and provide favourable conditions for the development of sustainable initiatives. Still, even though having the support from Central Government, one of the biggest challenges for large scale implantation remains in the final user's involvement and engagement. The same can be observed in the Mexican context for sustainable housing, where important environmental policies have been enacted (CONAVI and SEMARNAT, 2012; INECC, 2014) the lack of communication channels to promote and incentivize sustainability actions within the built environment hinders the reach and extent of the sustainability initiatives.

Additionally, the governance approach highly influences the design and implementation of sustainability strategies, for instance, the Green Deal and Sustainable Amsterdam initiatives both present a horizontal and participatory governance structure. The Green Deals are instruments that incite dialogue and collaboration between concerned parties and central government, while Sustainable Amsterdam emerged as a result of a previous comprehensive project (Urban Transform, 2015) which included a participatory, inclusive, and collaborative approach to define a transition agenda to more sustainable cities. More traditional approaches are utilized in the Mexican context, where the Mexican NAMA is the result of an international collaboration supported by the Mexican and German governments that aims for the promotion of sustainable initiatives. Meanwhile, the public refurbishment programme is a specific measure of the Mexico City's Environmental Office and is completely responsible for the design and implementation of the project, a traditional top-down strategy has been chosen for the programme's development.

Generally, involvement of local and directly affected actors can be improved. It has been previously stated that adding local knowledge can significantly improve the development and success of a project. However, in most of cases studied, due to the complexity of the systems involved, a major challenge identified is the proper and complete integration of actors across the value chain of the programme development. So, even though sustainability, circular economy, or energy efficiency are considered to be widely recognized concepts across general population, business developers, and authorities, initiatives are not reaching their full potential or opportunities for large-scale developments are disabled due to these barriers. To address this issue, awareness programmes play a key role, which, as expected, where extensively promoted during the development of all the studied initiatives.

5.2.2. System resources and innovation

The availability of knowledge, technical, and financial resources was reviewed. It was found that the more comprehensive strategies, and those with greater ambitions require a higher demand of resources. But at the same time, they generate greater opportunities for innovation, entrepreneurship, and political leadership, as well as enabling market opportunities for further developments. The Green Deal initiative attempts to integrate the best available materials, methods, and techniques in order to enhance the performance of buildings, while the city of Amsterdam includes diverse strategies for the improvement of district heating, electric vehicles, smart energy grid and distribution, among others. At their own scale, both initiatives are intensive in the need of non-conventional materials, state-of-the-art technologies and qualified workforce. However, due to their own complexity and ambitions, they present an open door for innovation and create market opportunities within and outside the project. Less ambitious initiatives, such as those reviewed in the Mexican context, present a simpler but reliable approach, based on previously proved and commercially available methods and techniques. This approach may not result in innovative developments nor present a great amount of opportunities for new business models, however, it focuses on fast implementations for quick result attainment in the short and mid-terms.

Interactions between the several actors involved were repeatedly identified as crucial for the overall success of an initiative. The former requires a strong leadership presence, either emerging from a commercial opportunity as an entrepreneurial leadership, or as a political entity attempting to disrupt the conventional governing methods. One of the biggest challenges identified in Mexico's context was the lack of political continuity and accountability for results. For instance, the traditional top-down governance approaches undermine supplementary actions, such as local or individual contributions, aimed to improve the initiative's development or processes. Enabling an entrepreneurial and political leadership presence can help bridge one of the most common gaps, identified in all of the initiatives studied, which is the commitment and engagement of important stakeholders and actors involved.

5.2.3. Communication and evaluation

The later layers of the proposed framework are mostly concerned on the outcomes of the initiatives. The process of communicating, reviewing, evaluating, and providing feedback are noted as essential elements in order to build social and political commitment. Communication process can take advantage of the many tools, technologies, and distribution networks currently available. While the measurement and

presentation of results will define the ultimate success of a programme. The strategies utilized mostly depend on the resources, capabilities, extent and reach of the programmes. For instance, participating within industry specialized conferences and seminars may help spread the goals and benefits of a programme more efficiently than targeting whole communities or the population in general. The Green Deal – Circular Building, even though, recognizes the importance of final users' involvement during the development of the project, understands that major endorsement is needed by building developers or operators, while the municipality of Amsterdam utilizes the communication channels and platforms of the municipality as it requires to reach larger populations.

