AMERICAN UNIVERSITY OF BEIRUT

NEW ECO-CITY PROJECTS: INCORPORATING SUSTAINABILITY REQUIREMENTS DURING PRE-PROJECT PLANNING

by
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IN THE NAME OF ALLÂH, THE MOST GRACIOUS, THE MOST MERCIFUL

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AN ABSTRACT OF THE THESIS OF

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Several international tools and standards (e.g. LEED, BREEAM) exist for evaluating the level of sustainability of buildings or neighborhoods. Nonetheless, they are still not available in the context of a larger-scale sustainable urban land development or new ecological city (eco-city). While such *sustainability appraisal tools* are important, of special interest for practitioners is how to ensure that their sustainability requirements are well integrated in a proposed new eco-city master plan. *New eco-city* development is the focus of this study. The research objective is to assist the *design manager* in directing the development of a *sustainability agenda* throughout *pre-project planning* stages, and ensuring the integration of sustainability requirements in the new eco-city master plan.

The research study is divided into three Tracks. In Track I, an initial literature review on eco-cities and the sustainable urban built environment resulted in the development of a list of eco-city *sustainability technical criteria* grouped under five main themes (Land Use and Urban Form, Mobility and Transport Infrastructure, Energy Demand and Energy-Supply Infrastructure, Water, Wastewater and Waste, and Technology). This basic list is supposed to be part of a survey questionnaire used by the design manager during a value management workshop to weigh the project-specific criteria for a new eco-city. In Track II, another literature review on early management practices for sustainable construction projects (pre-project planning process, role of design manager, stakeholders' involvement, use of decision-support tools, and value management) paved the way for the development of a proposed *pre-project planning process* for new eco-city projects. It consists of stages and activities promoting the incorporation of sustainability throughout the Concept Phase of pre-project planning. Such activities include the development of a tailored sustainability rating tool as a performance guide that assists the decision-maker in rating and comparing different design solutions. In Track III, a case study of a recently planned new eco-city is investigated. The pre-project planning stages and activities are delineated and compared to the proposed process, which validates its applicability. Finally, a list of lessons learned is inferred to assist practitioners of new eco-city projects.

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CHAPTER 1

INTRODUCTION

1.1. Research Background

1.1.1. Sustainable Development

Following several international acts and calls to protect the environment and save the Earth, the World Commission on Environment and Development (WCED) issued in 1987 the Brundtland Report "Our Common Future". The report introduced the concept of "sustainable development" and defined it as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations 1987).

Since then, efforts by different researchers, governmental bodies, and interest groups to explain this new concept have led to a variety of definitions, mostly sharing the following aspects:

- *the triple bottom line*: environmental, social and economic dimensions of sustainability, focusing on non-wastefulness in the allocation of natural resources, goods and services.
- *equity*: justice - intergenerational (between current and future generations), among current people, and between humans and nature - and over time preservation (inherently uncertain future) [Mori and Christodoulou 2012].

In the last 2012 United Nations Conference on Sustainable Development (UNCSD), the "Rio plus 20" report reiterated several objectives and requirements for sustainable development such as:

- promoting "green economy" as "one of the important tools for achieving sustainable development…, managing natural resources sustainably and with lower negative environmental impacts, increasing resource efficiency and reducing waste...",
- conserving biodiversity and ecosystems,
- reducing water pollution, increasing water quality and efficiency,
- improving wastewater treatment,
- improving solid waste management, chemicals and hazardous waste through life cycle approach…reduce, reuse and recycle waste (3Rs)…enhancing the corresponding policies and laws,
- encouraging green transportation and mobility that respect the environment (e.g., public mass transportation systems, clean fuels and vehicles),
- encouraging energy efficiency through measures in urban planning, buildings and transportation…promoting research and development in all countries and cleaner and energy-efficient technologies, and
- diversifying the energy mix, increasing the share of renewable energy.

In particular, the report emphasized the role cities play in promoting "economically, socially and environmentally sustainable societies…if they are well planned and developed…in affordable housing and infrastructure" (United Nations 2012).

This increasing awareness of the need to consider sustainable development, along with the increased challenges in the 21^{rst} century as a result of rapid urbanization, necessitate the development of new sustainable urban built environments (buildings, infrastructures, etc.), as presented in the next section.

1.1.2. Eco-Cities

Between the years 2000 and 2030, developing countries shall respond to the wave of urbanization by tripling the existing urban areas (World Bank 2010). Consequently, this boost in constructing urban built environments will result in more exploitation of resources (e.g., energy, water), production of waste, and emission of pollutants, during the construction phase of the new built up, and, mainly, at the implementation/operation phase. In order to absorb this increasing need for new urban areas and simultaneously respond to the global call for "sustainable development", countries need to consider a paradigm shift in their urban planning approach, while making successful development investment (World Bank 2010). Similarly, practitioners are nowadays advised to consider sustainable design solutions to counterbalance the negative effects of urbanization. Consequently, a new international trend of urban planning and development of the sustainable city has appeared. This term overlaps and is sometimes used interchangeably with "ecological-city" or simply "eco-city" and "zero/low-carbon city". Typically, eco-city initiatives aim at either (i) assessing, promoting, enhancing, or monitoring sustainability in an existing city, or (ii) planning for and developing urban lands to construct new sustainable cities. The newly planned eco-city is the focus of this research study as discussed in the following sections.

1.2. Research Problem

During the early planning (or pre-project planning) phase of a new eco-city construction project, including its infrastructure systems, buildings and public spaces, the *design management* practitioner - who is typically responsible of directing the project on behalf of the client - is faced with two main management challenges:

(i) Defining the project's sustainability criteria. For a new eco-city, sustainability is supposed to be the utmost measure of quality for the project. Sustainability requirements, such as reducing Green House Gases emissions, conserving water, or maintaining biodiversity, constitute the main components of the client's value system and need to be early identified. Furthermore, the likelihood of achieving the project's sustainability objectives is particularly important while comparing alternative planning and design solutions. Therefore, selecting the most sustainable solution is better supported by a "rating tool" with pre-defined set of criteria. While sustainability characteristics common to comparable smaller-scale projects (building or neighbourhood) are embedded in available rating systems and standards (e.g. LEED/USA, BREEAM/UK, and SB Tool/Canada), they are still not uniform and readily applicable in the context of new city-scale developments (Wallbaum et al. 2011 and Joss et al. 2012). In fact, new eco-cities are megaprojects with high investments, not yet as broadly spread as green buildings, and significantly depending on the project's local context (political, economic, social, legislative, etc.) and site conditions (topography, climate, hydrology, surrounding infrastructure, etc.). As such, eco-city sustainability is currently described through concepts, principles, or tailored guidelines spun-out from local contexts and typically lacking scientifically-proven internationally approved sustainability tool (Yip 2008, Joss 2011, and Mori and Christodoulou 2012). In addition, multidisciplinary teams are involved, such as infrastructure engineers, landscapers, transport planners, urban planners, etc. Thus, the final agreed-upon list of project-tailored sustainability criteria requires major trade-offs among the different disciplines (Lombardi et al. 2011). For example, water utility engineers consider water saving solutions while landscapers observe potentials to enhance biodiversity.

(ii) *Ensuring that sustainability criteria are incorporated in the new eco-city master plan.* As sustainability needs to be operationalized (Gilmour et al. 2011), it is vital for design managers to develop and maintain the *"sustainability agenda"* throughout the master plan (MP) development process that leads to the attainment of a new physical city. They need to ensure that the agreed-upon project's sustainability requirements (translated into strategic objectives, criteria, indicator system, etc.) are successfully reflected/ embedded in the eco-city MP. As such, practitioners can benefit from an early pre-project planning process encompassing typical managerial activities (e.g. stakeholder consultation, use of decision-support tools, etc.). For example, some *process guides* have been developed for regular construction projects (buildings, infrastructure, etc.) to assist project managers in identifying typical activities during the pre-project planning phase. Examples include process tools such as the IDEF0 model and the PDRI checklist [a process-development model and a weighted score sheet, respectively, developed by the Construction Industry Institute (CII)]. However, such tools do not yet explicitly address sustainability objectives (Weerasinghe et al. 2007); in addition, they are not devised for the pre-project planning of megaprojects, new cities in particular.

1.3. Research Objectives

This thesis addresses the aforementioned challenges faced by the design manager directing the development of a new eco-city MP. This type of projects entails the preliminary design of sustainable infrastructure, transport and utility systems, green buildings and public spaces. The overall goal is to propose typical activities that assist in developing the project's "sustainability agenda" and ensuring its incorporation in the

proposed solutions throughout the master plan development process. Hence, the research objectives are two-fold:

(i) To identify the sustainability criteria of an eco-city based on academic literature and international case study practices, and

(ii) To propose early management practices that assist in developing and maintaining the sustainability agenda, and ensuring its incorporation in the eco-city MP.

1.4. Research Scope

To recapitulate and define the framework of this study, Fig. 1 summarizes the scope of research and frames its dimensions.

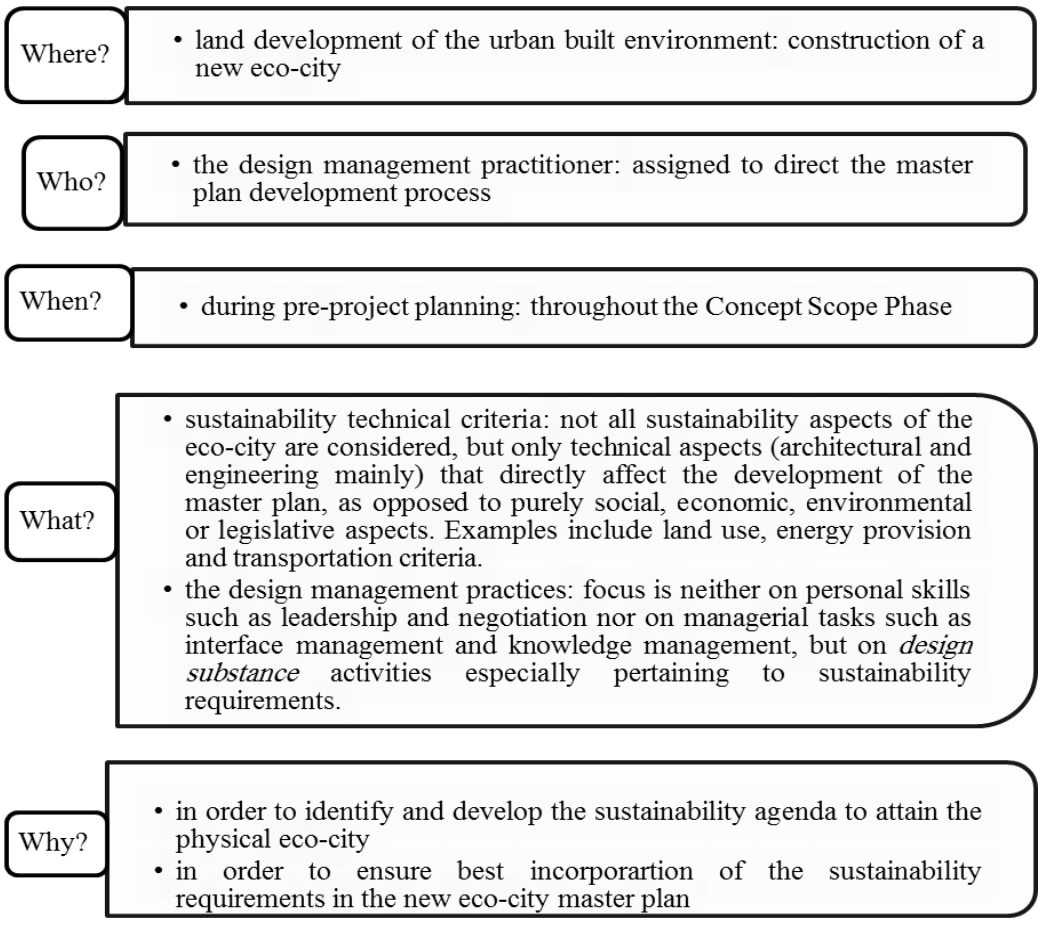

Fig. 1. Research scope

1.5. Research Methodology

To meet the research objectives, the following three-track methodology is adopted:

- In Track I, with reference to an initial literature review, Part (a), a preliminary list of eco-city sustainability technical criteria is developed. This track addresses the “where” (eco-city) and “what” (its characteristics) of the research scope.
- In Track II, with reference to another literature review, Part (b), a typical list of early management practices of sustainable construction projects (green buildings, sustainable infrastructure, urban land development, etc.) is developed. In addition, a pre-project planning process of stages and activities for new eco-city projects is proposed. The outcomes of this track address the “when” (timing/PPP stages), “who” (participants/design manager and other stakeholders), “what” and "how" (management activities) of the research scope.
- Finally, in Track III, a newly planned eco-city case study is investigated through content analysis and interviews. The project's stages, activities, and challenges in developing and maintaining sustainability requirements throughout the master plan development are delineated. The outcomes of this track serve as a test-bed to validate the applicability and significance of the identified management practices of Track II findings, illustrate and refine the proposed process, and infer lessons learned.

The three tracks are illustrated in Fig. 2. The following sections describe each track separately.

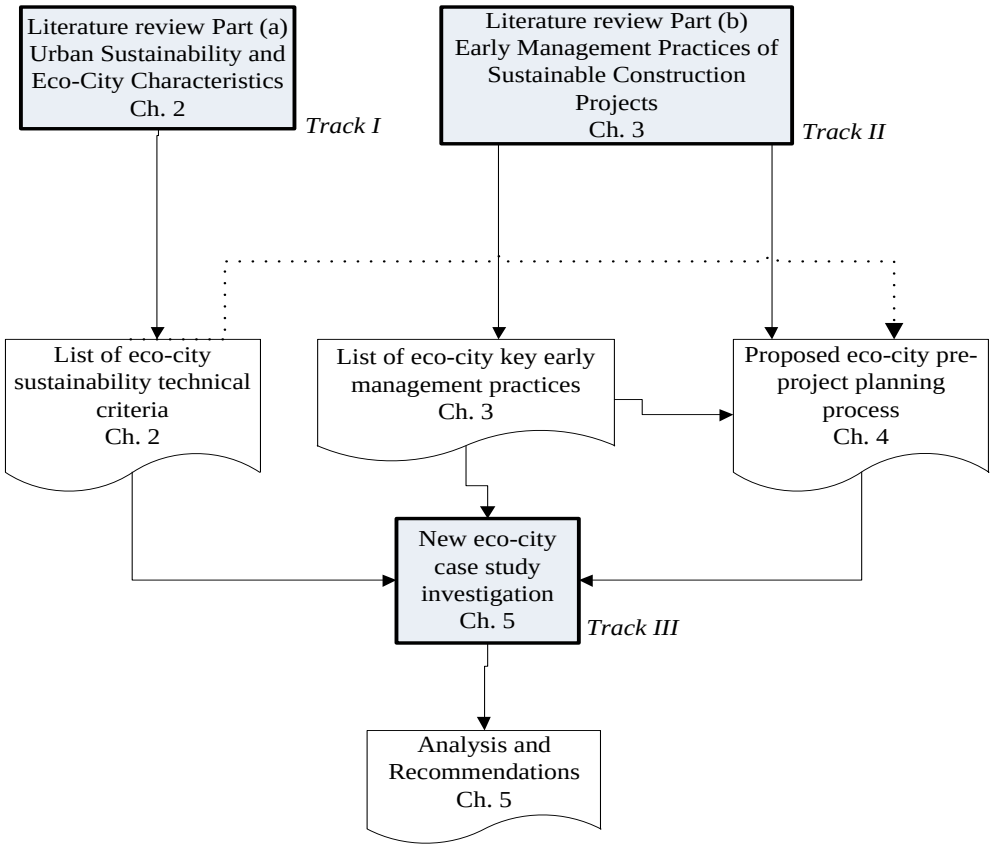

Fig. 2. Research methodology

1.5.1. Track I: Identifying Eco-City Sustainability Characteristics

As discussed before, the literature review of this thesis is undertaken in two Parts, (a) and (b). Relevant and reliable references include academic articles in peer-reviewed journals, papers from congress and conference proceedings, and book chapters. Various technical reports, policy documents, reports from international eco-city initiatives, and websites of international organizations/networks and interest groups are also reviewed.

Literature Review on Eco-Cities and the Sustainable Urban Environment

In Part (a), research studies on eco-cities and the sustainable urban built environment are explored to understand the development of the sustainable city and

infer its characteristics. Literature on urban sustainability consists of disparate streams of work. Pertinent information is identified by searching keywords such as “eco-city”, “smart city”, “sustainable city” in order to understand the difference between the various terminologies that describe the sustainable city.

Development of Eco-City Sustainability Technical Criteria

Consequently, the synthesis of literature review Part (a) guides the development of a proposed *preliminary list of eco-city sustainability technical criteria*. The thesis suggests that this basic list be part of a survey questionnaire developed and used by the design manager during a value management workshop for a new eco-city project. The list itemizes the criteria deemed relevant to the development of a new eco-city MP as inferred from literature review on eco-cities and the sustainable urban built environment. It is worth noting here that this list is non-exhaustive; it is can be calibrated with a thorough literature review and statistical analysis of findings. The proposed list is envisioned as a "knowledge-based tool" for the use of practitioners while embarking on a new eco-city project. It assists in identifying and prioritizing stakeholders’ opinions with respect to project-specific sustainability technical criteria. On the other hand, the developed list serves as a "benchmark" that justifies the selection of the case study and advocates it as an eco-city project. In this regard, the sustainability characteristics of the new eco-city case study, identified in Track III, are cross-matched to those in the proposed list to ensure reliability of the case study investigation outcomes.

Fig. 3 represents the steps followed in developing the eco-city sustainability characteristics throughout Track I of the study.

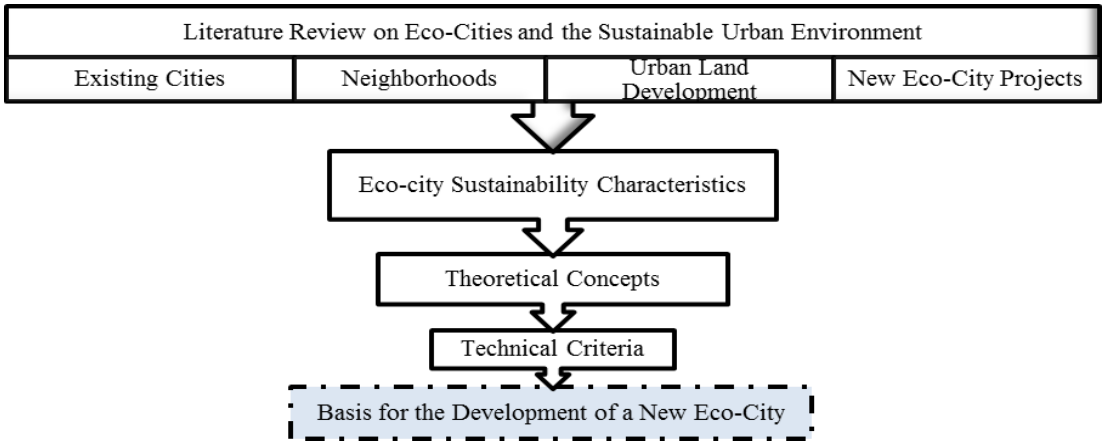

Fig. 3. Development of eco-city sustainability characteristics

1.5.2. Track II: Identifying Early Management Practices

Literature Review on Early Management Practices of Sustainable Construction Projects

In literature review Part (b), the focus is on reviewing the main management practices adopted at early phases of sustainable construction projects in general (e.g. green buildings, infrastructure systems…) and at new eco-cities in particular. Pertinent information is identified by searching keywords such as “pre-project planning”, "design management", “sustainability assessment”, "sustainability appraisal", "eco-city master plan", etc. The aim is to identify common and typical management practices enhancing the development of the "sustainability agenda" and contributing to its incorporation in the design solutions. Another objective is to delineate a possible PPP process for new eco-city projects, as described in the next section. A synthesis of literature review Part (b) summarizes the lessons learned from the identified management practices which are then compared to the findings from the case study practices.

