KTH Industrial Engineering
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Mapping of Sustainable Urban Development Models

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Abstract

Due to urbanisation and an increasing knowledge about the climate change and its potential impacts on the environment and human society, concepts like the Ecocity have become more relevant over time. Various sustainable urban development models and concepts focusing on planning and constructing sustainable communities and cities have been introduced. These models and concepts share some features but are also in many cases focusing on different aspects. This report aims to list models and concepts, used and referred to as tools for urban sustainable development. Further on, an evaluation will be made of six models and concepts based on the four criteria: holistic approach, interconnections of subsystems, adaptability and working procedure. Cases related to the models and concepts will be studied in order to make the analysis and comparison more profound.

The evaluation of the final models provides information that all the models discuss sustainability, but with a substantial focus on the ecological aspect. Interconnections and achieving synergies within subsystems are central and guiding, even though case studies sometimes reveal difficulties making these to work as intended. What seem to be of significance, besides a well-formulated model, are how well expectations from local authorities and policymakers are consistent with the intentions from those behind the model.

Keywords: Ecocity, sustainable urban development, holistic approach, subsystems, synergies

Sammanfattning

I och med urbanisering och en ökad förståelse kring klimatförändringen, och dess negativa konsekvenser på miljön, har begrepp såsom ”The Ecocity” fått allt större spridning globalt. Detta har lett till att flertalet modeller och koncept har utvecklats inom området för hållbar utveckling i stadsområden. Dessa modeller delar samma ideologi, att skapa hållbara samhällen, men deras fokusområden skiljer sig i hur detta ska uppnås. Den här rapporten syftar först och främst till att finna modeller och koncept som används och refereras till som mallar för hållbar stadsutveckling. Slutligen kommer en djupare analys och utvärdering att göras på sex modeller och koncept utifrån fyra kriterier: helhetssyn, sammankopplingar av delsystem, anpassningsförmåga och tillvägagångssätt. Fallstudier som är relaterade till varje modell kommer även att studeras för att göra analysen och jämförelsen av modellerna mer djupgående.

Utvärderingen av de utvalda modellerna visar på att alla diskuterar hållbarhet, men med ett betydande fokus mot den ekologiska aspekten. Sammankopplingar och strävan att uppnå synergier mellan delsystem är av stor vikt och oftast vägledande, dock visar fallstudierna på de svårigheter att få de teoretiska modellerna att fungera som avsett. Vad som verkar vara av stor betydelse, förutom en väl formulerad modell, är hur väl förväntningarna från lokala myndigheter och beslutsfattare stämmer överens med ändamålen som modellen vill uppnå.

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Abbreviations

Building Research Establishment Environmental Assessment Methodology	BREEAM
Center for Environmental Technology	CENTEC
European Federation of Engineering Consultancy Associations	EFCA
International Federation of Consulting Engineers	FIDIC
Greenhouse Gases	GHG
Groupe Spéciale Mobile Association	GSMA
Information and Communications Technology	ICT
International Ecocity Framework & Standards	IEFS
Integrated Resource Management	IRM
Intergovernmental Panel on Climate Change	IPCC
Institute for Research and Urban Planning of Curitiba	IPPUC
International Telecommunication Union	ITU
Key Performance Indicator	KPI
SymbioCity Approach	SCA
Swedish International Development Cooperation Agency	SIDA
Smart Sustainable City	SSC
Transportation Research Board	TRB
United Nations Environmental Programme	UNEP
World Commission on Environment and Development	WCED

1. Introduction

The world population is predicted to rise from current seven to about nine billion by 2050. With global urbanisation trends being intact, scenarios predict that around 2/3 of the world population to live in cities 2050 (World Urbanization Prospect, 2011). Cities have a big environmental impact due to their demographic weight and the amount of natural resources they consume (Ranhagen, 2010). Worldwide, about 50 million people are moving into cities every year (Ranhagen & Groth, 2012) and with rapid movement into urban areas come sustainability issues. Therefore it is of great importance to, at an early stage, plan our future cities, existing as well as upcoming, in a sustainable manner. Cities cover less than 2 % of the earth's surface but consume 78 % of the energy and produce more than 60 % of the carbon dioxide in the world (UN Habitat, 2009). Ecocities is a commonly used expression when referring to sustainable urban development and the idea is to create a form of living pattern within the means of the environment. The objectives of Ecocities are to generate energy entirely through renewable sources without consuming more than it produces, to be able to assimilate the waste produced and to not be toxic to itself or neighbouring ecosystems. Furthermore the intentions are to stimulate economic growth, reduce poverty and create high population density thus offering better opportunities to public transport and recycling management (Ecocity Builders, 2011).