The definition of targets and goal requires to be consistent and coherent with the resources and capabilities of the project. Setting unrealistic or overambitious targets will most likely damage the project by increasing outcome expectations and failing to achieve them. Nevertheless, setting easy to reach goals (or none at all) will diminish the importance of a project, limiting the ability to identify benefits and engage actors. Defining goals and targets, and the measuring and reporting techniques to be utilized, is a process that should be present since the first instance of an initiative, involving stakeholders, developers, and users, in order to ensure targets are achievable and live to the expectations of the concerned communities. Additionally, several evaluation methodologies can be chosen, quantitative or qualitative methods can be applied, however is important to choose a method that can truly represent the programme objectives. For example, the NAMA project for sustainable housing has as objective to foster the growth of sustainable dwellings throughout the country, but the goals and targets defined for evaluation are focused on the performance of single buildings, and, although it is beneficial to know this information, it fails to provide strategic and wider goals, in order to be able to evaluate the success of the programme as a whole.

5.3. Discussion

The section above breaks down sustainability initiatives accordingly to the frameworks' structure. It aims to present the basic components that drive forward sustainability initiatives. It shows how more complex sustainability strategies require higher political leadership and social support. Table 7 presents a summary of the initiatives' assessment, providing a clear view of the weaknesses and strengths of each initiative. Barriers and opportunities can be easily identified, and it would be recommended to focus further actions on the improvement of the lagging factors.

According to this brief study, the availability of technical and knowledge resources, public funds, and financial mechanisms is not as impactful as the governance approach and citizenship awareness. Where non-conventional governance methods are applied and citizenship involvement is greater, more comprehensive sustainability actions are being developed. The participatory governance approach enables authorities to better understand citizenship needs and facilitates the involvement of local actors. The collaboration between government and citizens creates opportunities for the development of long-term solutions, these strategies may not provide immediately evident results but may aspire for greater benefits.

Higher support and higher community involvement fosters the development of wider collaboration networks and innovation, leading to the development of new business models and new market opportunities. The former may help surpass the challenge of sustainable strategies regarding the need of more specialized technical, ecological, and knowledge resources. Comprehensive sustainability initiatives focus on bridging the gaps and overcoming the barriers that are currently limiting a large-scale transition to urban sustainability. By doing this, capacity is built driven by political, social, environmental, and market forces. New governance methods and regulatory instruments can be tested, more resilient materials and stringent standards are expected, knowledge and technical development focuses on sustainability enhancing alternatives, and business opportunities in new sectors become available. Enabling spaces for knowledge sharing and promoting business innovation, are key drivers for the development of the formerly described activities.

Adequate, timely, and transparent communication sources and information platforms support the process for enhancing actors' commitment and stakeholder engagement. The ability to properly measure, evaluate and report results supports the increase of social engagement and commitment. Enabling feedback loops that allow the adjustment and improvement of political, social, and technical factors along the process. Being able to capitalize the benefits of continual evaluation and improvement may support an accelerated transition towards a sustainable built environment. For this reason, well designed and managed strategies throughout all the key layers and factors are crucial for a sustainable development. The understanding and application of assessment methodologies increases the efficiency of processes and effectiveness of outcomes, maximizing benefits, and reducing environmental, social, and economic risks.