Proposing a Pre-Project Planning Process

With reference to literature review Part (b), a concise PPP process of stages and activities is proposed for the development of a new eco-city project. This "process

guide" entails the identified management practices. It assists the design manager in ensuring the incorporation of sustainability requirements in the eco-city MP. For example, in the proposed PPP process, developing a "tailored rating tool" is accomplished through value management workshops activities. It serves as a "performance guide" or a decision-support tool while appraising different solutions and comparing MP alternatives.

1.5.3. Track III: Investigating a Case Study

In order to provide a direct link between research and practice, a case study is investigated. The aim is to test the applicability of Tracks I and II research outcomes on a real-life project. A longitudinal (throughout the pre-project planning time window/stages) single case study of an ongoing eco-city construction project in the Middle East is selected. Data on this case study is accessed via the design management company which has been directing this eco-city project during the PPP Phase. As proposed by Phelps and Horman (2010) for the adoption of a single-site in-depth construction research study, this case study is selected based on two essential criteria:

- *validity*: the acquired information and available data are deemed accurate as they are obtained from truthful and different sources (internal project documents and interviews with lead design managers).
- *reliability*: as stated above, the case study sustainability characteristics are cross-checked against those identified in Track I and listed as "eco-city sustainability technical criteria". This is to justify its "generalizability" and ensure that it represents a relevant eco-city project. Thus, the thesis outcomes are supposed to be

consistent under similar conditions, with a broader application than for the case study at hand.

The case study investigation will be tackled in retrospect, at the end of the PPP process and start of the detailed design phase, through content analysis and interviews, as presented in the next sections. The case study is described in Chapter 5.

Content Analysis

Internal project documentation include credible reports, workshop presentations, design plans, evaluation matrices, toolkit data, meeting minutes, schedules, organizational diagrams and visuals. They are accessed, organized, and reviewed to collect pertinent raw data and reduce it in useful formats. The outcomes are analyzed and presented based on two-fold objectives:

(i) to identify the new eco-city sustainability characteristics (themes and corresponding criteria); the purpose is to cross-check them against the list of eco-city sustainability technical criteria, with an attempt to ensure advocacy and reliability of the selected project, and

(ii) to track (in Microsoft Project format) and illustrate (in a Microsoft Office Visio flow chart drawing) the project's PPP process, identifying the stages and major activities that pertain to the development of the sustainability agenda (e.g. identifying stakeholders, development of project-specific sustainability indicators, rating MP alternatives, etc.); the purpose is to compare to and test the applicability of the proposed PPP process.

Interviews

Two lead design managers are identified and interviewed, an urban planner and an engineer, responsible of directing the master plan development and the infrastructure design disciplines, respectively. Both interviews are semi-structured, with closed-ended

and open-ended questions revolving around the project's PPP stages, activities, challenges faced, and lessons learned while incorporating sustainability in the new eco-city MP. Following the interview sessions, the notes are compiled and sent to each interviewee for some clarification and verification of results. Based on the interview outcomes, a list of project's challenges is developed. This list, along with the main management practices synthesized from literature review Part (b) will pave the way for developing the lessons learned from this research study, as presented in the next section.

Analysis and Recommendations

The analysis of the research outcomes aims at identifying and illustrating the main design management practices for ensuring the incorporation of sustainability in the master plan of a new eco-city project. The methodology is adapted from Boyko et al. (2010) in comparing a proposed "to be" process (proposed based on literature) with the "as is" process (completed by the case study project) for urban land developments (see Chapter 3). As such, the PPP stages and activities corresponding to the incorporation of sustainability in the MP are analyzed and compared. Recommendations are drawn based on a cross-match and agglomeration of Track II [literature review Part (b)] and case study findings. Outcomes are amalgamated and summarized in a list of "lessons learned".

1.6. Thesis Organization

The thesis report is composed of six chapters.

- Chapter 1 (this chapter) introduces the research background, defines the research problem, objectives, methodology, and scope.

- The following Chapter 2 represents Part (a) of literature review. It examines urban sustainability and the characteristics of an eco-city. The chapter culminates in a synthesis of the eco-city predominant concepts and sustainability technical criteria.
- Chapter 3 represents Part (b) of literature review. It identifies and describes the early management practices of sustainable construction projects and infers lessons learned.
- Based on findings from literature review Part (b), Chapter 4 describes and illustrates a proposed pre-project planning process developed as a guide to assist the design manager of a new eco-city project.
- A case study of a newly planned eco-city is presented in Chapter 5, with emphasis on its pre-project planning stages, activities and design management challenges. The case study findings are compared to lessons learned from literature. Based on this analysis, the proposed PPP process is refined and best management practices recommended.
- Chapter 6 concludes with a summary of study findings, main contributions and significance, limitations, and recommendations for future research work.

CHAPTER 2

URBAN SUSTAINABILITY AND ECO-CITY CHARACTERISTICS

2.1. Introduction

This chapter represents the first round - Part (a) - of literature review. It addresses the "where" (eco-city) and "what" (its characteristics) of the research scope. Sustainability characteristics are reviewed in existing urban areas and new land developments, at the city-scale or neighbourhood-scale, in addition to infrastructure systems.

Most academic articles tackle urban sustainability issues and characteristics in the context of assessing, promoting, enhancing, and monitoring sustainability in an existing city, considering its localities and focusing on infrastructure systems such as transportation, water, or energy [*e.g. Austin city in Texas, U.S.A., Cork City in Ireland, Heidelberg city in Germany* (Yazar and Dede 2012)]. Others address the smaller scale of neighbourhood/district [e.g. inner suburban housing subdivision in Perth, Western Australia (Karol and Brunner 2009)]. Fewer researchers address the sustainability characteristics for a newly constructed sustainable city project in specific, such as Masdar city in Abu Dhabi, United Arab Emirates (Menichetti and Van Vuren 2011and Cugurullo 2013) and Caofeidian International Eco-City in China (Qiang 2009 and Joss and Molella 2013). This research study sheds light on the sustainability characteristics of different types and scales of urban areas with an attempt to infer the characteristics of a newly constructed sustainable city.

2.2. The Sustainable City Interest Groups

Literature on sustainable cities addresses two main categories of readers or interest groups, the theorists and the practitioners:

(i) *The theorists, visionaries and activists*: including the environmentalist, the socialist, and the economist. The main concern of this group is to define the overall characteristics of the sustainable city based on the three pillars (economic, social, and environmental), promoting it through policies and regulations to ensure a healthy equitable environment. Their focus is on the ecological and humanitarian perspectives of urban sustainability, issues like social ecology, equity, employment, and impact on climate change (Haughton 1997, Tanguay et al. 2010, and Agudelo-Vera et al. 2012).

(ii) *The practitioners*: including the urban planner, the architect, the engineer, and the transport planner. Their main concern is to find practical and innovative technical solutions through urban planning, urban design, and engineering for constructing the sustainable city.This group focuses on the physical, technical, specific characteristics of the sustainable city, irrespective of global concerns, issues like infrastructure system for clean energy production, wastewater treatment, attractively designed features and public spaces, low-carbon technology (Kenworthy 2006, Lechtenböhmer et al. 2010, Mulligan et al. 2011, and Wallbaum et al. 2011).

This thesis addresses the interest group of the second category, the practitioners.

2.3. Sustainable City Definitions

The concept of "sustainable city" is looked at differently by different researchers.

- A dominant objective is to conserve city resources and minimize waste and pollution. In this regard, many authors refer to the sustainable city as *ecological city* or simply *eco-city* (Roseland 1997, Kenworthy 2006, Joss 2011, Alusi et al. 2011, and Joss et al. 2012) or *low/zero-carbon city* (Menichetti and Van Vuren 2011 and Cugurullo 2013).
- Others highlight the importance of high density and mixed-use land which promotes less dependency on automobiles, resulting in reduced CO_2 emissions, more shading among close buildings, etc. As such, researchers designate the sustainable city by the term *compact city* (Jenks and Jones 2010).
- Some researchers expose the "independent"/self-sustained characteristic of the sustainable city. In this sense, they consider it a *resilient city* which has the potential to provide its own resources through urban harvesting (e.g. collecting rain water from the roofs, or solar energy to generate electricity) [Haughton 1997 and Agudelo-Vera et al. 2012].
- Several authors emphasize the role of technology, referring to the sustainable city by *smart/intelligent city* (Abdoullaev 2011) or *eco-tech city* (Ercoskun and Karaaslan 2011, and Joss and Molella 2013). For example, a smart city considers smart appliances for water supply that control consumption for efficient use of resources; it relies on information and communication technology (ICT) for smart automated power grids and Intelligent Transport Systems.
- Recently, some authors added a new aspect to the sustainable city, considering it as a *ubiquitous city* or *u-city*, focusing on the role city infrastructure can play in providing continuous and easily accessible services to all inhabitants.

> Ubiquitous computing provides networked environments which are supposed to promote connected communities (the social dimension of sustainability) and efficient use of resources (the ecological dimension of sustainability) [Shwayri 2013].

The term eco-city is mainly used across this study to emphasize the ecological aspect of sustainable development, while the other characteristics of the sustainable city (compactness, resilience, smartness, and ubiquitousness) are considered as key attributes promoting the sustainable city and simultaneously embedded in the definition of an eco-city.

The following sections present the eco-city origins, international initiatives and few examples.

2.4. Eco-City Origins, Initiatives, and Examples

The concept of an eco-city was first introduced in 1987 by Richard Register, a leading theorist and author in ecological city design and planning (Roseland 1997 and Eco-builders 2012). Since then, eco-city initiatives have evolved through three stages. A theoretical *normative perspective* characterized the first stage (1980s to early 1990s) whereby the sustainability aspects of a city have been mainly described. The second stage (1992 to early 2000s) was characterized by a *regulatory perspective* with some local and national initiatives of pilot projects on existing cities such as Curitiba in Brazil, Waitakere in New Zealand, and Schwabach in Germany, and several cities in China. The last and current stage (2000s to present) is characterized by an *innovative perspective* resulting in global expansion of city-scale land development projects to construct new eco-cities (Joss 2011).

To initiate an eco-city project, Joss (2011) delineates six possible driving factors: "environmental challenges", "socio-economic pressures", "business development", "cultural branding", "political leadership", and "international co-operation". Nevertheless, three key considerations are also critical: (i) *scale*, in terms of project area, infrastructure and innovation, (ii) *sectors*, including housing, transport, energy, waste, and water, and (iii*) policy*, the development being formulated as and supported by policy processes promoting sustainability (Joss 2011).

Since the early 2000s, geographically diverse eco-city initiatives have been undertaken with different aims, partnerships, financing schemes, and relative emphases on technology versus real estate development (Alusi et al. 2011). Several eco-cities are located in Europe (34), mainly in Scandinavian countries, UK, and Germany, while the second largest concentration is in Asia/Australia (27), followed by North America (9), Africa (4), Latin America (3) and the Middle East (2) (Joss 2011).

Today, some international actors -leading companies and governmental bodies- are working on promoting and guiding eco-cities initiatives. The *World Bank* launched IN 2010 the Eco^2 Cities Program to support existing cities in developing countries promoting ecological and economic sustainability through integrated urban planning and management (World Bank 2010). *Eco-City Builders,* a non-profit organization founded by Register in Berkeley, California, organizes several international eco-city conferences (Eco-builders 2012). The joint initiative between the *Clinton Climate Initiative and the U.S. Green Building Council* is working with world's largest cities committed to taking action on climate change (Alusi et al. 2011).

As stated earlier, eco-cities differ in their type; while few are newly planned/constructed cities, resulting from urban land development projects, most are

existing cities, resulting from urban retro-fit/regeneration projects to render cities more sustainable [e.g. Toronto/Canada, Freiburg/Germany, and Portland/USA] (Joss 2011). Examples of new eco-cities include: in China, *Dongtan (84 km^2)*, first announced as a new eco-city project in 2005 and suspended in 2008 (Chang and Sheppard 2013), and *Tangshan Caofeidian (150 km^2)* (Qiang 2009 and Joss and Molella 2013); in Korea *Songdo (6 km^2)* (Shwayri 2013); in the U.S.A. *New Destiny Florida (166 km^2)* (Joss 2011); in the United Arab Emirates *Masdar (7 km^2)* (Menichetti and Vuren 2011 and Cugurullo 2013); and in Saudi Arabia the newly planned *King Abdullah City for Atomic and Renewable energy (63 km^2)*.

2.5. Eco-City Sustainability Characteristics

This section builds on urban sustainability aspects identified in literature to describe the ecological city and infer its characteristics. In addition to new eco-city initiatives, sustainability characteristics of various urban areas (existing cities, neighbourhoods, urban land development projects, etc.) are reviewed and considered to infer typical sustainability requirements for a new eco-city project.

2.5.1. Characteristics of Sustainable Urban Areas

Several researchers (Haughton 1997, Roseland 1997, Tanguay et al. 2010, Jepson and Edwards 2010, and Mori and Christodoulou 2012) discuss the *principles and general characteristics* of the sustainable city. These are embedded within the three dimensions of sustainability, namely, economic (e.g. household income, employment, etc.), social (e.g. education, well-being, etc.) and environmental (e.g. energy, air quality, etc.). For example, Tanguay et al. (2010) propose to planners and decision-makers a

"scientifically based and operational" list of sustainability indicators. They survey the use of 188 sustainable development indicators for existing cities in developed western countries. They retain the 29 most frequently used indicators, and group them into categories (e.g. administration, health, transport, air, water, education, energy, governance, demographics, heritage, etc.), each belonging to one or more of the three sustainability pillars.

Some researchers focus on the *specific technical characteristics* of certain disciplines of the sustainable city such as transport and planning (Kenworthy 2006), architecture and urban design (Lehmann 2007), and smart infrastructure and use of technology (Abdoullaev 2011). *Operational frameworks* (Word Bank 2010), *business models* (Alusi et al. 2011), and *governance* (Joss et al. 2012) are also addressed.
In addition, international standards and rating tools are developed to appraise technical characteristics of the built environment.
Sharifi and Murayama (2013) compare seven international rating tools for neighborhoods. Each tool groups the sustainability characteristics into themes or categories.
The US-based LEED-ND rating system (Leadership in Energy and Environmental Design- Neighborhood Development) groups its sustainability credits into the following five categories and corresponding criteria (Sharifi and Murayama 2013):

A. "Smart Location and Linkage" (criteria: location, transportation alternatives, and preservation of sensitive lands)
B. "Neighborhood Pattern and Design" (criteria: vibrant, equitable, healthy, walkable, and mixed-use)

C. "Green Infrastructure and Buildings" (criteria: reduce energy and water use, sustainable use of materials, reuse of existing and historic structures)
D. "Innovation and Design Process" (criteria: exemplary and innovative performance beyond the existing credits, accredited professional on the design team)
E. "Regional Priority Credit" (criteria: significance to the project's local environment)

Similarly, the UK-based BREEAM communities rating tool (Building Research Establishment Environmental Assessment Method) identifies six main sustainability categories: "Governance", "Social and Economic Wellbeing", "Resources and Energy", "Land Use and Ecology", "Transport and Movement", and "Innovation" (BREEAM 2012).

Nonetheless, approaching sustainable development at the built environment entails a gap between theory and practice (Keirstead and Leach 2008). Practitioners in the construction field are much interested in "tangible" and "measurable" aspects of sustainability that can be practically considered and reflected in the design of the built-up. In this regard, this thesis identifies eco-city characteristics at two levels, theoretical and technical, with an attempt to differentiate between theory and practice. Top level-statements used to describe eco-city sustainability are considered as theoretical concepts (e.g. culture for reduced consumption, values for behavioural change in consumption patterns, biodiversity, urban harvesting, human well-being, etc.). On the other hand, technical criteria such as water recycling, dense and compact housing structures, and low carbon transport technologies represent reflections on the high-level concepts, rendering them more functional. Hence, technical criteria as operational tools are the

focus of this thesis since they have direct impact on the new eco-city construction project. These criteria are supposed to represent the basis to develop a *performance design guide* that assists the practitioner in judging the progress towards meeting the theoretical concept of sustainability in eco-cities.

2.5.2. Theoretical Concepts

Theoretical concepts are values guiding sustainability and describing the abstract, intangible, and mainly non-spatial characteristics of eco-cities [e.g. ways of living, economic activities] (Yip 2008). These emanate from the triple bottom line of sustainability comprising the social, economic, and environmental dimensions. With reference to literature review, the major theoretical concepts addressing urban sustainability are delineated, synthesized, and listed in Table 1 below, with an attempt to describe an eco-city project theoretically.