Ecocities are a growing phenomenon and serve as an innovation-fostering platform for urban development worldwide. It is however, at present, several models and frameworks with varying interpretations of what criteria an Ecocity should incorporate. The models often tend to focus on specific aspects within a system or subsystems, instead of having a holistic point of view (Shafqat, 2014). The holistic point of view, or system thinking, has become important when discussing the interactions between social, economic and ecological aspects and the absence of such thinking is discussed by Richard Register, founder of Ecocity Builders, who claims that if only a part of a system is considered, sustainable development may support the longevity of an unsustainable path (Register, 2006).

In 2011, in a global survey, 178 ecocity-profiled projects were presented. These are spread around the world but are mainly placed in Asia and Europe. Many of these are on-going projects where various models and frameworks are used (Joss, 2011). The fact that many projects still are in their planning and implementing phase implies that quite few have been evaluated in depth. Since that report was written, several projects have been initiated (one being Castleward, Derby, studied in Section 5.3.4) and in China only, around 250 Ecocities are planned (Stoltz & Shafqat, 2014).

2. Objective, problem statement and goals

The objective, goals and problem statement will give the reader a brief insight of what information the project will provide, what research that has to be done in order to achieve this information, and finally what results that are to be evaluated.

2.1 Objective

Due to the various sustainable urban models and conceptual frameworks that are being used today, and the spread of criteria among these, the objective of this project is to map different conceptual frameworks and eventually choose a few of these for further analysis based on a set of criteria (see section 3). Furthermore, a presentation of an associated case to each* model/framework will be carried out, to enable discussion of potential problems and lessons to be learned from city projects.

Since Ecocities are growing in the sense that is a more commonly used term worldwide when referring to sustainability projects, it is of essence to know what the models actually contains and what the intensions are. The outcome of the study will be a matrix identifying and discussing the models' holistic approach, interconnections of subsystems, their adaptability and finally if there is a clear working procedure. The objective is not to state whether a model is "good" or "bad" but to give the reader an insight of what possibly could be seen as benefits and drawbacks regarding the models and also to enable comparison between them. Furthermore, the cases will provide information regarding what key components that are of importance, besides the information provided from the frameworks, in order to succeed.

2.2 Problem Statement

Since there are various interpretations of the Ecocity concept and number of models that are being used, this study firstly aims to answer the question

- Which sustainable urban models are used when planning sustainable cities around the world today?

Secondly, when the final models have been chosen, they will be investigated further and aims to answer the question:

- What are the main contents and focus areas in the final models?

2.3 Goals

To summarise the objective and problem statement, the goals of the report can be divided into three parts:

- Map existing sustainable urban development models and conceptual frameworks.
- Analyse a few of these further based on a set of criteria and present an associated case to each model/framework.
- Discuss benefits and drawbacks of the models, partially based on the chosen criteria for evaluation and partially by comparing the models with case studies.

* Exception made for Rethink City, for explanation see section 5.3. The case of Hammarby Sjöstad includes the Hammarby model.

3. Method

The first step of this study will be to map existing Ecocity models and concepts. Since the subject of Ecocities is still under development, and the unclearness of what is being considered as a "model" or a "conceptual framework", there could exist more models than those that will be described. In table 2 however, the models that were found are briefly explained and categorised in alphabetic order. When the models' and concepts' summarised descriptions have been made, it is possible to exclude some terms due to resemblance. The next step is to make a deeper analysis of some of the selected models and concepts. In order to evaluate which models are to be chosen, we will have to make another delimitation: there must have been at least one initiative of implementation that can be associated with the model. This does not necessarily mean that a city has utilised an entire model with all the sub-goals and criteria to accomplish the city's visions, but rather as an inspirational complement to its base-outline. Furthermore it reveals that policymakers and planners believe in a model's approach that also could be seen as an indicator of its credibility. For making the analysis even more robust, projects corresponding to each model will be presented in order to compare the theoretical frameworks with actual cases.

When the choice of models has been done, a deeper reading of what the remaining models intend to accomplish will be made and also a listing of the models' different goals; what are they mainly focusing on and what is being considered as sub-goals. These parts will be taken from the organisations own reports, handling their own specific models. Even though it could be misleading to not consider assessment reports regarding the models, there are not enough material or credibility in these reports yet, thus making the organisations' reports most feasible for the objective of this report.