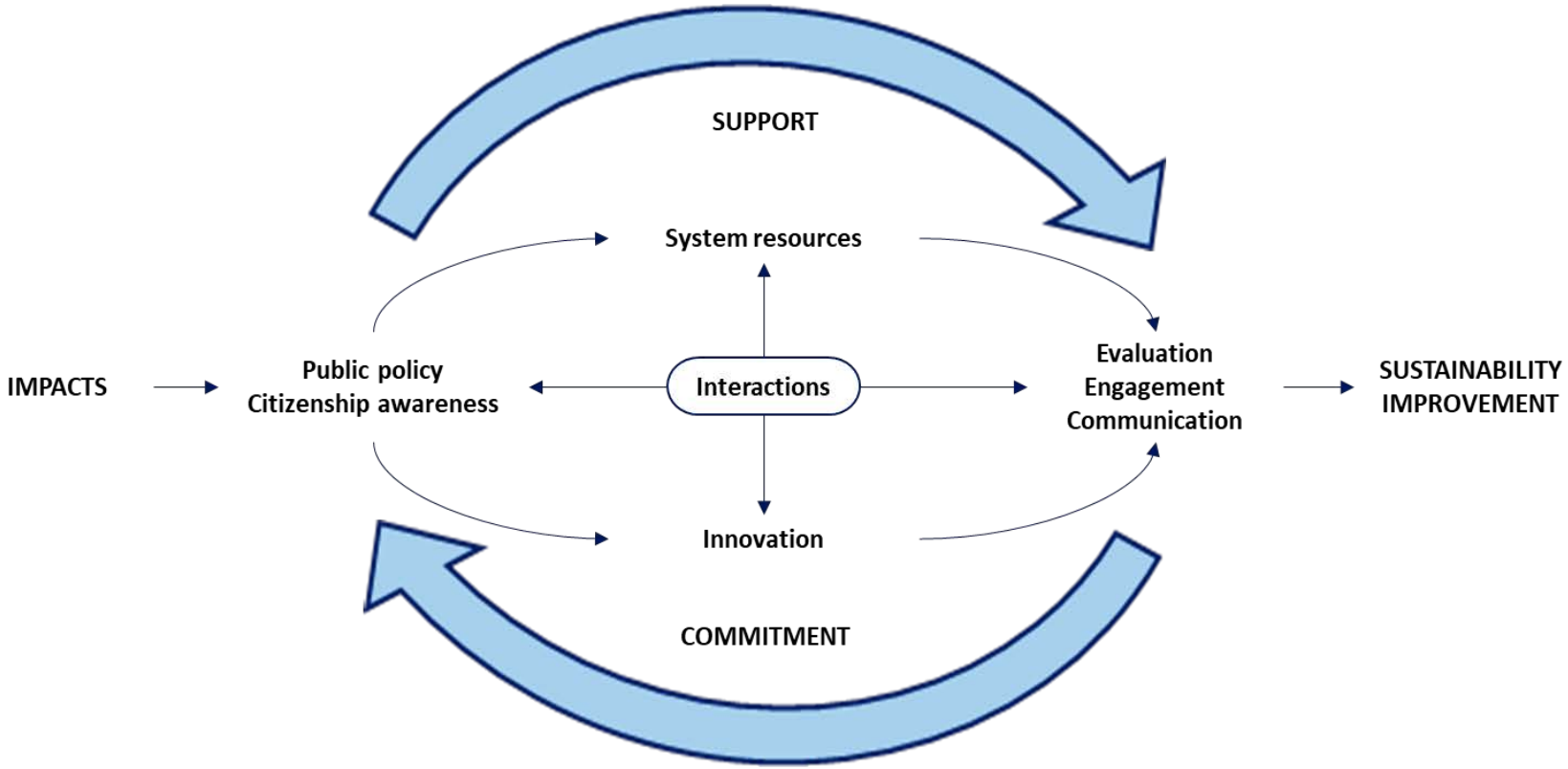

Figure 10. Feedback and improvement cycle for the urban sustainability framework. Greater citizenship awareness and adequate governance approaches increase initiative's support, while impactful result attainment and communication strategies build social engagement and commitment; which in turn, promotes community awareness and seeks for the development of more comprehensive and sustainable regulatory frameworks.

Table 4. Performance assessment of initiatives throughout the sustainability framework key factors.

	Supporting regulatory framework	Open governance approaches	Citizenship awareness	Involvement of concerned parties	Knowledge resources	Technical resources	Financial instruments	Market opportunities
Green Deal – Circular building	HIGH	HIGH	HIGH	MID	HIGH	HIGH	MID	MID
Sustainable Amsterdam	HIGH	HIGH	HIGH	MID	HIGH	HIGH	HIGH	MID
Public building refurbishment	HIGH	LOW	LOW	LOW	HIGH	LOW	LOW	LOW
Sustainable housing	HIGH	MID	MID	LOW	HIGH	MID	MID	MID

	Innovation	Leadership	Communication strategies	Targets and goals definition	Monitoring, reporting, and evaluating	Cross sectoral collaboration	Overall political and social support	Overall engagement and commitment
Green Deal – Circular building	MID	HIGH	MID	LOW	LOW	HIGH	MEDIUM	MEDIUM
Sustainable Amsterdam	HIGH	MID	HIGH	HIGH	MID	HIGH	HIGH	VERY HIGH
Public building refurbishment	LOW	LOW	LOW	LOW	LOW	MID	LOW	VERY LOW
Sustainable housing	LOW	MID	LOW	LOW	LOW	MID	MEDIUM	LOW