Table 1. Eco-City Predominant Concepts

Concept	Description	References
Integrated system approach	• the whole urban system is planned, designed, integrated, and managed through systems thinking, understanding "how the parts fit into the whole" • resource flow is addressed through integrated infrastructure system design and management of different sectors i.e. transport, energy, water, and waste management, in addition to green buildings and urban forestry • interaction and linkages are considered within and among infrastructure systems, and with the surrounding region; constraints imposed by larger network (electricity distribution, highways or water) are addressed by engineers	Engel-Yan et al. 2005, World Bank 2010, Willets et al. 2010, and Piechowski and Weerakkody 2011
Habitat for biodiversity	• habitat for biodiversity and food producing areas is provided • habitat of natural and biological functions and processes is protected	Roseland 1997, Kenworthy 2006, Qiang 2009, Jenks and Jones 2010, Jepson and Edwards 2010, and Ecobuilders 2012
Self-reliance, resilience and urban harvesting	• demand for natural resources is minimized by changing behavior or installing technologies • the city's own resources are provided through a *"circular metabolism"* approach whereby designs and management tools capitalize on the internal flows of resource usage and waste production within the urban system • the city is self-reliant, with reduced pattern of external dependence on resources • "urban resource management" is achieved through "urban harvesting"	Haughton 1997, Kennedy et al. 2011, and Agudelo-Vera et al. 2012

Social sustainability	• social diversity is maintained, with affordable housing for all income groups • cultural and local identity is preserved • public realm expresses a high-quality public culture, community, equity and governance • public space is characterized by vitality, interaction/group activities and contact with nature • education addresses behavioral change of consumption patterns, promoting low consumption rate (recycle, reuse, reduce) • civic empowerment and local community involvement are adopted	Roseland 1997, Kenworthy 2006, Lehmann 2007, Qiang 2009, World Bank 2010, Jenks and Jones 2010, and Jepson and Edwards 2010
Economic sustainability	• investment framework values sustainability and resilience • economic diversity and vitality is maintained • small-medium enterprises are considered • employment is provided through innovation and the unique local environment including environmental and social quality of the city's public places	Kenworthy 2006, World Bank 2010, Jenks and Jones 2010, and Alusi et al. 2011
Participatory sustainable planning and policy	• integrated sustainability planning for the future of the city is a visionary 'debate and decide' process, not a 'predict and provide' • Planners and policy makers discuss with engineers medium to long-term sustainability strategies so that they can be based on technically feasible solutions • eco-city development is "formulated as, embedded in, and supported by, policy processes"	Kenworthy 2006, Willets et al. 2010, Joss 2011, and Joss et al. 2012

2.5.3. Technical Criteria

Mulligan et al. (2011) pinpoint the need to differentiate between sustainability characteristics that "guide internal design issues" (the technical) and those that describe sustainability performance (top-level statements). For instance, biodiversity, measured by the number of species in an area, does not guide the design for this area, while the square meter of area to be assigned to a habitat may be a viable design indicator. As such, urban sustainability technical criteria consist of physical tangible, spatial, and technical indicators. Land use and master plan features, transportation system, and wastewater treatment criteria are examples of technical characteristics, whereas ways of living, changing behavior, economic activities, social diversity, civic empowerment, and housing affordability are not.

As proposed by Keirstead and Leach (2008), urban sustainability criteria are best categorized by "service niches" (categories or themes), such as energy, water, transport, and waste management. To identify these criteria, a survey-based selection strategy is adopted with reference to different sources of literature on sustainable cities and the sustainable urban built environment. This methodology is inspired from Tanguay et al. (2010) while reviewing urban sustainability indicators.
Hence, a descriptive preliminary list is developed and presented in Table 2. Similar to LEED-ND and BREEAM communities (which address sustainability in neighborhoods), the proposed list identifies five common technical themes to be considered while planning for eco-cities, along with their corresponding main technical criteria. This list represents a *knowledge-based tool*, inferred from literature, [as proposed by Fernández-Solís et al. (2011)] to be initially used by the practitioner embarking on the management of a new eco-city project. As stated before, the list

addresses the physical tangible spatial aspects of the new eco-city as opposed to the abstract intangible non-spatial sustainability characteristics. The five technical themes are:

1) Land Use and Urban Form
2) Mobility and Transport Infrastructure
3) Energy Demand and Energy-Supply Infrastructure
4) Water, Wastewater and Waste
5) Technology

Only sustainability criteria that need to be addressed during the early planning phase are listed within these themes. For example, criteria such as "provision of public transport infrastructure" and "renewable energy power plants" are considered since they are considered during pre-project planning; whereas "materials used", "building indoor environment", "management and operations processes" are not included in the list since they are best addressed at later project phases (detailed design, construction, or start up and operations).

Table 2. Eco-City Main Technical Criteria

Technical Theme	Technical Criterion	References
Land use and urban form	*accessible* site location	Eryildiz and Xhexhi 2012 and Sharifi and Murayama 2013
	mixed-use land development	Lehmann 2007, Qiang 2009, Jenks and Jones 2010, Jepson and Edwards 2010
	dense, space saving, compact housing structures	Haughton 1997, Kenworthy 2006, Lehmann 2007, Yip 2008, Jenks and Jones 2010, Jepson and Edwards 2010, Ecobuilders 2012, and Eryildiz and Xhexhi 2012
	energy-efficient settlement patterns through optimized building placement (orientation, solar shading reducing surface and air temperatures, source of fresh air 'freely' cooling building through natural rather than mechanical ventilation, etc.)	Haughton 1997, Kenworthy 2006, Lehmann 2007, Qiang 2009, Jenks and Jones 2010, Jepson and Edwards 2010, and Eryildiz and Xhexhi 2012
	Resilient and varied physical structure and urban design (especially public spaces), considering a variety of people at various times for varied reasons through flexibility of four parameters: quantity, quality, location and time	Kenworthy 2006, Yip 2008, Jepson and Edwards 2010, and Eryildiz and Xhexhi 2012
	legible, rich, personalized physical structure and urban design (especially public spaces), visually appropriate through attractive landscaping and clearly identified through street function, landmarks, etc.	Kenworthy 2006, Yip 2008, Qiang 2009, Jepson and Edwards 2010, Eryildiz and Xhexhi 2012, and Joss and Molella 2013
	provision of *energy efficient buildings* (sustainable building materials, indoor air quality, reduced heat and electricity demand, efficient heat and electricity supply through efficient electric appliances, resource sharing between buildings, etc.)	Engel-Yan et al. 2005, Kenworthy 2006, Lehmann 2007, Qiang 2009, and Piechowski and Weerakkody 2011
	integrated green areas and urban agriculture	Engel-Yan et al. 2005, Kenworthy 2006, Lehmann 2007, Qiang 2009, Jenks and Jones 2010, and Eryildiz and Xhexhi 2012

Mobility and transport infrastructure	*reduced use of car/motorcycle* through de-emphasized freeway and road infrastructure, restricted parking, and emphasized non-motorized transport infrastructure, *e.g.* walking /pedestrian network (settlements structures that promote short distances, etc.), cycling (supportive street infrastructure, bikeways), etc.	Engel-Yan et al. 2005, Kenworthy 2006, Lehmann 2007, Qiang 2009, Jenks and Jones 2010, and Joss and Molella 2013
	provision of *public transport grid* (light rail systems, Bus Rapid Transit/BRT, personal rapid transit/PRT, etc.)	Kenworthy 2006, Lehmann 2007, Menichetti and Vuren 2011, and Joss and Molella 2013
	reduced energy demand for transport through low carbon technologies (electric transport system e.g. eco-friendly buses, fully electric/plug-in hybrid cars, etc.)	Menichetti and Vuren 2011 and Eryildiz and Xhexhi 2012
	transport inter-modal connectivity	Jepson and Edwards 2010 and Menichetti and Vuren 2011
Energy consumption and energy-supply infrastructure	*energy savings/reduced consumption* (demand for heat, cold and electricity) through technical measures: e.g. high level of insulation, intelligent lighting, innovative heat storage, smart electricity grid, combined heat and power/CHP, energy harvesting, micro power generation, enhanced resource sharing between buildings	Lehmann 2007, Qiang 2009, Jenks and Jones 2010, Piechowski and Weerakkody 2011, Agudelo-Vera et al. 2012, and Eryildiz and Xhexhi 2012
	local renewable and/or low-carbon energy sources for energy supply (demand for heat, cold and electricity), integrated with urban design, e.g. biomass, geothermal, photovoltaic electricity generation, wind power, concentrated solar power, etc.	Yip 2008, Qiang 2009, Jepson and Edwards 2010, Jenks and Jones 2010, Piechowski and Weerakkody 2011, Eryildiz and Xhexhi 2012, and Joss and Molella 2013
Water, wastewater and waste	provision of *sufficient potable water*	Engel-Yan et al. 2005 and Eryildiz and Xhexhi 2012
	water savings/reduced consumption (e.g. local harvesting, storage techniques, etc.)	Engel-Yan et al. 2005, Eryildiz and Xhexhi 2012, and Joss and Molella 2013
	local wastewater recycling for reuse (e.g. in gardening/green spaces, car washing, etc.)	Engel-Yan et al. 2005, Jenks and Jones 2010, and Agudelo-Vera et al. 2012
	local waste recycling for reuse (e.g. waste to energy/production of biogas, etc.)	Engel-Yan et al. 2005, Jenks and Jones 2010, Piechowski and Weerakkody 2011, Eryildiz and Xhexhi 2012, and Joss and Molella 2013

Technology	provision of *Information and Communication Technology (ICT)* through high-tech smart infrastructure for management and operations of complex systems and services (e.g. internet, mobility patterns, electric grid, etc.)	Alusi et al. 2011, Abdoullaev 2011, and Shwayri 2013
	provision of *low carbon technologies (LCT)* for the corresponding infrastructure fields of building design, electricity, transport, energy supply, energy production, water management, waste management, sewage treatment, etc.	Kenworthy 2006, Lechtenböhmer et al. 2010, Joss 2011, and Joss and Molella 2013

CHAPTER 3

EARLY MANAGEMENT PRACTICES OF SUSTAINABLE CONSTRUCTION PROJECTS

3.1. Introduction

Literature review on new eco-cities reveals that this type of sustainable large-scale urban land development is not yet broadly addressed. As presented in Chapter 2, various researchers address the characteristics of the sustainable city; however, the master plan (MP) development process that leads to the attainment of a new constructed eco-city is not specifically covered. Some papers (e.g., Alusi et al. 2011, Eryildiz and Xhexhi 2012, and Joss et al. 2012) *compare new eco-cities* of different scales; others describe *single new eco-city case studies* such as Caofeidian International eco-city in China (Joss and Molella 2013), Masdar in Abu Dhabi/United Arab Emirates (Menichetti and Van Vuren 2011 and Cugurullo 2013) and Songdo in Korea (Shwayri 2013). Very few papers (Yip 2008 and Qiang 2009) highlight the development of the MP of a new eco-city, which is the emphasis of this study. Examples from the MP development of new eco-cities in China are briefly presented in the next section.

As such, assuming that they apply to eco-city MP development, the early management practices of sustainable construction projects in general are also investigated through a second round of literature review - Part (b) - and synthesized in this chapter. Several authors propose frameworks, tools and activities to plan for sustainable construction projects, new or regeneration, at different scales including infrastructure systems, land development, neighborhood or green buildings.

3.2. Eco-City Master Plan Development

Yip (2008) presents a case study of *Changxing eco-city* in the Chinese city of Beijing, to be developed over a 6 km^2 area to accommodate a population of 60,000. After setting the project's vision and objectives (energy efficiency, environmental friendliness, economic growth, and social harmony) by the client and project's stakeholders, Key Performance Indicators (KPI)s with their target measures were established and applied to quantify performance of the proposed MP alternatives against meeting sustainability requirements. For example, a suitable target for the KPI "open space provision" may be "more than 40% of the MP is open space with a density of 20 m^2/person". "Buildings and facilities are 50% within 600 m of mass transit, 100% within < 400 m from bus stops" is another example of a reachable target for the KPI "accessibility to public transport". For the KPI "provision of renewable energy", one of the targets could be "at least 15% renewable energy"; similarly for the KPI "water usage" can be reached through the target "less than 150 l/p/d for potable water usage" (Yip 2008). In order to technically translate the KPIs into site specific performance requirements, various quantifiable modeling techniques (micro-climate assessment, water resource balance, storm-water management assessment, open space oxygen emission capability assessment, as well as the sun and solar accessibility studies) were applied. The paper also pinpoints the adoption of project management to ensure holistic multi-disciplinary approach (Yip 2008).

Qiang (2009) describes the planned Sino-Singapore *Tianjin eco-city*, to be constructed over a 30 km^2 area for 350,000 residents when fully completed in around 2020. The start-up area is scheduled for completion by end of 2013 (Tianjin Eco-City website). A system of KPIs was developed in the process of planning. A set of 26 KPIs

were grouped into four categories: “Good Natural Environment”, “Healthy Balance in the Man-made Environment”, “Good Lifestyle Habits”, and “Developing a Dynamic and Efficient Economy” (Qiang 2009). For example, under the category “Good Lifestyle Habits”, one of the KPIs is “per capita daily water consumption”, with target measure described as “each person should not exceed 120 litres daily water consumption by 2013” (Tiangin Eco-City website).

Qiang (2009) also describes the development of *Caofeidian eco-city*, in the Chinese city of Tangshan. The master plan was completed in three stages (November 2007 to February 2009): a first round of international planning competition of 10 teams and overseas universities, a second round of international planning competition, and a joint concept planning by two Master Planners (Qiang 2009). A sustainability indicator system of 52 KPIs was formulated and grouped under an “eight-dimensional” technical system. The eight categories are: (1) "water use and disposal", (2) "garbage disposal and utilization", (3) "new energy development and utilization", (4) "transportation security", (5) "greening ecology", (6) "public utilities", (7) "urban landscape", and (8) "ecological construction". Today, the overall master plan (area 150 km^2 to accommodate one million people by 2020) is completed, along with a 30 km^2 of start-up area and the detailed construction plan for 12 km^2 urban area (Caofeidian eco-city website).

Both papers (Yip 2008 and Qiang 2009) do not systematically describe the pre-project planning process or management practices that promote the incorporation of sustainability requirements while appraising/rating MP alternatives. As such, another literature review on sustainable construction projects, in general, is explored and presented next. Five main management practices are identified in literature as deemed

essential while incorporating sustainability in construction projects in general. These are focused around the following settings:

- *timing*: (A) the pre-project planning process of a construction project (addressing the "when" of the research scope)
- *participants*: (B) the essential role of the design manager and (C) stakeholders' involvement, including the sustainability advisor (addressing the "who" of the research scope)
- *activities*: (D) the use of decision-support tools and (E) value management activities (addressing the "what" of the research scope)

3.3. (A) The Pre-Project Planning Process

3.3.1. Definition

The pre-project planning (PPP) or front-end planning process includes all the activities to be undertaken at early phases of a construction project's life cycle. It starts with project initiation and ends with a decision to proceed for detailed design (Gibson and Gebken 2003). Many researchers stress the importance of this early phase whereby 80% of the construction project can be specified. Accordingly, to improve the planning of their capital projects, companies around the world implement a formal PPP process (Griffith and Yarossi 2005). Gibson et al. (2006) consider that the PPP process is similar for most capital projects but needs to be tailored to project-specific requirements. Yet, it consists of three main distinct phases, as presented next.

3.3.2. Pre-Project Planning Phases

For large capital projects, Griffith and Yarossi (2005) refer to the entire pre-project planning by the *definition phase.* They propose a three-step process that breaks it into three separate stages with a set of objectives and deliverables for each stage. A formal "gate review" between each stage serves as check points to ensure that all deliverables are completed. The three stages are designated by:

(1) *Business Planning*, with the objective of quantifying a business opportunity through market forecast, competitive studies, comparative cost estimates, etc.

(2) *Facility Planning*, whereby the project manager is assigned, project team built, and project alternatives developed and compared. The selected alternative is then tested against the business case defined through the Business Planning Stage.

(3) *Project Planning*, with the objective of detailing the project's scope, cost, schedule, and execution plan in preparation for the next Execution Stage.

Alternatively, for building projects in specific, the Royal Institute of British Architects (RIBA) proposes a plan of work model for the building design and construction process in the UK. The 2013 RIBA plan of work identifies eight stages for the overall project life cycle: (0) strategic definition; (1) preparation and brief; (2) concept design; (3) developed design; (4) technical design; (5) construction; (6) handover and close out; (7) in use (operation) [RIBA 2013]. It can be inferred that RIBA Stages 0, 1, 2, and part of 3 correspond to the PPP phase.

As shown in Fig. 4, the Construction Industry Institute (CII) delineates three principal phases (feasibility, concept and detailed scope) representing the PPP of the project's life cycle (the remaining phases being the design, construction, commissioning and startup, and operations). Gibson and Bosfield (2012) stress the importance of the

sequential order of the project's phases since each one provides needed information and risk mitigation before the next.

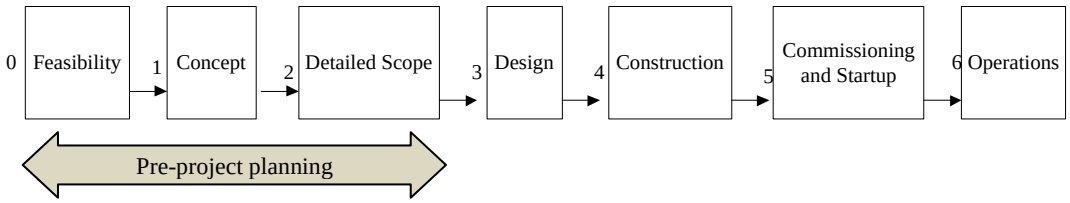

Fig. 4. Project phases by CII (adapted from Gibson and Bosfield 2012)

The PPP phases proposed by CII are described as follows (Gibson and Bosfield 2012):

(1) *Feasibility*, also known as business/strategic planning or strategy formulation Phase. It aims at elucidating the project's vision, broad scope, and the client's business needs, assessing available resources, and organizing for the entire pre-project planning process to achieve alignment among stakeholders. Its output is a decision that the project is economically and technically feasible.

(2) *Concept*, also known as alternative selection, project scope definition, conceptual design, programming or briefing Phase. It aims at defining, evaluating, and selecting the best solution alternative(s) which is supposed to generate maximum value to the client. During this Phase, project team alignment is ensured, key decisions are addressed, and basic design documents are analyzed to produce a plan that defines the project scope. This phase provides flexibility in defining the project while different alternatives are still being evaluated. Gibson et al. (2006) stress the importance of performing adequate site investigation and programing (space planning) before moving to schematic design.

(3) *Detailed Scope*, also known as schematic design, design development, scope finalization, preliminary engineering, or project definition Phase. It aims at developing a

project definition package which includes the technical scope, early preliminary designs as design basis, execution plans, definitive cost estimate and schedule. This Phase usually ends with project authorization and provides a smooth transition from pre-project planning to design and construction.

For urban design projects, and similar to RIBA plan of work addressing buildings, Boyko et al. (2005) develop a conceptual "to be" process inferred from the amalgamation of design processes from different sources and fields (urban design, planning, architecture, manufacturing, construction and engineering industries, business, and non-governmental organizations). The authors claim that the proposed process may be applied to construction projects of different scales including large-scale development. The proposed process consists of four stages, representing tasks to be performed by key stakeholders. Intermediate transition stages redefine the goals before proceeding to subsequent stages. The four stages are:

- Stage 1: "creating teams, appraising the situation and forming goals"
- Stage 2: "designing and developing"
- Stage 3: "evaluating, selecting and creating a plan"
- Stage 4: "implementing, monitoring and following up"

To test the validity of the "to be" baseline model developed in Boyko et al. (2005), Boyko et al. (2010) investigate an urban master plan redevelopment case study. Through analysis of archival material and interviews, the authors map the "as is" project's stages which proved to be similar to the proposed process in Boyko et al. (2005). Particularly, the authors identify the following PPP activities:

- "early vision development and group formation" (formation of a steering group representing local entities and preparation of a briefing document)

- "international competition and first stage brief" (invitation of creative consultants to develop visual presentation of the broad design theme).
- "entries to first stage" (five teams invited to submit to the second stage of the MP process)
- "second stage briefing"
- "judging and selecting teams" (compare the visions developed by the competing teams and assess them by public, local experts in architecture, planning and urban regeneration, in addition to a judging panel for the selection decisions"

The authors conclude that, in general, the stages of the "to be" process model proposed in Boyko et al. (2005) for urban design projects are comparable to the actual "in-practice" process as depicted for a case study in UK. However, both processes do not explicitly address sustainability issues, when and how to consider their incorporation at the various project's stages.