When the descriptions of the models' contents are finished, it will provide an overview that facilitates the comparison between the models and also the proceeding comparison between the models can be done. The comparison will consist of a set of criteria that are chosen in order to make an evaluation where the tendency is to keep a clear boundary, and eventually provide information of the models' focus areas and the differences among them. The four criteria that the models will be analysed from are:

Interconnections of subsystems – This criterion is chosen to see how well a model approaches the idea of the city's subsystems, to actual solutions and interdependencies. It can be seen as a system analysis, meaning it defines and applies the system thinking thus providing key elements and the synergies that could be possessed.

Adaptability – The models and frameworks have a tendency of giving their idea of what components and factors that should be included in order to reach a sustainable solution for a city. This criterion will evaluate a model's flexibility in the sense of how well it could be applied in different situations. Questions that could be asked regarding adaptability/replicability of a model are: What are the core elements for a project with a restricted budget? Does a model consider suitability for different topographies? Does it consider the fact of cities/countries varying phases of development?

Holistic approach – This criterion will be the appraisal of how well a model includes sustainability aspects in a bigger context. It could be seen as the evaluation of a model's

system thinking and the criterion will have its outline from the three pillars of sustainability (see section 4.2.4).

Working procedure - Another aspect of the evaluation is the model's idea of how an implementation should be orchestrated. What type of collaboration between public and private sector is suggested and does it encourage citizens to get involved in the project?

In Figure 1 the method of the project is briefly described in a flow chart. The first step is to list existing models and then certain steps have to be fulfilled before the project will proceed.

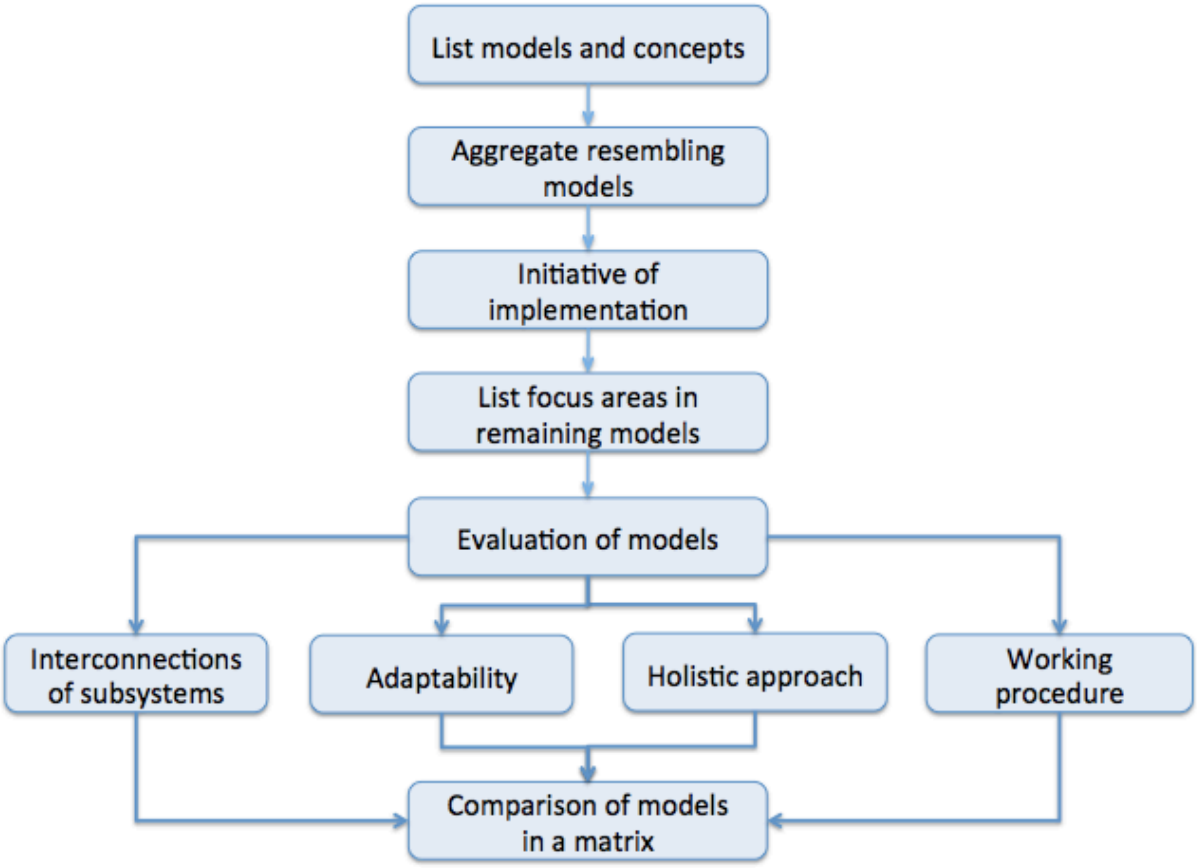

Figure 1. Method flow chart

The analysis and choices of the evaluation criteria are influenced by an article written by Lekamge and Marasinghe (2014) that discusses how a Smart City model should be developed in order to be applicable at cities of any size. The authors have identified six key features that are necessary:

1. Government-led initiatives that collaborates with private sector.
2. The needs, which the project aims to meet, should follow a hierarchy where physical needs are in priority, followed by safety and security, love and belonging, self-esteem and self-actualisation.
3. The importance of enabling the cities to identify and define the needs and aspirations by their own.

4. Continuity in feedback from residents and stakeholders are of importance as the project evolves and will give the model a cyclic behaviour.
5. Identifying and optimising the interconnections between different entities in the system are necessary when utilising the existing city resources and will be manageable through collecting both supply and demand side data.
6. Use universal design in order to make it accessible and liveable for as many as possible regardless of age, ability or status in life (Lekamge and Marasinghe, 2014).

3.1 Limitations

In order to answer the goals and reach objective of the report, there must be limitations regarding numbers of models analysed, what aspects to consider and how deep these aspects should be analysed. The number of models and concepts that will be analysed will be brought down to six. This is partially because the analyse of the models will be better than if more models were to be evaluated and partially to make the project's scope manageable given the time frame and length of project.

The next limitation is the choosing of criteria and method of evaluation. Even though there are existing evaluation tools for city systems today, the conclusion is that these would bring too much subjectivity if a ranking system of arbitrarily selected criteria within the sectors of environmental, social and economic aspects would be chosen. Instead, the criteria stated in the previous section, will provide a more objective summary of the analysed models. Furthermore it is difficult to make calculations and quantifying a complex system as a city, regarding the holistic and sustainability approach, since there are many interpretations of what components that are to be considered and also the fact that many models are under a development phase and are being evaluated as time passes.

4. Literature Study

This part of the project will firstly provide a background on why Ecocity concepts and models have been developed and why it is of interest to investigate the concepts and models further. After this the Ecocity concept will be presented and defined as it is in today's context. Finally, a more profound presentation of the final models will be made.

4.1 Climate Change

It is no longer just a scientific curiosity that climate change is occurring. As the Intergovernmental Panel on Climate Change states in its fifth Assessment Report: "Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentration of green house gases have increased." (IPCC, 2013)

The increasing knowledge of human activities' impact on the environment in the continuous measurements of numerous areas provides alarming evidence (UNEP, 2010). The collected data provides information that forms clear patterns; the increase of GHGs is anthropogenic and is the only valid explanation of the last decades warming trends. It also states the likelihood of significant damage and irreversible consequences of accelerating emissions on global ecology (McGregor et al, 2013).

The climate change and its impact on the ecology are hard to predict with high accuracy, but the scientific evidence indicate that the negative externalities are going to be larger the higher amount of GHGs that exists in the atmosphere. However, the circumstances of climate change may be avoided, or at least mitigated, if our dependency on hydrocarbon based energy systems is adjusted. The technology to do it is available, but must be applied aggressively and in close future (UNEP, 2010).

4.2 Sustainable Development

The theoretical concept for sustainable development was evolved during 1972-1992 when series of international conferences and collaborations were held (Drexhage & Murphy, 2010). During these years, several definitions were developed, some of them earning more recognition than others. They all originate from the same visionary paradigm, but differ among the opinions on what should be included and excluded.

4.2.1 Brundtland Commission

In the report *Our Common Future* by The World Commission on Environment and Development in 1987, sustainable development was defined as: "The development that meets the needs of the present without compromising the ability of future generations to meet their own needs." The definition contains two key concepts; firstly the word "need" is particularly the essential needs of the world's poor to which priority should be evident. The other is the idea of limitations on the environment's ability to meet present and future needs (Brundtland. et al, 1987).

4.2.2 The Ecological Footprint

Another definition of sustainability is the so-called ecological footprint. W. Rees and M. Wackernagel published the book *Our Ecological Footprint: Reducing Human Impact on the Earth* in 1996. They define the Ecological Footprint as: "A measure of 'load' imposed by a given population of nature. It represents the land area necessary to sustain current levels of resource consumption and waste discharge by that population." This means that the ecological footprint for a city is represented by the total area that is essential for the continued existence of the city (Rees & Wackernagel, 1996).