Chapter VI: Conclusions

This research project is the result of extensive desk research and analysis on urban sustainability and environmental management. Chapters II and III provided a thorough literature review, exploring the environmental impacts and challenges of urbanization, as well as the current trends, techniques, and methods applied to improve the sustainability of the urban built environment. Although, there is a great extent of available information and studies, it was often found fragmented due to the vast complexity (and the wide range of interpretations) that engulf the concept of *sustainability.* In an attempt to understand this complexity, selected urban sustainability programmes were conceptualized under the same measures. Due to the available information, and the approach of the project, a deep and quantitative analysis was not allowed. An interesting challenge remains in the development of relevant sustainability indicators to enable cross-sectoral and multileveled assessments. Further opportunities for the breakdown of sustainability categories and its factors could result in more enriching and complete comparisons. Nevertheless, the brief qualitative assessment presented in this study performed as expected, presenting a clear and meaningful categorization of urban sustainability strategies. Its intention is to support the decision-making processes and the prioritization of sustainability initiatives regarding the expected benefits, capabilities, and interests of the concerned parties.

Subsequently, this study developed a tool to support sustainability management following an often-used process, in literature and practice. However, specific methods and concepts were adapted to the approach and aim of this study. As a result, a general framework focused on the assessment of urban sustainability strategies is delivered. This tool can be utilized to identify the main barriers, challenges, and opportunities of a programme. The framework was used to assess, on-going sustainability programmes in two different contexts. Although this “test” assessment, lacked depth, due to information and time constraints, it provided an insight of the framework’s application and functionality. Additionally, the final tool and results obtained are consistent with similar studies found in literature. The strategic approach adopted through the development of the project, provides the framework with the adaptability and flexibility required for the assessment of sustainability programmes across different contexts, sectors, and levels within the complexity of urban environments. Nevertheless, this project only represents the highest level of management integration, where only the most basic (and common) factors are being considered. In order to attain more efficient and effective solutions, further layers, comprised by their specific systems, sub-systems, and variables, must be explored.

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Appendices

Appendix 1. Comparative analysis of urban sustainability strategies

This appendix presents the materials and the methodology applied for the categorization of urban sustainability strategy. The aim of this analysis is to conceptualize the "sustainability" of the reviewed measures and initiatives in the first section of Chapter III. This classification relatively ranks sustainable strategies across three dimensions: time, capacity, and benefits, in an attempt to provide a simple, but clear, representation of the advantages and challenges inherent to each urban sustainability programme. From the first sections of Chapter III, relevant sustainability initiatives were selected for assessment. These are included in Table 5. The sources analysed and studied for their assessment are presented consecutively in Table 6

Table 5. Urban sustainability strategies assessed

Initiative	Type
Energy Enhancements	Energy Efficiency
Building refurbishments	Energy Efficiency
Energy efficient design	Energy Efficiency
Circular buildings	Circular Economy
Circular business models	Circular Economy
Open urban spaces	Low carbon cities
City-wide sustainability programmes	Low carbon cities

Table 6. Sources reviewed for the classification of urban sustainability strategies

Time Scale	Capacity Building	Benefits
Curwell, S. and Cooper, I. (1998); Koppenjan, J. F. M., & Enserink, 2009; TEEB, 2010; Economist Intelligence Unit, 2012; Ma et al, 2012; Dangerman and Schellnhuber, 2013; IEA, 2013; Schuetze et al, 2013; The Green Construction Board, 2013; de la Rue du Can et al, 2014; Zuo, and Zhao, 2014; Koehler et al, 2015; ARUP, 2016b;	Cash et al, 2003; Geller et al, 2006; Marnay et al, 2008; The Royal Academy of Engineering 2010; Nakata et al, 2011; Baeumler et al, 2012; Wilson et al, 2012; Mumovic and Santamouris, 2013; EU, 2016; IEA, 2016b; Hagbert and Femenías, 2016; van Buren et al, 2016; Veenstra and Kaashoek, 2016; WEF, 2016; Carra and Magdani, 2017	Bolund and Hunhammar 1999; Kates and Parris, 2003; Adger et al, 2005; Urban Catalyst Associates, 2005; UNEP, 2007; Omer, 2008; Paskaleva, 2011; Santamouris, 2011; Cox et al, 2013; Jansson, 2013; Nielsen et al, 2013; Wolch et al, 2014; C40 Cities, 2016; Lewandowski, 2016; NCC, 2016; ARUP, 2016a; IEA, 2016a;