Table 3 compares the stages of the aforementioned development-process models, with CII PPP phases as basis.

Table 3. Comparison between the Stages of some Development-Process Models

	CII	Griffith and Yarossi (2005)	RIBA plan of work (2013)	Boyko et al. (2005)
Pre-Project Planning	Feasibility	Business Planning	Strategic definition Preparation and brief	"Creating teams, appraising the situation and forming goals"
	Concept	Facility Planning	Concept design	"Designing and developing" "Evaluating, selecting and creating a plan"
	Detailed Scope	Project Planning	Developed Design	
	Design		Technical design	
	Construction		Construction	"Implementing, monitoring and following up"
	Commissioning and startup		Handover and close out	
	Operations		In use	

The following section describes the correlation between the PPP process and sustainability in construction projects of various scales (green building to large-scale land development).

3.3.3. Application to Sustainable Construction Projects

For sustainable construction projects in particular, the PPP process is essential in progressing from sustainability goals to definite outcomes that meet sustainability. This process assists practitioners in ensuring early incorporation of sustainability requirements into conceptual plans, considering sustainability priorities as early as the feasibility Phase, and establishing the framework for future decisions thus minimizing the risk of costly modifications at later phases (Robichaud and Anantatmula 2011). For example, early feasibility studies for investigating sustainable development options (e.g. wind vs. solar for renewable energy; sourcing local materials, etc.) ensure that locally

suitable opportunities are considered throughout the decision-making process. Moreover, a strategic design brief developed during PPP - including sustainability directives such as energy targets and selection of environmentally preferable materials - ensures that sustainability requirements are formally considered in design development (Weerasinghe et al. 2007, Hunt et al. 2008, Thomson et al. 2008, Lombardi et al. 2011, and BREEAM 2012).

Researchers study sustainability incorporation in construction projects with respect to the entire project's life cycle, in general, or during the PPP Phase, in specific. In order to effectively develop the scope of a sustainable project at PPP, Gordon and Azambuja (2011) list four groups of success factors identified while investigating case studies of LEED-certified projects: (1*) goals*, their attributes (e.g. clear, early) and timing (e.g. early documentation), (2) *process*, e.g. using planning tools such as charettes, (3) *team dynamics*, their experience, commitment, communication, and collaboration, and (4) *deliverables*, quality of documentation over the project lifecycle. For green buildings, Robichaud and Anantatmula (2011) pinpoint the need for considering site characteristics before developing the design charrette/ brief toolkit during PPP.

Weerasinghe et al. (2007) present an adapted tool from the Project Development Rating Index (PDRI) to be used for the sustainable scope development of green buildings, given that PDRI does not address sustainability requirements. Developed by CII in 1999, the PDRI for buildings represents a checkpoint throughout the pre-project planning process to monitor the development and score the status/level of completeness of the construction project scope (Gibson and Gebken 2003, Weerasinghe et al. 2007, and Gibson and Bosfield 2012). It consists of a weighted

checklist/matrix of 64 scope definition elements (e.g. site surveys, open space requirements, special water treatment, safety procedures, etc.). The aim is to ensure that client requirements are captured and incorporated into the project's definition package (Cho et al. 2001 and Gibson and Gebken 2003). The proposed tool by Weerasinghe et al. (2007) incorporates each LEED credit within the pre-project planning activities for a green building in an attempt to complement the PDRI tool by addressing sustainability objectives. As such, a "sustainability matrix" matches each LEED credit with the corresponding PDRI elements and suggests when appropriate decisions need to be made during PPP. For example, LEED credit "parking capacity" requires decision under PDRI elements D1 (site layout), E1 (program statement), and E9 (transportation requirements).

With reference to RIBA plan of work 2007, Thomson et al. (2008) delineate five "phases for managing sustainability assessment" across a building project lifecycle: "scoping", "planning", "assessing", "monitoring" and "auditing". For the early project's phases (PPP), sustainability scoping, planning, and assessing activities include:

- "Developing a sustainability vision of the project"
- "Identifying major issues relating to sustainability"
- "Setting sustainability priorities based on context"
- "Establishing and defining sustainability goals, targets, and Key Performance Indicators"
- "Developing procedures to monitor and record sustainable targets"
- "Identifying the certification and testing measures for sustainability assessment"
- "Creating a plan to achieve sustainability goals, coordinating with project work plan"

- "Implementing sustainability action plan in the schematic design"

For large-scale land developments, BREEAM communities (2012) devise a checklist to assist practitioners in linking the planning and design stages to the sustainability assessment process. A three-step planning and design process is proposed to ensure that each sustainability criterion (of the corresponding BREEAM category) is addressed at the appropriate time in the master plan development process:

- "Step 1- establishing the principle of development": understand opportunities to improve sustainability such as community-scale energy generation, transport and amenity requirements, etc.
- "Step 2- determining the layout of the development": detailed plans for mobility, buildings and amenities location, etc.
- "Step 3- designing the details": landscaping, sustainable drainage solutions, transport facilities, detailed design of the built environment, etc.

A matrix matches each BREEAM communities' criterion to one of the three planning and design steps. For example, under category "Transport and Movement", the criterion TM 01 (transport assessment) is considered during Step 1; while criteria TM 02 (safe and appealing streets), TM 03 (cycling network), and TM 04 (access to public transport) are considered during Step 2; and TM 05 (cycling facilities) and TM 06 (public transport facilities) addressed during Step 3.

This review of pre-project planning practices, stages and activities of various types of sustainable construction projects will inform/guide the identification of stages and activities for a proposed PPP process guide for a new eco-city proposed in Chapter 4.

Typically directing the project on behalf of a client, the *design manager* is the owner or responsible for the PPP process. The following section describes his/her role in construction projects in general and sustainable projects in specific.

3.4. (B) The Design Manager Role

3.4.1. Definition

The design manager, or chief designer as called by the Finnish building code, is the owner or responsible for the pre-project planning process. The design manager is represented by a project management or architectural design company (Rekola et al. 2012). Thyssen et al. (2010) consider design managers as project leaders who explore client needs and translate values into understandable design criteria. They contribute to the brief development, coordinate activities, and integrate multi-disciplinary design consultants through interface/liaison management to achieve consensus and teamwork. They monitor, inform on design progress, and critically examine and reformulate both requirements and solutions (London and Cadman 2009, Mills and Glass 2009, and Rekola et al. 2012).

3.4.2. Application to Sustainable Construction Projects

Throughout a development process, various actors (e.g. client, architects, engineers, real estate developers, etc.) are involved in series of events and activities (Lombardi et al. 2011). In particular, eco-city development is a complex megaproject entailing multi-disciplinary multi-cultural design teams and stakeholders. As such, their coordination and alignment at PPP stages call for a design management entity or person. Likewise, the success of sustainable construction projects/green buildings depends on a

design management process during the scope definition phase. The design manager acts as a *sustainability administrator* who guides and maintains the design towards sustainable solutions. He/she owns the sustainability agenda while monitoring and promoting continuous reference to sustainability objectives throughout the decision-making process (Weerasinghe et al. 2007, Mills and Glass 2009, Mulligan et al. 2011, and Rekola et al. 2012).

For a sustainable building project, Rekola et al. (2012) envision the roles of the design manager under four levels:

- *"Technical level"*: coordinating, scheduling, and processing the design forward through agreements, documentations, and schedules.
- *"Substance level":* enhancing and monitoring design substance issues, such as value creation and raising sustainability awareness (Zainul Abidin and Pasquire 2007 and Thyssen et al. 2010).
- *"Communication level":* team building, interface management, and information management among multi-disciplinary teams especially with cultural differences (London and Cadman 2009).
- *"Personal level":* experience, leadership, and skills such as persuasion tactics to influence stakeholders. Particularly, for sustainable construction projects, both the skills for successful design management and sustainability knowledge are critical (London and Cadman 2009, Mills and Glass 2009, and Robichaud and Anantatmula 2011).

In conclusion, a design manager plays a key role in the success of sustainable construction projects. The following section identifies other key players and participants in sustainable construction projects.

3.5. (C) Stakeholders' Involvement

3.5.1. Definition

Researchers emphasize the importance of stakeholders' participation during the pre-project planning process whereby collective knowledge and team alignment are achieved, and stakeholders' needs and values translated into criteria used to generate and test design concepts (Whelton et al. 2002 and Gibson et al. 2006). Key players involved in PPP include the client, the project engineer/architect, the discipline leads (infrastructure, urban planning, etc.), the technical representatives, the user representatives, and the design/builder or construction manager (Gebson and Gebken 2003). Gibson and Bosfield (2012) highlight the importance of the client upper management's commitment to the success of the PPP process. According to Thyssen et al. (2010), clients' types may be differentiated and classified as experienced/ inexperienced, public/private, and short-term (developers)/long-term clients (owners).

3.5.2. Application to Sustainable Construction Projects

Several authors consider the importance of stakeholders' participation in developing the sustainability requirements for a construction project**.** Thomson et al. (2008) stress the need to involve project's stakeholders as early as the scoping phase of a construction project to ensure that their values/sustainability objectives are expressed in project's goals and sustainability assessment basis. Similarly, the World Bank (2010) focuses on stakeholders' contribution while enhancing sustainability in existing cities of developing countries; they participate in workshops to agree on sustainability vision, considering project's localities. BREEAM communities (2012) envision stakeholders'

consultation and engagement as an essential process in the development of a sustainable neighborhood.

For sustainable urban developments, London and Cadman (2009) recognize three groups of project stakeholders: (i) *community stakeholders* (users, external groups), (ii) *the proposers or project team* (client, architects, and developers) and (iii*) the assessors or regulators* (local government agencies). Alternatively, for sustainable infrastructure projects, two types of stakeholders are identified by Scanlon and Davis (2011): *internal* (individual or organizations working directly on the project) versus *external* (community groups, end users).

For sustainable building projects, Lombardi et al. (2011) highlight the importance of dialogue between different design consultants working in parallel during the concept stage, which minimizes tensions and trade-offs among multiple sustainability objectives, usually considered in isolation. Similarly, for sustainable urban land developments, Wallbaum et al. (2011) emphasize the role of the *planning team* including architects, landscapers, urban planners, traffic planner, and sustainability advisors; however, the authors suppose that, at the early competition stage, both developers and end users - who might be still anonymous- do not need to be consulted. Willets et al. (2010) and Robichaud and Anantatmula (2011) highlight the need for *engineers' participation* to foster sustainability in construction projects during the early stakeholders' involvement. Engineers are expected to use their technical skills to educate and influence decision-makers and work closely with architects during the feasibility and programming stages.

Hunt et al. (2008), Thomson et al. (2008), and Scanlon and Davis (2011) stress the importance of expert knowledge and early participation of the sustainability advisor

in decision making, especially for large-scale projects. A sustainability advisor has a key role in developing sustainability requirements, benchmarking against other projects, and educating the project team on integrating sustainability thinking in the project.

BREEAM communities (2012) identify several types of consultations with community representatives and other stakeholders. Each consultation type is matched to the corresponding stage(s) of BREEAM communities' design and planning process steps. For example, consultations for SE02 (demographic needs and priorities) and SE 03 (flood risk assessment) are undertaken during Step 1, while consultation for SE 12 (local parking) and TM 03 (cycling network) are undertaken during Step 2 of the development process.

In conclusion, the involvement of various stakeholders (mainly client, sustainability advisor, design consultants including the engineer) during the pre-project planning process of sustainable construction projects is crucial to reach consensus on project's sustainability issues.

The remaining sections shed light on two types of typical activities in managing sustainable construction projects: use of decision-support tools and value management.

3.6. (D) Use of Decision-Support Tools

3.6.1. Definitions

The project's early stages are most difficult to appraise against meeting sustainability requirements since design solutions are not completely developed. As such, to promote sustainability in construction projects, several authors consider the importance of developing and/or using tools while evaluating design alternatives. In the context of sustainable urban development, Jensen and Elle (2007) review sustainability

tools used in 60 case studies in eight European countries covering various sectors (energy, water/sewage, waste, transport, buildings, etc.). They delineate four broad categories of tools to assist in the management of sustainable construction projects:

1) *Process Guides*. These are roadmaps, processes and frameworks that describe the steps to be followed in project management towards achieving sustainability requirements. The process guide is expected to constitute a useful tool for the practitioner, as per Austin et al. (2001) who mapped the design process during the Conceptual Phase of a building construction project; the authors conclude that interdisciplinary design teams profit from a design process guide to follow prior to commencing the design activity to facilitate the integration of client requirements into the process at the appropriate time. An example of such tools, currently available for building and infrastructure projects, is the IDEF0 process map developed by CII in 1995 based on the three phases of PPP proposed by CII and described before. The process identifies four major steps: 1- "organize for pre-project planning"; 2- "select project alternatives"; 3- "develop a project definition package"; and 4- "decide whether to proceed with detailed design of the project" [Gibson et al. 2006]. Another example presented before is the urban design baseline model by Boyko et al. (2005) composed of stages and activities. Yet, these process models do not explicitly address sustainability objectives for megaprojects such as new cities.
2) *Appraisal or Rating Tools*. These are knowledge-based tools or performance guides developed based on multi-criteria, indicators or indices, weighing different aspects of sustainability. They typically provide performance indicators, both quantitative (such as annual energy use, water consumption, GHG emissions, etc.) and

qualitative (such as impact on the ecological value of the site, impact on local wind patterns, etc.) For green buildings, they assist designers in tracking sustainability design criteria, or design performance not addressed by building codes, which gives credits to the overall rating for a green building project (Fernández-Solís et al. 2011). The aim is to maintain a functional standard based on the required sustainability goals and representing sustainable urban models. Examples of such standard international tools for buildings and neighborhoods/communities include SB Tool 07/Canada, LEED/USA, BREEAM/UK, and Qatar Sustainability Assessment System (QSAS)/Qatar (Fernández-Solís et al. 2011 and Sharifi and Murayama 2013).

For infrastructure systems, locally-developed tools of indicators and indices are devised (Dasgupta and Tam 2005 and Shen et al. 2011). Fernández-Solís et al. (2011) suggest that such tools can be inferred from peer reviewed journals and case study information.

Project-specific appraisal tools that consider stakeholders' opinions and project's context through prioritized criteria are also developed and used at the strategic planning stage of large-scale projects (Wallbaum et al. 2011 and Mulligan et al. 2011). For example, Wallbaum et al. (2011) make use of SB tool 07 Canada (devised for green buildings) to identify sustainability issues pertaining to the initial planning stages of an urban redevelopment project of inner city areas. Sustainability criteria are then prioritized and tailored to the project based on stakeholders' opinions. Involving the client and the design team in developing the project-specific appraisal tool allows them demonstrate leadership on sustainability and integrate its requirements in decision-making (Mulligan et al. 2011).

For neighborhoods, Sharifi and Murayama (2013) identify the following characteristics of sustainability indicators: "sustainability coverage/comprehensiveness", "adaptation to locality/context-specific needs and priorities", "participation/involvement of different stakeholders during the development stage", and "presentation of results/useful as decision support systems".

3) *Assessment Tools*. These are quantitative performance evaluation or decision-support calculation tools. They are used to evaluate different design alternatives by measuring key performance indicators in different sectors such as calculating the level of CO_2 emissions as an environmental outcome. In other words, while appraisal/rating tools determine the performance level of a design solution, assessment tools measure performance indicators to reflect the attainment of sustainability in a proposed design solution. Different urban sustainability assessment tools exist at the scale of an existing city or neighborhood such as Life Cycle Analysis, Ecological Footprint, Environmental Sustainability Index, Dashboard of Sustainability (Mori and Christodoulou 2012), in addition to system simulation tools for calculating energy consumption, lighting and indoor environmental quality, etc. (Fernandez Solis et al. 2011).
4) *Monitoring Tools.* These are used to monitor sustainability performance during operation, in sectors such as energy, water, and waste, or used to inform and involve consumers. This category falls outside the scope of the research study since it addresses the operational phase of projects.

3.6.2. Application to Sustainable Construction Projects

Several authors consider the importance of developing and/or using *appraisal/rating tools* in sustainable construction projects. Mulligan et al. (2011) describe the evolution of sustainability appraisal in various complex regional-scale case studies (park, neighborhood, Greenfield mixed-use development). They argue that there could be no generic standard tools to appraise sustainability in such large-scale projects, but there is a need for tailored appraisal tools that consider the local context. In this regard, project-specific objectives, along with corresponding indicators and targets, need to be defined by multi-stakeholders (client and design team mainly) in order to reach consensus, commitment and alignment. However, tailored appraisal tools are not robust if the goal is to compare project's sustainability with other projects (Mulligan et al. 2011). Wallbaum et al. (2011) describe how each sustainability criterion of SB tool 07 Canada for green buildings is matched, by the project team, to the different stages of an urban redevelopment project. The purpose is to identify when sustainability issues need to be considered. In addition, criteria are prioritized through a "prioritization process" to reflect different stakeholder's sustainability priorities at early stages. Similarly, for infrastructure projects, Gilmour et al. (2011) develop sustainability indicators based on UK and EU framework indicators, but tailored to the project at hand through interviews with stakeholders during a scoping study. Hunt et al. (2008) track the time when (visioning, design, construction, etc.) sustainability is considered in five sustainable urban regeneration case studies. They conclude that the application of the indicator systems is most influential during the early visioning stage when they are most efficient in guiding the planning process toward achieving sustainability requirements.

The authors also indicate that local conditions and local priorities need to be reflected in the indicator system.

Other authors consider the need for *sustainability assessment tools* to support decision-making in different types of sustainable construction projects. Fernández-Solís et al. (2011) identify which LEED credits need to be assessed and propose a matrix that matches sustainability assessment tools available for buildings to the corresponding LEED credit. For example, for energy simulation, the authors identify eight available leading tools (Autodesk Ecotect Analysis, HEED, Design Builder, e-QUEST, etc.). Each LEED credit requiring decision-support is correlated to its corresponding assessment tool(s) to offer ready access to suitable tools.

In conclusion, both appraisal tools and assessment tools are important in sustainable construction projects. Process guides are also helpful if they consider sustainability issues within the proposed activities.
The identification and prioritization of project-specific sustainability criteria and indicators are best practiced through value management, as presented next.

3.7. (E) Value Management

3.7.1. Definition

Value management (VM) is a practice aiming at identifying and defining the project's objectives while accounting for different stakeholders' needs, values, priorities, and expectations in order to maximize the project's functional value and reach consensus while comparing alternatives (Thyssen et al. 2010 and Shen and Yu 2012). It is worth noting that VM is differentiated from value engineering. While the latter aims at finding optimum solutions and is usually conducted as an audit on the

basis of sketch design, VM process is undertaken by managing the project's development through the audit of all decisions against a value system approved by the client. As such, through VM different alternatives are explored before proposing the solution that best meets clients' needs (Zainul Abidin and Pasquire 2005 and Thyssen et al. 2010).

Of most importance to VM are the early pre-project planning stages of a construction project when structured workshops (WS)s and multi-disciplinary team-oriented exercises are performed.

Thyssen et al. (2010) emphasize the need to incorporate client values into the conceptual design of construction projects with VM as an underlying principle. Cost and time savings are better achieved when various client values are early identified, understood, aligned then fulfilled as integral part of design solutions (Lin et al. 2011).

Zainul Abidin and Pasquire (2005) identify three types of participants in VM workshops: (i) *decision makers* (clients or clients' representatives), (ii) *VM facilitators* (control and lead the workshops), and (iii) *team members*.

Thyssen et al. (2010) propose a four-stage value-based workshop model to be undertaken during the Conceptual Phase of a construction project to explore client values, on the basis of the client brief, and incorporate them into the conceptual (sketch) design. The first VM workshop- the *vision workshop*- is preceded by a *partnering workshop* to build up trust, consensus and communication among all stakeholders. The objective of the *vision WS* is to understand the underlying values that determine the client's judgment of the end product and prepare a prioritized value tree. Following the vision workshop, design alternatives are developed. W*orkshop two* is next undertaken to evaluate all *design alternatives* against the "product values" and rank them using a

decision matrix. A winning proposal is then selected for further articulation. The winning alternative is evaluated in *workshop three* in order to ensure client values are well incorporated.

3.7.2. Application to Sustainable Construction Projects

For sustainable construction projects, VM contributes to enhancing the integration of sustainability requirements throughout the project's life (Shen and Yu 2012). At early project stages, VM WSs are crucial to identify, blend, and integrate the client's sustainability objectives into planning and concept design (Zainul Abidin and Pasquire 2005). Formal stakeholders' participation and interaction during VM WSs provide opportunities to clarify client's objectives, produce and disseminate sustainability knowledge effectively, and highlight potential problems at the very beginning of the project (Zainul Abidin and Pasquire 2005, Zainul Abidin and Pasquire 2007, Lin et al. 2011, and Shen and Yu 2012).

Zainul Abidin and Pasquire (2007) propose a VM model as a series of three-stage WSs that guide the development and maintenance of the "sustainability agenda" of a construction project:

1) *Sustainability input at pre-workshop stage*: the objective of this stage is to define the client's needs and project drivers, raise awareness on sustainability requirements by the VM facilitator, identify key sustainability objectives, and gather relevant information.

2) *Sustainability process at workshop stage*: the objective of this stage is to present the project's sustainability requirements as input to the project team so that they can transform them into solution output through proposals, to be next developed and

presented to the decision-makers. This workshop stage is further subdivided into different sub-stages including information, creation, evaluation, development, and presentation.

3) *Sustainability output at post-workshop stage*: the objective of this stage is to implement the outcome from the workshop stage in the form of proposal to be accepted, modified or rejected by the client.

In conclusion, value management workshops contribute to the success of sustainable construction projects during PPP phases in particular.

3.8. Summary

To recap, the main management practices enhancing sustainability incorporation into construction projects are identified through literature review Part (b): (A) the pre-project planning process, (B) the role of the design manager, (C) the stakeholders' involvement, (D) the use of decision support tools, and (E) value management. Nonetheless, the reviewed literature does not correlate them to new eco-city projects in particular where sustainability requirements are vital. This study assumes that the identified management practices apply to sustainable land development projects such as eco-cities. Thus, Table 4 below represents a synthesis of the main early management practices informing the master plan development of new eco-city projects. In addition, the PPP process described in this chapter for various types of construction projects will inform/guide the identification of stages and activities for a proposed pre-project planning process for a new eco-city, as presented in the next chapter.

Table 4. Early Management Practices in Sustainable Construction Projects

Management practice	Lessons learned	References
A. Pre-project planning process	A1 perform adequate *site investigation* and *programing/space planning* prior to schematic design A2 include sustainability strategic *directives* in the design brief A3 ensure that *locally suitable* opportunities are considered throughout the decision-making process A4 progress from *sustainability goals to definite outcomes* that meet sustainability	Boyko et al. 2005, Gibson et al. 2006, Weerasinghe et al. 2007, Hunt et al. 2008, Thomson et al. 2008, Lombardi et al. 2011, and BREEAM communities 2012
B. Role of the design manager	B1 consider a *design management process* to guide and lead the design, coordinate multi-disciplinary teams, maintain the sustainability agenda, monitor and promote continuous reference to sustainability objectives throughout the decision-making process	Mills and Glass 2009, London and Cadman 2009, and Rekola et al. 2012
C. Stakeholders' involvement	C1 *consider two stakeholders' groups*: (i) proposers or internal project team (individual or organizations working directly on the project mainly the client, architects, and developers) and (ii) assessors or regulators (local government agencies) C2 *consult and engage stakeholders* in workshops during the scoping Phase to ensure their values/sustainability objectives and project's localities are considered and expressed in project's goals and the basis for sustainability appraisal C3 foster dialogue between different *consultants/planning team* working in parallel during the concept stage (landscapers, urban planners, traffic planner, and sustainable development consultants, with emphasis on engineers' participation) C4 integrate expert knowledge through *sustainability advisors* while developing and prioritizing project-specific sustainability outcomes, benchmarking against other projects, and educating project team members on sustainability thinking	Thomson et al. 2008, Hunt et al. 2008, London and Cadman 2009, World Bank 2010, Willets et al. 2010, Scanlon and Davis 2011, Lombardi et al. 2011,Wallbaum et al. 2011, and BREEAM communities 2012

D. Use of decision support tools	D1 develop *tailored appraisal tools* that consider local/project-specific context to appraise sustainability D2 *prioritize sustainability criteria* through a "prioritization process" to reflect different stakeholder's priorities D3 identify *sustainability indicators* requiring decision-support and match them to corresponding available *sustainability assessment tools*	Dasgupta and Tam 2005, Jensen and Elle 2007, Hunt et al. 2008, Fernandez Solis et al. 2011, Gilmour et al. 2011, Shen et al. 2011, Mori and Christodoulou 2012, and Sharifi and Murayama 2013
E. Value management	E1 perform *value management (VM) workshops* at early project stages to identify, blend, and integrate the client's sustainability objectives into planning and concept design E2 promote *formal stakeholders' participation and interaction during VM workshops* to clarify client's objectives, produce and disseminate sustainability knowledge, and highlight potential problems at the very beginning of the project	Zainul Abidin and Pasquire 2005, Zainul Abidin and Pasquire 2007, Thyssen et al. 2010, Lin et al. 2011, and Shen and Yu 2012

CHAPTER 4

PRE-PROJECT PLANNING PROCESS FOR NEW ECO-CITY

4.1. Introduction

For regular construction projects (buildings, infrastructure, etc.), process models such as the IDEF0 developed by the Construction Industry Institute (CII) are currently available to assist project managers in identifying pre-project planning activities and developing the project's conceptual scope. However, they do not explicitly address sustainability objectives; in addition, they are not devised for new complex mega-development projects in particular. In this regard, the research study proposes a *process guide* or a management framework that describes the steps to be followed while developing the "sustainability agenda" during the Pre-Project Planning (PPP) Phase of new eco-city projects.

While Boyko et al. (2005) derive their proposed "baseline model" for sustainable urban design from relevant processes found in a variety of disciplines and professions (e.g. architecture, business, manufacturing, etc.) [see Chapter 3], this thesis builds on the findings from literature on early management practices promoting sustainability in construction projects in general. In addition, Boyko et al. (2005) process does not explicitly describe how sustainability objectives are considered throughout the proposed stages. Alternatively, the proposed PPP process recognizes specific activities promoting the incorporation of sustainability. The lessons learned from the identified management practices and synthesized in Table 4 (Chapter 3) lead the delineation of the process stages and corresponding activities.

4.2. General Description

The proposed process is an adaptation of the PPP process developed by CII. It focuses on the Concept Scope Phase [the second phase of pre-project planning, alternatively designated as “select alternative” according to IDEF0 model (Gibson et al. 2006)]. As stated earlier in the thesis, this phase is particularly important for the PPP process, whereby 80% of the project outcome can be specified through basic design documents, guiding project success at later life cycle phases (detailed design, construction, and start-up) [Gibson et al. 2006,Thyssen et al. 2010, and Gibson and Bosfield 2012]. Similarly, this Phase is expected to be the most influential for eco-city projects since it encompasses critical activities related to the incorporation of sustainability requirements into the master plan (MP). During this Phase, sustainability technical criteria are identified and MP alternatives appraised and compared to select the one that best meets sustainability requirements.

Thus, the process depicted in Fig. 5 starts at the end of the feasibility/strategy formulation Phase. It is limited to Phase II (Concept Scope) and subdivides it into four successive stages which entail the typical activities for developing and maintaining the sustainability agenda as inferred from literature. Examples of such activities include "prioritizing project-specific sustainability criteria" and using them in "developing a tailored sustainability rating tool to appraise/rate different MP alternatives".
During Stage 1, the project's sustainability strategic objectives are first formulated by the client and sustainability advisor. Stage 2 represents the preparation of the new eco-city "conceptual scope" by different experts in sustainable urban plan development. The outcomes represent the basis for preparing the charrette that would lead to developed sustainability strategic objectives and to a competition brief as part of the Terms of

References (ToR) for the Master Plan competition. Selected Master Planners are then invited to participate in the development of a "sustainability agenda" throughout a separate stage (Stage 3). Finally, Stage 4 completes the Concept Scope Phase with a conceptual master plan competition among the selected master planners who participated in Stage 3. The outcome is a conceptual master plan with sustainable development strategic guidelines ready for further development throughout Phase III (Project Definition) of pre-project planning.

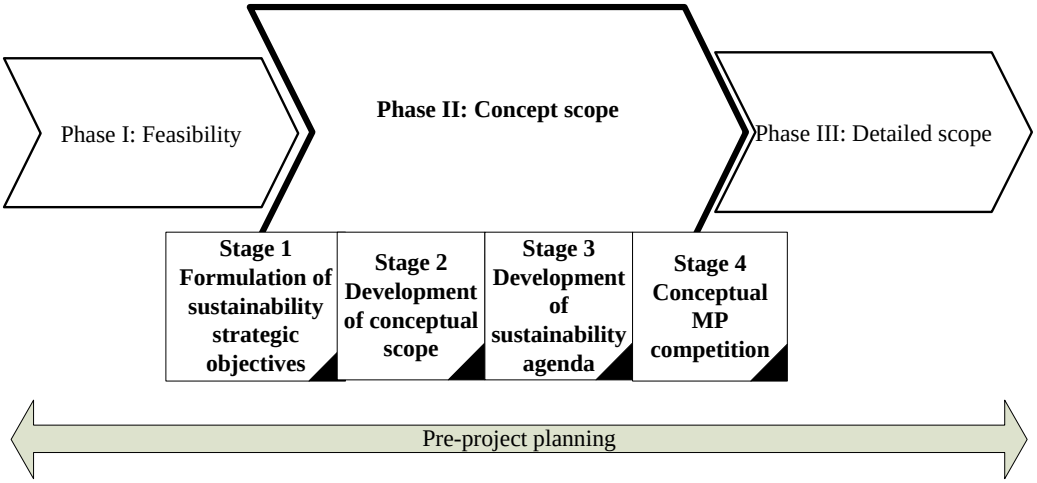

Fig. 5. Proposed four-stage Concept Scope Phase of new eco-city project

Fig. 6 zooms at Phase II (Concept Scope) to illustrate the proposed process throughout this phase, depicting the four stages along with the corresponding input data, activities and outcomes. This process is envisioned to assist practitioners in ensuring the incorporation of sustainability requirements throughout the master plan development of a new mixed-use eco-city project.

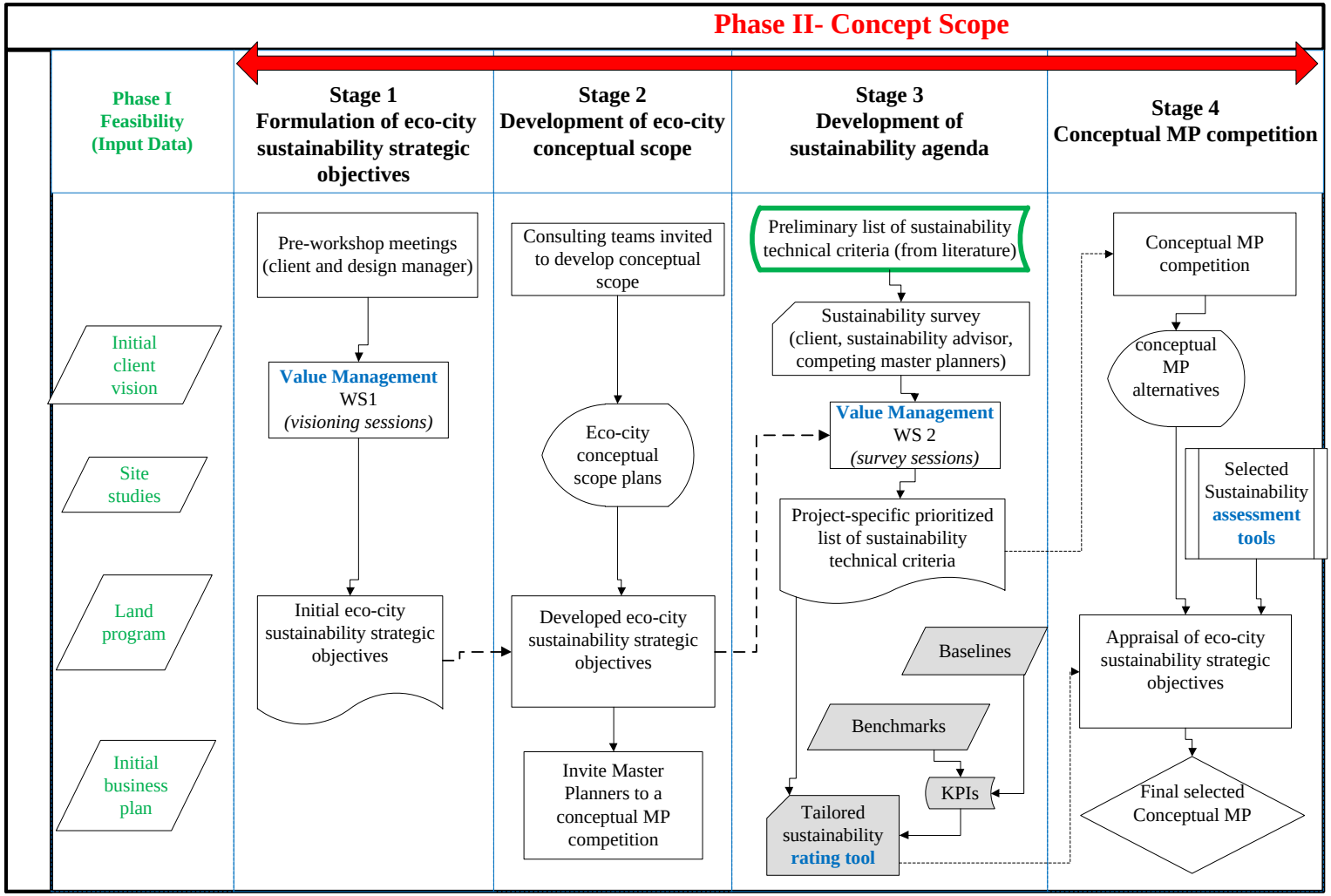

Fig. 6. Proposed pre-project planning process for new eco-city

4.3. The Process Stages

This section describes the four stages of the proposed process, with the corresponding activities. In order to relate the proposed process to literature findings, reference to "lessons learned" from literature (listed in Table 4 of Chapter 3) is indicated for the corresponding practices in each stage.

Stage 1: Formulation of Sustainability Strategic Objectives

- This stage starts with meetings between the assigned design manager and client representatives of the eco-city to elucidate the client's vision towards sustainable development requirements and identify the project context.
- Typical input data to this stage from Phase I (feasibility) include initial client vision, feasibility analysis (economic and technical considerations given the available resources), initial business plan (functional programming and space allocation), and project background information (e.g. site location, land use rules, results of geotechnical and environmental investigation studies, surrounding infrastructure).
- Next, the first value management (VM) workshop (WS1) is initiated, as proposed by Zainul Abidin and Pasquire (2007). Key participants include client representatives and the design manager, in addition to advisors appointed by the client (e.g. experts in sustainable development and urban planning). During WS1, visioning sessions clarify client's needs and solicit ideas on sustainability issues consistent with the project's local context.
- A list of *eco-city sustainability strategic objectives* is then developed. It represents the major part of the project's directives which are formulated before soliciting proposals for developing a first high-level eco-city concept scope in the following

Stage 2. Examples of sustainability strategic objectives include those used in the case of the Chinese Caofeidian eco-city: “to protect the ecology and the environment”, “to integrate land-use and green transportation”, and “to adopt green energy and material conservation” (Qiang 2009).

The activities of this stage are mainly informed by the lessons learned from literature: A1, A2, B1, C1, C2, C4, and E1 in Table 4.

Stage 2: Development of Conceptual Scope

- Experts in sustainable urban development are selected to prepare the initial eco-city "conceptual scope" with reference to the list of *eco-city sustainability strategic objectives* developed in Stage 1. The outcomes represent the basis for preparing the charrette that would lead to developed sustainability strategic objectives and to a competition brief as part of the Terms of References (ToR) for the Master Plan competition. This activity is inferred from the practice adopted in developing the concept MP for the Chinese cities Changxing Beijing and Caofeidian (Yip 2008 and Qiang 2009).
- A jury, formed of client representatives and advisors (experts in sustainability, urban planning, infrastructure engineering, etc.) appraises each conceptual scope plan with reference to the sustainability strategic objectives developed in Stage 1. Other non-sustainability objectives deemed important to the project, such as feasibility of the proposed solution, creativity, and adherence to business plan and land use rules, are also considered in this early appraisal, but are not highlighted in this study which focuses on sustainability objectives.

- A shortlist of highest-score conceptual scope plans is prepared as the basis for the charrette that defines the project's brief and Terms of References (ToR) for a Master Plan competition in next Stages. It includes the developed sustainability strategic objectives.

The activities of this stage are mainly informed by the lessons learned from literature: A2, A4, B1, C4, and E2 in Table 4.