A qualitative comparative analysis was performed based on the review of available literature and empirical sources (see Table 6). The time scale classification included factors such as the market readiness of the solutions, the design, planning and implementation complexity, and the period required to perceive returns or attain results. Capacity building was integrated from factors that are recurrently discussed in literature, they include a combination of human, financial and technical resources that support the development of sustainability programmes. The extent and reach of the positive impacts of sustainability strategies were explored to define the benefits of urban sustainability strategies. *Benefits were categorized as punctual, local, or extended according to their range and environmental, economic, and social effects*. Though, weighting and adequately comparing this wide range of initiatives will require a much more extensive analysis, this classification provides a quick first glance to the "integrity" of urban sustainability strategies.

Time scale

	Readiness	Complexity	Returns
Energy enhancements	-1	-1	-1
Building refurbishment	0	0	-1
Energy efficient design	-1	1	0
Circular buildings	0	1	0
Circular business models	-1	0	-1
Open spaces	0	1	1
City-wide sustainability integration	1	1	1

Criteria applied for the analysis of the time scale of urban sustainability strategies

	-1	0	1
Market Readiness	Methods and technologies are available for rapid deployment	Industry development is rapidly advancing	Significant research and development is still required
Complexity	Design and implementation run relatively steady and smooth, through the application of well know processes and techniques	Emerging methods and techniques support the planning, implementation, and management of a programme	Much coordination is required, in order to introduce new concepts, methods, and techniques
Returns	Time frame for result attainment and return rates is relatively short	Result attainment may not be immediately evident but reasonable return rates are expected	Time frame for result attainment and return rates is relatively long

Capacity building

	Resources	Technologies	Infrastructure	Finance	Stakeholder Engagement
Energy enhancements	-1	-1	-1	-1	-1
Building refurbishment	-1	-1	0	0	0
Energy efficient design	-1	0	0	-1	0
Circular buildings	0	0	1	0	0
Circular business models	0	0	0	0	1
Open spaces	1	0	1	1	1
System integration	1	1	1	1	1

Criteria applied for the analysis of capacity building requirements

	-1	0	1
Resources	Low requirement of highly available materials; opportunities for re use and recycle	High requirement of highly available materials; consumption of raw resources	High requirement of limited resources
Technologies	Non-advanced or expensive technologies required	Readily available and commercially accessible can be applied	Requires state-of-the art technology deeply embedded in the system
Infrastructure	Non-significant, or one-time capital investment required	Investment is required but providing returns over reasonable periods of time	High capital investment required plus operating cost after implementation must be considered
Finance	Wide availability of options and mechanisms	Few and sector specific options offered	Non-publicly available financial options, and few private instruments
Stakeholder Engagement	Can be achieved with minimum stakeholder participation	Requires action and attention from stakeholders, but not at great extent	Significant attention and continual involvement of stakeholders is required

Appendix 2. Urban sustainability strategies assessment

The proposed framework in Chapter IV, may function as a guide for the assessment and selection of adequate sustainability strategies. The exercise presented in Chapter V utilizes the framework main concepts to create a "common ground" in the study of sustainability initiatives across different contexts, sectors, and scales. The assessment focused on gathering information relevant to the factors presented on the framework, these factors were previously identified as key elements for the development and success of urban sustainability strategies. Information sources included official reports, seminars, workshops, and interviews with programme personnel.

Key components of the framework's concepts

Category	Concept	Key Components
Supporting factors	Public policy	• Regulatory framework • Governance approaches
	Citizenship awareness	• Identification of concerned parties • Citizenship involvement
Enabling factors	System resources	• Knowledge resources • Technical resources • Financial instruments
	Innovation	• Market opportunities • Leadership • Entrepreneurship
Engaging factors	Communication	• Communication strategies
	Evaluation	• Target and goal definition • Monitoring and reporting
Interactions	Collaboration and change	• Cross sector collaboration • Ability to adapt in changing environments

Sample questions

Sample asked questions...	Concerning...
Does the main actors' expected outcomes and interests converge?	Governance and awareness
Are users and local actors willing to get involved?	Governance and awareness
Is a favourable regulatory framework in place?	Governance and awareness
What are the governance methods and approaches?	Governance and awareness
Are there standards or limitations to comply with?	Capabilities
Are materials and technologies required readily available?	Capabilities
Is it possible to receive (or provide) financial or non-financial assistance?	Capabilities
Is it expected for the project to return profits (applicable for publicly funded projects)?	Capabilities
Can public-private partnerships be considered?	Capabilities
What is the level of ambition and outcome expectation?	Communication and evaluation
Are there strong communication channels to distribute information?	Communication and evaluation
Are metrics, targets, and goals clearly set?	Communication and evaluation
Can the performance and results of the project be adequately measured?	Communication and evaluation
What are the main barriers and remaining challenges?	Interactions
What are the opportunities for growth and improvement?	Interaction
How are the relations with the main actors involved?	Interactions
What are the reactions towards the expected outcomes and the actual result attainment?	Interactions

Detailed assessment results

	Regulatory framework	Governance approaches	Citizenship awareness	Involvement of concerned parties
Green Deal – Circular building	Promotes the removal of regulatory and legislative barriers to accelerate sustainable initiatives	Horizontal approach based on collaboration with Central Government	Front-runners in the circular economy sector	Building developers, operators, and final users are not fully integrated
Sustainable Amsterdam	Supportive local, regional, and international legislation programmes	Participatory and cross-sectoral collaboration strategies	Highly positioned topic in the social and political landscape	High level of involvement, project development, and engagement to the programme
Public building refurbishment	Adequate legislative support, but lack of strong regulation enforcement	Traditional top-down programme development	Public is generally sensitised with growing engagement	Programme development is completely independent form final users
Sustainable housing	National and international legislative and knowledge support	Traditional governance approach focused in the promotion of sustainable initiatives	Pro-active approach to increase final users and local authorities' awareness	Barriers with conventional models for large-scale building development

	Knowledge resources	Technical resources	Financial instruments	Market opportunities	Innovation	Leadership
Green Deal – Circular building	Benchmarking, performance, and standard sharing	Incorporation of less common low-impact materials and state-of-the-art technologies	Promotion of private financial mechanisms (subsidies available just for energy enhancement)	Explores the collaboration opportunities within the supply chain to close waste loops	Disruption of the traditional building methods	Public-private collaborative initiative focused on improving initiative's development
Sustainable Amsterdam	Based on the EU funded project TRANSFORM which included a wide collaborative network of actors	Application of mitigation and low-impact methods and techniques when possible	Municipality funds and public financial mechanisms available	Increasingly required capacity building for sustainability regulation, monitoring and implementation	Supports the development of circular business models and integration of new technologies	Municipality-led initiative promoting city-wide integration
Public building refurbishment	Contributions from international organizations and partnerships	Widely available materials and technologies	Publicly financed project	Reduced energy consumption costs	Applies commonly known technologies and techniques	Publicly-led initiative focussed on improving buildings energy consumption
Sustainable housing	Support from international agencies, organizations, and field experts.	Incorporation of best-economically viable-materials and technologies	Public funds, subsidies, and grants available	Development of performance measurement methods and tools	Relies on the sector's best practices	Publicly-led initiative focused on involving stakeholders and raising awareness

	Communication strategies	Targets and goals definition	Monitoring, reporting, and evaluating	Cross sectoral collaboration
Green Deal – Circular building	Promotion through strategic partnerships, symposiums, seminars, and workshops	Based on a phased implementation approach	Sparse and periodic official communications and news publications	Attempts to integrate companies and organization along with central government
Sustainable Amsterdam	Development of several information platforms at a municipality level	Clearly stated and defined	Official channels of the municipality, goals are difficult to track, measure, and evaluate	Presents a comprehensive plan involving key sectors of the municipality
Public building refurbishment	*Unable to identify*	In line with general legislation	*Unable to identify*	*Unable to identify*
Sustainable housing	Initiative openly available for application and encourages citizen participation	Defined at a technical level but lacks strategic and measurable goals	Evaluation of building performance through specialized tools	Collaboration mainly focused between the housing sector and local authorities