Stage 3: Development of Sustainability Agenda

- This is an important Stage of the Concept Phase whereby group learning and team alignment on sustainability requirements should be reached. During this Stage, the project's *"sustainability agenda"* is developed and maintained by the design manager being responsible for tracking and ensuring the incorporation of the sustainability technical criteria in the eco-city MP.
- A second VM workshop (WS2) is held at the start of this stage. In addition to client representatives, advisors (mainly sustainability advisor) and design manager, the competing master plan development teams participate. The objective is to reach consensus on the eco-city sustainability agenda which translates sustainability strategic objectives to detailed technical criteria. The main activity of VM WS2 is the *sustainability survey* described in detail in a separate later section of this chapter.
- Following WS2, the sustainability survey results are compiled into a project-tailored [as suggested by Mulligan et al. (2011)] *prioritized list of sustainability technical criteria* with the corresponding sustainability strategic objectives. This list is the basis for the revised detailed directives for the Conceptual MP competition during the following Stage 4. In addition, the list is the basis for the eco-city *sustainability*

rating tool prepared during Stage 3 to be used for appraising and comparing concept MP alternatives in Stage 4. This tool is also described in a separate later section of this chapter.

The activities of this stage are mainly informed by the lessons learned from literature: A3, A4, B1, C1, C2, C3, C4, D1, D2, D3, and E2 in Table 4.

Stage 4: Conceptual MP Competition

- The selected master planners are invited to further develop the initial conceptual scope for the eco-city (which was developed in Stage 2 based on the *initial sustainability strategic objectives*) and submit the conceptual MPs of the eco-city (with reference to the *prioritized list of sustainability technical criteria* developed in Stage 3).
- At this stage, the MPs are appraised by the jury for meeting the project's strategic objectives and technical criteria using the devised eco-city *sustainability rating tool*.
- KPIs that need to be measured using sustainability *performance assessment tools* are identified, as suggested by Fernández-Solís et al. (2011) for green buildings, and the corresponding tools are selected. For example, performance assessment tools may make use of simulation techniques to calculate a variety of outcomes of a proposed alternative, such as traffic patterns, energy consumption, greenhouse gas or CO_2 emissions, water consumption or wind patterns. KPIs (with baselines and benchmarks) are described in the last section of this chapter.
- The MP with the highest rating scores is then selected as basis for the detailed concept MP in the next Phase III of PPP, the Detailed Scope.

The activities of this stage are mainly informed by the lessons learned from literature: B1, C3, C4, D1, D2, and D3 in Table 4.

The key participants in the PPP are identified and organized according to the proposed project organizational structure in **Fig. 7** : client representatives, the design manager, external stakeholders that are consulted on legal and policy issues, the assigned design manager who directs the project on behalf of the client, the project advisors (sustainability, urban planning, infrastructure, technology, etc.), business planners, and the competing master plan development teams.

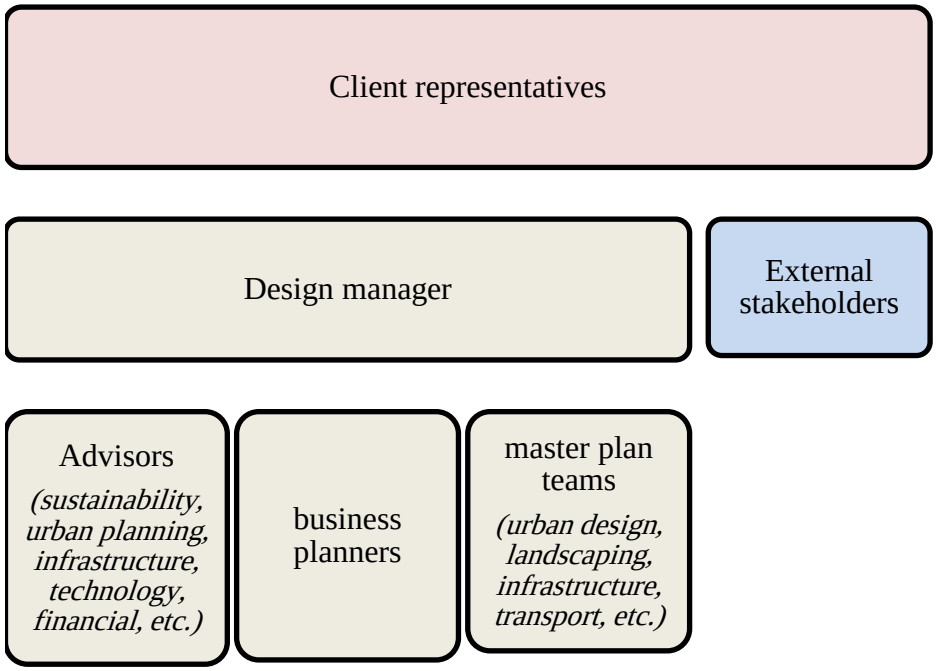

Fig. 7. Proposed new eco-city PPP high-level organizational structure

4.4. Stakeholders' Survey

During VM WS2 in Stage 3, a survey investigates stakeholders' opinions (client representatives, advisors, and the competing master plan development teams) about the importance of each sustainability technical criterion with reference to the project's strategic objectives identified in Stage 1. As such, a questionnaire matrix needs to be prepared by the design manager, in advance, based on two main sources of information:

a) *The project's strategic objectives* developed in Stage 1 through VM WS1. This list represents the eco-city tailored basic sustainability requirements.

b) The *preliminary list of eco-city sustainability technical criteria* developed in Chapter 2 as inferred from literature review Part (a) on eco-cities and the sustainable urban built environment.

Therefore, the questionnaire is represented in a 2-D matrix consisting of:

- *Horizontal rows,* the sustainability themes, with their corresponding itemized technical criteria (Table 2 of Chapter 2). Examples of eco-city technical criteria include: "dense and compact housing structures", "emphasized non-motorized transport", "energy supply for heat and electricity based on local renewable and low-carbon energy sources", "waste recycling and use for production of biogas", "digital/ICT/high-tech smart infrastructure", and "low carbon technologies". If additional technical criteria are suggested by the respondents, they may be added in separate rows and considered if repeated twice or more.
- *Vertical columns,* sustainability strategic objectives as defined in Stage 1.

Survey participants (client, sustainability advisor, and design and planning teams) fill the 2-D matrix and assign a weight to each criterion to reflect its relevance/importance to the overall project. In addition, they need to match it to the corresponding project's sustainability strategic objectives. For example, the sustainability strategic objective "to protect the ecology and the environment" is addressed by the technical criterion "low carbon technologies (LCTs)" and unaddressed through the technical criterion "socially diverse settlement patterns of affordable housing for various income groups". Similarly, the strategic objective "to adopt green energy" is met through the technical criterion "recycled waste used for production of biogas" and unaddressed through "dense and compact housing structures".
Survey responses are next compiled by the design manager in order to calculate the average results and develop the tailored *sustainability rating tool*.

4.5. Sustainability Rating Tool

The *sustainability rating tool* is a project-specific tailored/customized "performance guide" devised during Stage 3 of the proposed PPP process. The sustainability advisor assists the design manager in developing this rating tool based on WS2 stakeholders' survey outcomes. It represents a system of prioritized technical criteria assigned to each sustainability objectives, with a system of key performance indicators, including benchmarks and baseline measures. The sustainability rating tool is used for decision-support while rating the proposed Concept Master Plan alternatives. Design solutions are rated against meeting the project's sustainability strategic objectives by scoring the key performance indicator(s) of the corresponding technical criteria.

A *Key Performance Indicator* (KPI) describes the desired performance of each sustainability technical criterion. In other words, a predicted outcome of a proposed design solution can be considered as a KPI for a certain sustainability technical criterion. For example, “predicted domestic potable water use” can be considered as an indicator for the criterion “the eco-city is equipped with best available technologies for water supply”. Therefore, a sustainability technical criterion is scored by measuring its corresponding KPI(s). Some indicators are qualitatively scored while others are quantitatively scored and call for "assessment tools" to measure certain values such as the "annual energy use", "water consumption", "greenhouse gas emissions", etc. KPIs that need to be measured are identified and the corresponding sustainability assessment tools selected (Ugwu et al. 2006, Yip 2008, and Fernández-Solís et al. 2011). For example, simulation techniques calculate a variety of outcomes of a proposed alternative, such as traffic patterns, energy consumption, greenhouse gas/CO_2 emissions, water consumption or wind patterns.

A *benchmark* assigns a desired level, standard for targets, or ranges of values, for a given KPI such as "105 liters per person per day". For example, in BREEAM rating tool, CO_2 emissions are acceptable for the range of values 160 to 140 kg per m^2 per year (Ding 2008). Benchmarks are selected based on international standards, case studies, and established sources like the U.S. Energy Standard ASHRAE (Hunt et al. 2008, Mulligan et al. 2011, and Scanlon and Davis 2011).

Baseline measures reflect the project’s current or base conditions. They are part of the project’s background information input. They are considered in selecting feasible benchmarks. For example, if the current local CO_2 emissions (the baseline) are much more than 140 kg/m^2 per year (a possible benchmark), it might be unfeasible to

set the target at this low level. Targets need to be reasonably selected to prevent restricting the scope of possible solutions.

The selection and use of KPIs, benchmarks, baseline measures, and sustainability assessment tools for each technical criterion are not addressed in this study.

Fig. 8 illustrates the development of the sustainability rating tool during Stage 3 of the proposed PPP process for a new eco-city project. The project's strategic sustainability objectives represent input from Stage 1; the prioritized criteria are input from the same Stage 3; KPIs, benchmarks, baseline measures and selected sustainability assessment tools are also input during Stage 3. The scored sustainability objectives as met by each Concept Master Plan alternative in addition to the ratings of each Concept MP represent the outcomes of the rating tool obtained during Stage 4.

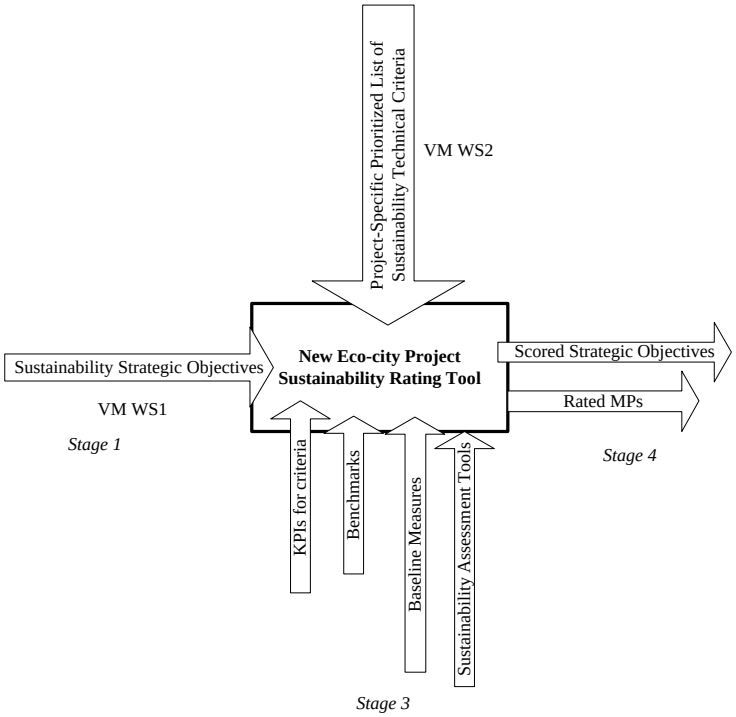

Fig. 8. Development of the sustainability rating tool

CHAPTER 5

CASE STUDY INVESTIGATION

5.1. Introduction

A longitudinal (throughout pre-project planning time window/stages) single case study of a new real-world eco-city project in the Middle East is selected. The purpose is to illustrate the pre-project planning (PPP) process and activities, and infer lessons learned in developing and incorporating the sustainability agenda throughout the master plan development process. The project is envisioned by the client to represent a showcase model of sustainable urban development. Hence, it is assumed to serve as an advocate test-bed for the research outcomes. Due to strict confidentiality purposes, detailed information on this project is not revealed.

The main reviewed documents consist of the following:

- 14 folders, each folder by a Master Planning consulting firm, including final reports for the first Stage 1 competition
- Holistic report prepared by the design manager by the end of stage 1: Master Plan assessment report summarizing the outcomes from the 12 MPs and two visions. The report compares the 14 schemes and provides first input on sustainability strategic objectives as directives for Stage 2.
- Stage 2 toolkit documents prepared by the design manager, which include the eco-city objectives and economic targets, development directives grouped under different themes (i.e. Site Development Strategy; Structure of the Master Plan; Land Use Strategy; Growth Pattern; Landscaping Strategy; Infrastructure Standards and integration systems; Sustainable Transport and Roads)

- Stage 2 launching workshop presentation slides prepared by the design manager, which include description of (1) Design directives, (2) utilities directives, and (3) transport directives to the three retained Master Planners
- Final reports of the three competing MPs by the end of Stage 2
- The sustainability advisor reports (over Stage 2) for the evaluation of Stage 2 MPs prepared by the three consultants (qualitative reports + quantitative scores)
- Stage 2 final workshop presentations by the three MPs and advisors (sustainability and other)
- Final Qualitative Evaluation of each of the three Stage MPs (in Excel and Word formats)
- Request for proposals for each of Stages 1, 2, and 3
- Meeting minutes between client representatives and design manager
- Bi-weekly progress reports prepared by the design manager Company (A) over a three-year period
- Project schedules in MS Project format.

The interviews with two design managers (in November 27 and December 6, 2013, respectively) revolved around three main questions:

- validate the eco-city PPP process prepared based on content analysis and ensure that most key activities related to the development of sustainability agenda are captured and correctly sequenced
- Identify lessons learned from the design manager's experience in directing this project (e.g. suggest avoidable, re-sequenced or merged activities and propose a streamlined process to assist design managers embarking on similar projects)

- Identify the challenges faced by the design manager in ensuring the integration of sustainability in MP at each stage of the project and suggest best practices to address them.

In this chapter, a general description of the planned city is presented first. Based on content analysis of the project soft documents provided by the design management company (A), the project's sustainability aspects are depicted and compared to the list of sustainability technical criteria identified in literature (Chapter 2) to demonstrate that these criteria are addressed in the project, which advocates its selection as a representative case study. Furthermore, the master plan development stages and activities are delineated and presented in a flow chart figure. Finally, based on interview outcomes, the challenges faced by the design manager throughout the master plan development process are identified and presented in the last section of this chapter.

5.2. General Description

The project represents the development of the master plan of a new mixed-use (institutional, research facilities, commercial, recreational, housing, infrastructure systems) eco-city. The client expressed a clear objective of reflecting sustainability principles and their state-of-the-art applications in the development of the site area (around 50 km^2), encompassing utilities and transport infrastructure systems, building clusters, and open spaces. He assigned a design manager (Company A) responsible for processing the project according to the initial vision. A major specific concern is to ensure that the sustainability requirements are incorporated in the eco-city Master Plan (MP). Consequently, sustainability was embedded in most formulated design directives,

from the overarching requirements of resource conservation, renewable energy provision, enhanced quality of life, to specific design elements. The city was planned to be constructed based on a particular "phasing strategy" that identifies the most economically viable (low initial development cost) and versatile area in the site (proximity to the main road, allowing easy access to the city) for the start-up Phase. The development shall then proceed in a "polycentric pattern" for the remaining Phases, with the city evolving around a number of complementary centers.

5.2.1. Sustainability Aspects

In comparison with the various new eco-city initiatives around the globe, as inferred from literature review presented in Chapter 2, this case study may be considered as: a new eco-city project, conceptualized and planned through a 'holistic' sustainability approach that considers the environmental, economic, social and cultural aspects, with special attention to technological innovation, mainly technologies for renewable energy.

With reference to the project's internal documents, sustainability is depicted to represent an integral base of decision-making while developing the eco-city MP. Examples of the project's sustainability strategic objectives include "reducing dependency on energy-intensive transport means and on vehicular mobility", "reducing energy consumption needed for cooling within buildings", "demonstrating sustainable and appropriate carrying capacity of water supply solutions", etc. As such, sustainable design alternatives at different levels (passive design measures, open space landscaping, walkable neighborhoods, sustainable transport systems, etc.) have been proposed by the competing MP teams.

For confidentiality, the project's detailed sustainability agenda/framework completed by the end of the PPP phase is not described. Otherwise, Table 5 below is prepared as a checklist for the eco-city sustainability aspects against the list of eco-city sustainability technical criteria inferred from literature and presented in Table 2 of Chapter 2. As shown in this table, the main sustainability technical criteria are addressed in this project which justifies its generalizability and ensures that it represents a relevant eco-city project.

Table 5. Checklist of Eco-City Sustainability Tehnical Criteria in the Case Study

Technical Theme	Technical Criterion	Case Study
Land use and urban form	*accessible* site location	√
	mixed-use land development	√
	dense, space saving, compact housing structures	√
	energy-efficient settlement patterns through optimized building placement (orientation, solar shading reducing surface and air temperatures, source of fresh air 'freely' cooling building through natural rather than mechanical ventilation, etc.)	√
	resilient ,robust , varied physical structure and urban design (especially public spaces), considering a variety of people at various times for varied reasons through flexibility of four parameters: quantity, quality, location and time	√
	legible, rich, personalized physical structure and urban design (especially public spaces), visually appropriate through attractive landscaping and clearly identified through street function, landmarks, etc.	√
	provision of energy efficient buildings (sustainable building materials, indoor air quality, reduced heat and electricity demand, efficient heat and electricity supply through efficient electric appliances, resource sharing between buildings, etc.)	√
	integrated green areas and urban agriculture	√
Mobility and transport infrastructure	*reduced use of car/motorcycle* through de-emphasized freeway and road infrastructure, restricted parking, and emphasized non-motorized transport infrastructure, *e.g.* walking /pedestrian network (settlements structures that promote short distances, etc.), cycling (supportive street infrastructure, bikeways), etc.	√
	provision of public transport grid (light rail systems, Bus Rapid Transit/BRT, personal rapid transit/PRT, etc.)	√
	reduced energy demand for transport through low carbon technologies (electric transport system e.g. eco-friendly buses, fully electric/plug-in hybrid cars, etc.)	√
	transport inter-modal connectivity	√
Energy consumption and energy-supply infrastructure	*energy savings/reduced consumption* (demand for heat, cold and electricity) through technical measures: e.g. high level of insulation, intelligent lighting, innovative heat storage, smart electricity grid, combined heat and power/CHP, energy harvesting, micro power generation, enhanced resource sharing between buildings	√
	local renewable and/or low-carbon energy sources for energy supply (demand for heat, cold and electricity), integrated with urban design, e.g. biomass, geothermal, photovoltaic electricity generation, wind power, concentrated solar power, etc.	√
Water, wastewater and waste	*provision of sufficient potable water*	√
	water savings/reduced consumption (e.g. local harvesting, storage techniques, etc.)	√
	local wastewater recycling for reuse (e.g. in gardening/green spaces, car washing, etc.)	√
	local waste recycling for reuse (e.g. waste to energy/production of biogas, etc.)	√
Technology	*provision of Information and Communication Technology (ICT)* through high-tech smart infrastructure for management and operations of complex systems and services (e.g. internet, mobility patterns, electric grid, etc.)	√
	provision of low carbon technologies (LCT) for the corresponding infrastructure fields of building design, electricity, transport, energy supply, energy production, water management, waste management, sewage treatment, etc.	√

5.2.2. Stages and Activities

With reference to the project's internal document analysis and interviews with design managers, the PPP stages and activities are identified. The Master Plan development has been undertaken through three successive stages over about three years. Different alternatives of visionary and conceptual plans have been proposed and thoroughly analyzed for meeting the various project directives. At Stage 1, 14 international and local firms/entities contributed to identifying the directions for city development with innovative ideas for meeting sustainability objectives. At Stage 2, three MP consultants were retained to submit a concept design for the eco-city. One MP consultant was selected to submit a developed concept design at Stage 3.

A design management organization (company A) was assigned by the client to direct the master plan competition. The design manager with a sustainability advisor thoroughly analyzed and assessed each alternative to ensure optimal integration of sustainability requirements in the master plan. The lead design manager relied on his experience in following a PPP process; he did not adopt a formal process such as IDEF0 model.

The project's PPP stages and activities are described in the following sections and illustrated in Fig. 9 flow chart below. Typical PPP activities (site investigation, feasibility analysis, functional programming, developing alternatives, schematic design, project definition, etc.) are encompassed within the three stages of the eco-city project, namely, "Stage 1: Master Plan Ideas Competition", "Stage 2: Concept Master Plan- Three Alternatives Competition", and "Stage 3: Advanced Master Plan Concept- One Alternative".

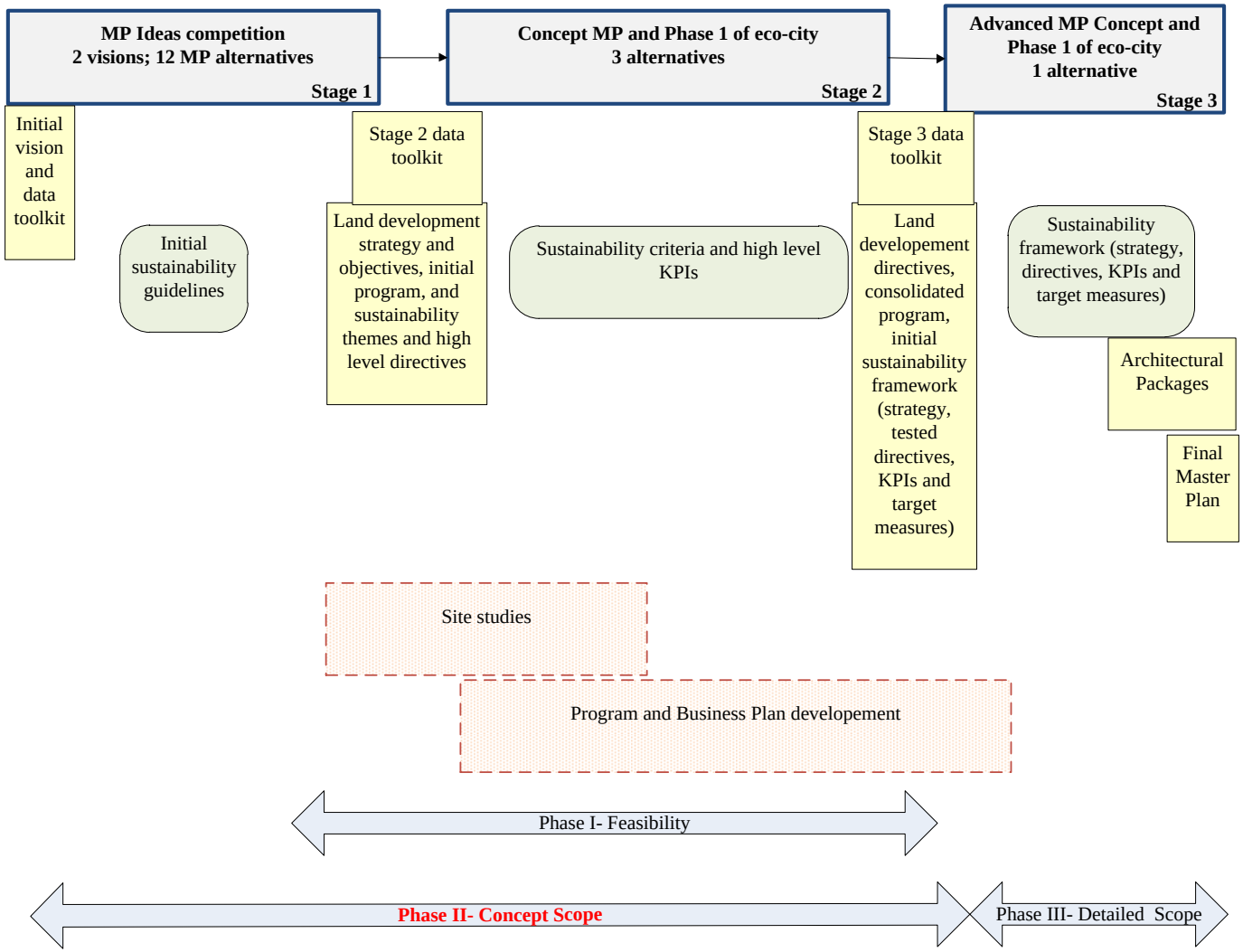

Fig. 9. Case study stages and main activities flow chart

Stage 1 "Ideas Competition"

- The initial eco-city vision statement was developed by the client and design manager who prepared the initial project data toolkit (initial objectives, site satellite images, etc.) to guide the master plan development exercise.
- Urban planning as well as infrastructure and sustainability advisors were appointed.
- 14 international MP teams (12 Master Planners and two visionary teams) with sustainability experience were invited to propose innovative ideas for the first competition.
- Next, the infrastructure and sustainability advisor prepared the initial sustainable infrastructure guidelines.
- The design manager and advisors reviewed the interim and final submittals by the MPs and discussed every scheme through a series of webinars and workshops.
- By the end of Stage 1, 12 conceptual MPs and 2 visions were developed and evaluated with reference to the project's initial vision and initial toolkit.
- The main outcome of the evaluation process was the synthesis of the eco-city strategic objectives, the preliminary land program (residential, edutainment, commercial, etc.), and the sustainability themes (energy, water, transport, etc.) along with corresponding sub-categories and high level directives.
- Each sustainability theme was evaluated across the 12 MPs to identify areas of strength and weakness, highlight innovative ideas, and derive lessons learned.
- Site survey studies (topographic, geotechnical, socio economic, environmental) were initiated by the end of Stage 1.
- Stage 2 data toolkit was prepared to comprise detailed directives and major collected data.

Stage 2 "Concept Master Plan and Phase 1 of development - Three Alternatives Competition"

- Stage 2 was the stage that transformed the study in Stage 1 from a vision to a concept master plan of the city.
- Three retained MP teams from Stage 1 were invited to develop their initial concepts with reference to Stage 2 data toolkit and detailed directives.
- A new infrastructure and sustainability advisor was appointed.
- In addition, two business planning (BP) consultants were assigned to develop the land program and business plan.
- The design manager and advisors reviewed the interim and final submittals by MPs through webinars and workshops. Meanwhile, an overall evaluation matrix was prepared by the design manager (main issues as compiled from advisors).
- In particular, the infrastructure and sustainability advisor prepared an initial sustainability framework which encompasses sustainability strategy and directives, as well as high level key performance indicators (KPI)s with their target measures.
- The evaluation process culminated in the development of the detailed design directives tested through a high level sketch layout by the design manager and infrastructure/sustainability advisor.
- In addition, the land program was consolidated and Stage 3 data toolkit prepared to include all outcomes (program, design directives, site studies, etc.).

Stage 3 "Advanced Master Plan Concept and Phase I of development- One Alternative"

- One MP consultant was retained to develop the Advanced Master Plan and Phase 1 architectural packages.

- The sustainability framework was further developed with more focus on smart and sustainable infrastructure including transport, energy, water, and waste management.
- The design manager and advisors reviewed the interim and final submittals by the MP consultant through webinars and workshops.
- The MP consultant submitted the final MP concept and Phase 1 urban planning and design guidelines.

5.3. Design Management Challenges

The interviews with the design managers (an urban planner and an engineer) focused on identifying the main design management activities and corresponding challenges while developing and maintaining the sustainability agenda throughout the PPP process. The aim is to infer best practices and identify lessons learned to assist managers of similar projects. What follows is a synthesis of the eco-city project's challenges identified through interviews with the two design managers.

1) Two-dimensional complexity

   - *City-scale multi-disciplinary land development project*: urban planning track was initially ahead of the infrastructure track with minor interaction at early stages. In addition, the business planning outcomes (land program/facilities, population, etc.) were not initially available to validate the MP proposed solutions.
   - *Dynamics of sustainability technologies*: non-traditional sustainable design solutions are challenged by the rapid evolution of state-of-the-art sustainability technologies. Moreover, some sustainable solutions call for the formation of

new governmental entities for the proposed sustainable utilities (e.g. new division for renewable energy under the ministry of energy and water).

2) Project uncertainties

- *Incomplete data at early stages*: the client initiated the project with a technically-driven master plan competition, exploring design alternatives as an investigation and research exercise to identify the project's value proposition. Consequently, land program, projected population, legal and financial parameters were unknown [e.g. Feed In Tariff (FIT) to lock in the private power producers etc.]. This resulted in pushing the design further within Stage 2, waiting for the business plan outcomes. In addition, exact and complete site data was not initially available. Stage 1 MP exercise depended on satellite images showing high-level topography. Site investigation studies (topography, geotechnical, environmental, etc.) have not revealed site potentials and carrying capacity until mid-Stage 2.
- *Market dynamics*: due to the dynamic aspect of real estate market trends in the Middle East, it was difficult to detect a pattern and refer to relatively unstable operations. The new eco-city development was challenged by unpredictable market needs (mainly real estate and technology). As such, the project was not initiated with a business plan resulting in proposed land program as input to the master plan track. On the other hand, a sustainable land development project will have its own dynamics that would impact the market itself. No final decisive solution can be reached as far as it is unforeseen how the market will react to these innovations until they are tested first.

3) Compromising conflicting values among stakeholders

- The design managers practiced *value management* through intensive meetings with client representatives. However, they faced conflicts compromising the project's values among stakeholders. For example, one of the design directives stipulated by the client-"state-of-the-art public transportation system"-was deemed financially infeasible by the business planner.
- The main project's tracks (master plan, infrastructure systems and sustainability, and business plan) had *different priorities*. For example, the proposed business plan model, emanating from past unsustainable social behaviors, was not conforming to the master plan sustainability objectives pushing towards innovative solutions.

4) Developing the sustainability agenda

- *No available sustainable infrastructure rating system*: the design team referred to available standards provided by current rating systems to identify KPIs for buildings (e.g. LEED, ISTIDAMA, and BREEAM) and roads (Greenroads U.S.). However, these are not available for sustainable utility and infrastructure systems.
- *Assessing sustainability in proposed solutions*: a design solution needs to be validated and tested against meeting the target measures and its impact on other KPIs. For integrated infrastructure systems, there was a need to study the correlation between a proposed solution for one utility system and another. For example, proposing electric vehicles as a sustainable transport alternative results

in less gasoline consumption and CO_2 emissions but more electricity consumption (transport-energy correlation).

5) Reality Checks

- Some *existing regulations and plans* were not identified, acquired or considered until Stage 2. As such, some resolved solutions turned out to be infeasible and constrained by existing laws, practices, or prices. For example, initially proposing a smart electricity grid, with a back-up plan of connecting to the existing grid, was later deemed financially unjustified for a new operator as long as the competitive prices of subsidized electricity offered through the existing grid were in effect.
- Some *solutions were not initially checked* for their impact on surrounding infrastructure systems. They were later deemed infeasible, which resulted in wasted time and effort. For example, the proposed solutions for water harvesting through a water-shed management plan for rainfall runoff and floods (subsurface dams, also increasing infiltration and potable water provision by recharging the aquifer) might negatively affect water quality and quantity in surrounding areas.

These challenges are assumed to apply to similar projects. Therefore, best management practices are recommended to address these challenges.

5.4. Analysis and Recommendations

In this section, the pre-project planning (PPP) process depicted for the newly planned eco-city case study is analyzed and compared to the proposed PPP process in Chapter 4 as informed by the early management practices of sustainable construction

projects. This analysis paves the way for refining the proposed process and recommending "lessons learned" that comply with literature review findings and address the design management challenges identified through the case study investigation, as presented in the following sections.

5.4.1. Comparing the PPP Processes

As adopted by Boyko et al. (2010) in comparing the "to be" (proposed based on literature) with the "as is" (completed by the case study project) processes, the proposed PPP process presented in Chapter 4 is compared to the case study PPP process presented in section 5.2. By comparing the PPP stages and activities of the case study with the proposed process, the following remarks are noted:

- For the case study project, *site information pertaining to sustainability issues* (e.g. wind patterns, rainfall precipitation, etc.) was not initially captured. Only satellite images were provided as input to the first Stage 1 of MP competition. Alternatively, in the proposed process, site investigation studies are supposed to represent key input data to the first Stage 1 of the Concept Scope Phase II, which is supposed to allow the project's stakeholders develop the project-specific sustainability strategic objectives as key directives to initiate the MP competition.
- For the case study project, *functional programming and space planning* were not available at the start of the first MP competition. In fact, the land program was not consolidated till the end of Stage 2 (i.e. start of the Detailed Scope Phase III of PPP). According to one of the interviewees (the lead urban planning design manager), the client was not committed to early business plans; he preferred to explore design alternatives through a MP competition without being restricted to

business plan outcomes. Furthermore, the multi-dimensional complexity - as a result of both sustainability and large-scale nature of the project - made it inefficient to start with a business plan and impose it on the eco-city MP. The interviewee revealed that:

"the business plan and master plan tracks needed to start in parallel with consistent and close coordination to test the feasibility of the proposed solutions against meeting sustainability objectives".

Alternatively, in the proposed process, land program is supposed to be developed during Phase I of PPP to serve as input to the first Stage 1 of the Concept Scope Phase II.

- For the case study project, the *visioning WS sessions* were not performed in a separate stage, as is the case for the proposed PPP process. Instead, they were part of the first MP competition whereby two visioning teams developed two possible visions for the eco-city. Consequently, the project's sustainability strategic objectives were not part of the initial directives; instead, they have been developed as outcomes of the first MP competition. The client had the objective of starting with a first MP competition to solicit innovative ideas and seek various alternatives that feed into Stage 2 without being restricted by imposed directives.
- For the case study project, there was *no clear separate stage for sustainability agenda development.* Otherwise, the three competing master plan teams, with the sustainability advisor, developed the sustainability agenda while developing the eco-city MP throughout Stage 2 of the process (which corresponds to Stage 4 only of the proposed process). Furthermore, the eco-city sustainability framework has not been set until Stage 3 (which corresponds to Detailed Scope Phase III of PPP). Alternatively, the proposed PPP process suggests that a separate stage (Stage 3) be

allocated for the development of the sustainability agenda before launching the MP competition; outcomes from Stage 3 serve as basis for the evaluation and comparison of the proposed solutions and selection of MP for Phase III (project definition).

- For the case study project, *the sustainability themes* (transport, energy, water, etc.) were identified as part of Stage 1 outcomes. Alternatively, in the proposed process, these are supposed to be part of the "list of sustainability technical criteria" inferred from literature and used as input to the VM workshop in a separate Stage 3 "development of the sustainability agenda".
- For both the case study and the proposed process, *the role of the sustainability advisor* is essential in developing the sustainability framework and rating tool. However, the proposed process suggests more stakeholders' participation and involvement (including the competing MP teams) in developing and mainly prioritizing the sustainability criteria through value management workshops, which is supposed to align participants and reduce trade-offs and tensions.
- For both the case study and the proposed process, a *design manager is assigned* to direct the eco-city master plan development.

Table 6 compares the stages of the proposed PPP process with those of the eco-city case study PPP process. The baseline for this comparison is the three-phase PPP process proposed by CII, including the "Feasibility Phase I", "Concept Scope Phase II", and "Detailed Scope Phase III".

Table 6. Comparison of the Case Study with the Proposed Pre-Project Planning Process

CII Phases	Case study process	Proposed pre-project planning process
Feasibility Phase I	Feasibility is not a separate Stage but part of the Concept Scope Phase II *(still no site studies, no business plan, no land program)*	Feasibility is a separate Phase outputs from this initial phase (initial project's vision, feasibility analysis, local background information, site investigation studies, initial business plan and land program) constitute substantial input to Phase II
Concept Scope Phase II	main phase, start of PPP, encompasses two stages:	main phase for sustainability incorporation in MP, subdivided into four stages:
	Stage 1, two visioning teams and 12 MP teams competing in parallel, lead to definition of the eco-city vision, and sustainability themes and key directives	Stage 1, visioning sessions lead to development of initial sustainability strategic objectives Stage 2, development of eco-city concept scope to prepare the brief and invite master planners for a concept MP competition Stage 3, "sustainability agenda" developed; prioritized sustainability criteria and tailored rating tool, with the participation of the MPs through value management workshops
	Stage 2, second MP competition among three competing master plan teams developing the MP alternatives + business plan + site studies	Stage 4, MP competition to retain 1 successful team
Detailed Scope Phase III	Stage 3, sustainability framework more developed, architectural packages prepared for the design Phase	Detailed Scope is a separate Phase whereby one final Conceptual MP selected to be the basis for the development of "project definition package" for the design Phase

This comparison informs the refinement of the PPP process proposed in Chapter 4. By merging the Feasibility Phase with the Concept Scope Phase (see revised PPP process in Fig. 10), some activities, namely, "site investigation studies" and "functional programming/space planning", would be completed before or parallel to the development of the new eco-city conceptual scope. More precisely, "site investigation studies" are best performed before initiating the conceptual scope development (Stage 2) while "functional programming/space planning" goes simultaneously with Stage 2 synchronized with the conceptual scope development, prior to moving to Stage 3. This refinement is supposed to promote more interaction between the business plan and master plan development, hence, achieving better alignment on the sustainability agenda. In fact, undertaking the Feasibility Phase parallel to the Concept Scope Phase was one of the lessons learned throughout the design management of the new-eco city case study, as suggested by one of the interviewees (the urban planner). This outcome contradicts with Gibson and Bosfield (2012) who stress the importance of the sequential order of the PPP phases (feasibility, concept and detailed scope), assuming that "each phase provides needed information and risk mitigation before the next". This research study suggests that, for a city-scale sustainable urban land development project, direct parallel interaction is needed between business planners and master planners at early phases of the project.

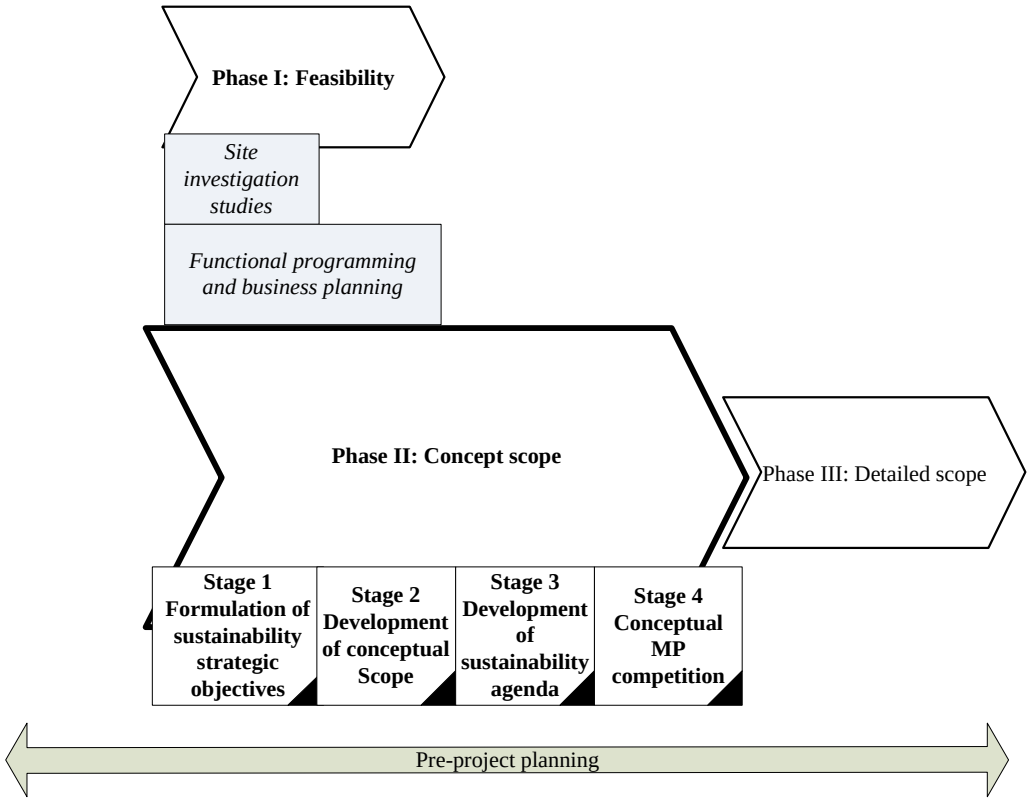

Fig. 10. The revised pre-project planning process for a new eco-city project

What follows is a list of main lessons learned and recommended as best management practices to assist the design manager while developing and incorporating the sustainability agenda in the MP of a new eco-city project.

5.4.2. Recommending Best Management Practices

To overcome or alleviate the challenges identified through the case study investigation (section 5.3), the following list of ten "lessons learned" (Table 7) is recommended as best management practices for the design management of a new eco-city project. This list is developed based on a cross-match and agglomeration of PPP activities and practices of literature (Chapter 3 mainly) and case study.

Table 7. Main Management Practices during Eco-City Pre-Project Planning

Lessons learned	Description	Challenges addressed [i]	literature findings [ii]
1. Follow a formal three-phase pre-project planning process	• Start with Phase I (Feasibility Phase) parallel to the first two stages of Phase II (Concept Scope Phase). • Phase II is subdivided into four Stages: ○ During Stage 1, the project's sustainability strategic objectives are first formulated. ○ Stage 2 represents the development of the eco-city conceptual scope to refine the sustainability strategic directives which will be part of the Terms of References for the concept Master Plan competition. ○ Selected master planners are invited to participate in the development of a "sustainability agenda" throughout a separate Stage 3. ○ Finally, Stage 4 completes the Concept Scope Phase with a concept master plan competition among the selected master planners. • Complete "site investigation studies" and "functional programming/space planning" (from Phase I) in parallel with Stages 1 and 2 of Phase II, to serve as input to Stage 3 of Phase II. • The outcome from Stage 4 of Phase II is a conceptual master plan ready for further development throughout Phase III (Project Definition) of pre-project planning.	(1) the project's complexity (large-scale), (2) project uncertainties (incomplete data at early stages and market dynamics), (3) compromising values among stakeholders, (4) developing the sustainability agenda, and (5) ensuring reality check	A1, A2, A4

2.	Appoint a "sustainability advisor" as of Phase I of PPP process	Appoint a "sustainability advisor" with experience in regional projects and define his scope of work: • Developing sustainability directives and suggesting acceptable and reachable KPI targets • Assessing master plan proposals, reviewing submittals • Developing a tailored sustainability decision-support modeling and simulation rating tool • Qualitatively appraising sustainability approach • Quantitatively validating and comparing design outcomes with respect to meeting sustainability KPI targets and their implications on other parameters; for example, effect of electric cars as an alternative sustainable transport means on electricity demand, etc.	(1) the project's complexity (sustainability), (4) developing the sustainability agenda, and (5) ensuring reality check (initially check impact of proposed sustainable solutions on the surrounding)	C4
3.	Appoint a "risk manager" [iii] of large-scale projects as of Phase I of PPP process	Appoint a "risk manager" with experience in complex projects and define his scope of work: • Initially laying down the foreseen project risks • Planning for risk mitigation early on throughout the design management process, etc.	(1) the project's complexity (large-scale), (2) project uncertainties (market dynamics), and (5) ensuring reality check	C1

4.	Synchronize between the business plan and master plan tracks since Phase I of PPP process	Foster early synchronization between the business planning and master plan development tracks: • Initiate the pre-project planning phase with parallel business planning and master plan development tracks • Test and tune key performance indicators (water, energy, public transportation, etc.) from a business perspective by justifying the proposed solutions for financial feasibility through business case studies.	(1) the project's two-dimensional complexity (large-scale and sustainability), (2) project uncertainties (incomplete data at early stages and market dynamics), and (3) compromising values among stakeholders	A1, A3, C2, C3
5.	Undertake the required sustainability-related site investigation studies during Phase I of PPP process	hydrological (rainfall, runoff), meteorological (solar radiation, wind pattern and intensity), topographical, geological, socio-economic, etc.	(1) the project's complexity (sustainability) and (2) project uncertainties (incomplete data at early stages)	A1
6.	Maintain an integrated management structure throughout the PPP process	• Continuously coordinate and horizontally integrate internal stakeholders (client representatives, multi-disciplinary design teams, business planner, etc.) to compromise the foreseen conflicting objectives among different entities. • Continuously coordinate with client representatives to induce quick feedback on sustainability issues and proposed solutions from client upper management and early identify and consult official entities to address existing laws, regulations, urban plans (e.g. set-back rules, floor number) and avoid ad-hoc starting and repetitive efforts.	(1) the project's two-dimensional complexity (large-scale and sustainability), (3) compromising values among stakeholders, and (5) ensuring reality checks	B1, C1, C2, C3

7.	Facilitate value management throughout the PPP process	• Involve stakeholders (client representatives, advisors, MP consultants, business planner, etc.) in value management workshops • Infer, refine and consolidate the prioritized values and sustainability objectives throughout the master plan development process.	1) the project's two-dimensional complexity (large-scale and sustainability), (3) compromising values among stakeholders, and (4) developing the sustainability agenda	C2, C3, E1, E2
8.	Develop and maintain the sustainability agenda throughout the PPP process	Develop and maintain the sustainability agenda through "a vertical spiraling approach, narrowing down the circle as you move forward": • Initially review international state-of-the art sustainability practices and similar sustainable land development projects • Coordinate with the sustainability advisor on identifying, developing, and refining the project's sustainability goals, themes, categories, guiding principles/directives, KPIs and target measures, throughout the master plan development process • Prepare and continuously update the sustainability-related issues in the project brief toolkit and test-fit the sustainability directives (criteria, key performance indicators and target measures) on a high-level sketch design • Coordinate with the sustainability advisor on developing a "sustainability criteria evaluation matrix", and a corresponding clear scoring system • Analyze and compare the generated alternatives and recommend best solutions	(1) the project's two-dimensional complexity (large-scale and sustainability), (2) project uncertainties, (3) compromising values among stakeholders, (4) developing the sustainability agenda, and (5) ensuring reality check	A4, B1, C4

	• Track the business plan sustainability-related outcomes (land program, financially feasible sustainable design solutions, business case for some proposed sustainable technologies, etc.)		
9. Phase the project's path to sustainability [iii]	Monitor the incremental project's development to meet sustainability. For example, endorse clusters of sustainable neighborhoods as land agglomerations, and sustainable infrastructure systems accommodating future growth and needs; ensure that MPs propose KPIs achieving target measures with optimal phasing over the project's development phases (e.g. start-up, 25 years, etc.)	(1) the project's two-dimensional complexity (large-scale and sustainability), (2) project uncertainties, (3) compromising values among stakeholders, (4) developing the sustainability agenda, and (5) ensuring reality check	A4
10. Embed "flexibility" in design directives [iii]	• Ensure that the master plan is not developed as an end result but as a tool/system enabling future resolutions as parameters change. • Promote a "parametric design" strategy, injecting land program and sustainable design alternatives. This strategy achieves a flexible design process unrestricting urban planning from fixed options when accurate input parameters are not available.	(1) the project's two-dimensional complexity (large-scale and sustainability) and (2) project uncertainties	[iii]

[i] Eco-city case study PPP challenges identified through the interview with the design managers and listed in Chapter 5

[ii] Early management practices inferred from literature on sustainable construction projects and listed in Table 4 of Chapter 3

[iii] This practice was recommended by one of the case study interviewees (lead urban plan design manager)

CHAPTER 6

CONCLUSIONS

6.1. Summary of Research Findings

Practitioners in the urban planning and construction industry are challenged by the crucial need for considering sustainability while developing new urban land areas. In particular, during the pre-project planning (PPP) phase of a new eco-city construction project, the design management practitioner is interested in developing the project's sustainability agenda and ensuring its successful incorporation in the eco-city master plan (MP). To assist the design manager, this thesis proposes management tools and recommends management practices.

The core of the research study pivoted around findings of three tracks:

I- A critical review of literature on urban sustainability and eco-cities,

II- A critical review of literature on the management practices adopted while considering sustainability in construction projects, and

III- A case study investigation of a newly planned eco-city project.

Through the first round of literature review, the term eco-city was defined; its evolution and initiatives were described, with some examples presented. Different types of sustainable urban areas were examined (existing and new cities, neighborhoods, etc.) and their sustainability characteristics investigated. As a result, two interest groups of sustainable urban areas were classified as (i) theorists (focusing on sustainability concepts under the triple bottom line of environmental, economic, and social dimensions) and (ii) practitioners (addressing technical design aspects of the physical built environment).

The literature review resulted in inferring a list of main sustainability technical criteria. This generic list represents a *performance tool* which is supposed to guide the practitioner while embarking on a new eco-city project. It identifies five sustainability technical themes for a new eco-city with corresponding criteria:

1) *Land Use and Urban Form* (criteria: mixed-use, compact, energy-efficient settlement patterns, accessible, resilient , personalized physical structure and urban design, energy efficient buildings, integrated green areas and urban agriculture).
2) *Mobility and Transport Infrastructure* (criteria: reduced use of car/motorcycle, provision of public transport grid, reduced energy demand for transport, transport inter-modal connectivity).
3) *Energy Demand and Energy-Supply Infrastructure* (criteria: energy savings/reduced consumption, local renewable and/or low-carbon energy sources).
4) *Water, Wastewater and Waste* (criteria: sufficient potable water, water savings/reduced consumption, local wastewater recycling, local waste recycling).
5) *Technology* (criteria: Information and Communication Technology/ICT, low carbon technologies/LCT).

In order to respect localities and project's uniqueness, this generic list needs to be tailored to any new eco-city project's context. Hence, a project-specific and prioritized "sustainability agenda" needs to be developed. In this regard, a *process tool* of PPP stages and activities guides the practitioner in developing the sustainability

agenda, prioritizing its requirements, and ensuring its incorporation in the new eco-city MP.

As such, a second round of literature review on early management practices of sustainable construction projects (e.g. infrastructure systems, green buildings, neighborhood, etc.) was performed to identify the PPP stages and activities. Five main practices were identified, revolving around three settings:

- *timing*: (A) the pre-project planning process of a construction project,
- *participants*: (B) the essential role of the design manager and (C) stakeholders' involvement (client, urban planner, transport planner, utility engineer, landscape architect, etc., and mainly the sustainability advisor), and
- *activities*: (D) the use of decision-support tools and (E) value management activities.

To embed the identified practices within a process tool for the development of a new eco-city, a four-stage pre-project planning process was developed.

To illustrate and refine the proposed process, a case study of a newly planned eco-city construction project in the Middle East was investigated. The project's PPP stages were tracked, major activities and challenges faced by the design manager identified.

Next, the case study PPP process was compared to the proposed process to validate its applicability. The case study investigation outcomes complied with the identified practices in literature.

Finally, a list of ten lessons learned is inferred as part of the recommended management practices for ensuring the incorporation of sustainability in the MP of new eco-city projects.

6.2. Research Contributions

This research study has achieved theoretical contributions in the fields of engineering management and urban planning.

While several existing rating tools (LEED, BREEAM, etc.) identify the standards for sustainable buildings and neighborhoods, this research study has built on a literature review synthesis to propose a list of sustainability technical criteria for new eco-city. The list represents a scientifically-proven basis; it serves as a generic "benchmark" while developing the projects tailored sustainability agenda. Using this list is expected to save the design manager's time spent in identifying the initial typical sustainability requirements of an eco-city, at the very early PPP stages. Ultimately, if further developed and validated through thorough literature review, this list can assist decision-makers in achieving consensus while comparing initiatives of sustainable cities over time and place. It may be considered as a first step towards devising a holistic "blueprint for an eco-city sustainability rating tool/certification scheme" to guide future eco-city development and facilitate replicability.

On another front, while several process tools (IDEF0, RIBA plan of work, etc.) identify the PPP stages and activities for construction projects irrespective of sustainability considerations, this research study builds on a literature review synthesis to develop a Pre-Project Planning process that focuses on developing the sustainability agenda for new eco-city projects. It is expected to assist the design manager in ensuring the incorporation of the project's sustainability requirements in the eco-city MP.

Finally, while several authors address separate management practices for sustainable construction projects in general [e.g. Weerasinghe et al. (2007): use of PDRI tool during PPP of green buildings; Rekola et al. (2012): role of the design manager in

sustainable building projects; Scanlon and Davis (2011): role of sustainability advisor in infrastructure projects; Fernández-Solís et al. (2011): use of assessment tools for LEED credits in green building projects; and Zainul Abidin and Pasquire (2007): value management workshops in sustainable building projects], this research study builds on a literature review synthesis and the findings from a valid case study investigation to recommend main early management practices for new eco-city projects. The recommended practices assist the design manager in overcoming the expected challenges while directing the project at early phases.

In a nutshell, the proposed list of criteria, pre-project planning process, and recommended list of management practices are supposed to add a useful contribution to the body of literature on eco-cities on one hand, and on design management and pre-project planning practices on the other hand. The proposed activities (e.g. survey sessions during value management workshops, development of a prioritized sustainability rating tool, etc.) enhance stakeholders' alignment on sustainability issues, and thus minimize the risk of misunderstanding among multidisciplinary teams. This results in accelerating the decision making process while rating the proposed solutions, enhancing objectivity and transparency, facilitating the integration of client requirements/values in the MP at the appropriate time, thus avoiding later costly modifications.

6.3. Research Limitations

Although the research study was based on reliable and varied academic literature review, valid and relevant case study investigation, yet it encompasses several assumptions and limitations.

First, the proposed list of "main technical criteria" does not represent all sustainability requirements for a new eco-city project; only physical aspects deemed essential for a construction project are considered. Social and economic aspects are not explicitly addressed. In addition, the listed concepts and criteria are not derived based on a statistical selection strategy, as proposed by Tanguay et al. (2010). Some criteria (e.g. accessible site location, provision of sufficient potable water) are included in the list though they are indicated only twice in the reviewed articles, while others (e.g. compactness, local renewable and/or low-carbon energy sources) are indicated in more than six references.

Moreover, the literature reviewed on early management practices of sustainable construction projects revolves around only five main practices (pre-project planning process, role of the design manager, stakeholders' involvement, use of decision-support tools, and value management). Other practices such as knowledge management among stakeholders, risk management, interface management, etc., are not considered.

Another major limitation is relying on a single case study to illustrate the PPP of a new eco-city, identify the design management challenges, and infer lessons learned. Though the case study is advocated by its sustainability aspects - complying with the sustainability criteria inferred from literature- the PPP process and challenges might be project-specific (local economy, local business culture, etc.). For example, the client was interested in seeking innovative MP ideas before imposing a land program for the eco-city. Consequently, the PPP started with the "master plan idea competition" before the functional programming; this may not be the case for eco-cities in a different region. Another example is one of the challenges recognized by the design manager as "market

dynamics" which is critical in the Middle East region while it could be of less importance in other areas such as Europe or the U.S.

In addition, the number of interviews is limited to two, both with design managers, highlighting challenges and inferring lessons learned from one perspective. Other project stakeholders (e.g. client, master planners, sustainability advisor, etc.) are not interviewed, which excludes other points of views on incorporating sustainability in the eco-city MP.

6.4. Recommendations for Future Research

Further research work on eco-city characteristics can be undertaken to refine and complete the proposed list of technical criteria:

- More case studies of international eco-cities (planned and existing) may be statistically investigated to measure the recurrence of sustainability criteria among different initiatives and refine the proposed list accordingly.
- Key performance indicator(s) may be suggested for each technical criterion to complement the proposed list of sustainability technical criteria.

On the other hand, future research work may be performed to enhance the proposed PPP process:

- An adapted PDRI tool for eco-cities can be developed to assist practitioners in checking the completeness of the PPP Phase, similar to the currently available version for green buildings. In this regard, the eco-city sustainability criteria can be matched to the corresponding PDRI elements to specify when each requirement needs to be considered. For example, the criterion "*transport intermodal connectivity*" needs to be first considered during "feasibility analysis/

site investigation" whereas "*local renewable and/or low-carbon energy sources for energy supply*" is best considered during "feasibility analysis/functional programming" and "concept scope/schematic design".

- The process may also include the owner/responsible(s) for implementing each technical criterion (e.g. urban planner for "*mixed-use*" and "*energy-efficient settlement*"; transport planner for "*public transport grid*", landscaper for "*integrated green areas and urban agriculture*" and "*water savings/reduced consumption*", etc.).
- Indicators requiring the use of assessment tools during PPP can be specified and assigned to support decision-making.

To further test the validity and significance of the proposed process and main management practices/lessons learned, a survey questionnaire may be prepared to investigate the opinion of design managers of new eco-cities. Alternatively, the research outcomes can be also applied to a new ongoing eco-city project.

Finally, though it is devised to address a new eco-city, the proposed process can be adapted, through future research, to the development of an existing city master plan to improve its sustainability. For example, different types of stakeholders (e.g. residents) need to be consulted outside the value management workshops (e.g. through community surveys); existing conditions and baseline data need to be highly considered as overarching constraints (e.g. current land use/zoning regulations, existing infrastructure and utility systems, population density, and sustainability-awareness).

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