4.2.3 The Three Spheres of Sustainability

Although the concepts and definitions of sustainable development differ in scope, they are all ways of approaching sustainability and share the fundamental thought of improving the environment and setting restrictions for human influence. Furthermore they are designed for governments, businesses and civil society to have premises to draw conclusions from. A summarised way of describing sustainability in a comprehensive manner is by introducing the three interdependent "spheres of sustainability" (see Figure 2) that are described in various chapters in Agenda 21†, these being; Ecological, Economic and Social sustainability (Rodriguez, et al, 2002).

Ecological Sustainability:
Agenda 21 states that energy supplied is used in ways that may not be sustained if overall demand continues to increase and technology remains constant. The conclusion is that energy sources need to be provided by renewable energy sources and used in a manner that does not exhaust natural resources (Rodriguez et al, 2002).

Economic Sustainability:
The economic sustainability is a complex term with lots of variables and interdependencies to take into account when describing it. However, in economic debate, sustainable development is often described as "the need to maintain a permanent income for humankind, generated from non-declining capital stocks." (Spangenberg, 2005)

Social Sustainability:
There is no clear definition on social sustainability. The definitions that exist tend to derive from discipline-specific criteria rather than being general (Weingaertner & Moberg, 2011). However, one definition, defined by sociologists Beate Littig and Erich Greissler, is: "Social sustainability is a quality of societies. It signifies the nature-society relationships, mediated by work, as well as relationships within the society. Social sustainability is given, if work within a society and the related institutional arrangements:

- Satisfy an extended set of human needs
- Are shaped in a way that nature and its reproductive capabilities are preserved over a long period of time and the normative claims of social justice, human dignity and participation are fulfilled." (Littig & Griessler, 2005)

† Agenda 21 is an action programme regarding social, economic and environmental sustainability that was adopted at the UN conference in Rio de Janeiro, Brazil, in June 1992 (UNSP, 1992).

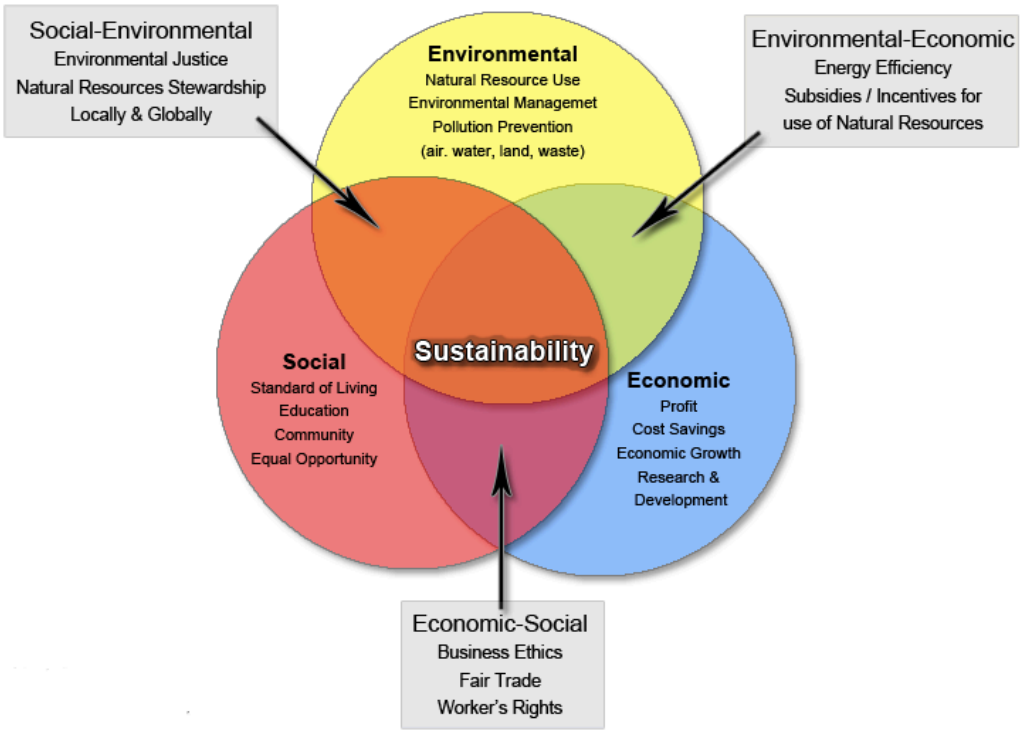

Figure 2. The Three Spheres of Sustainability
(Rodriguez et al, 2002.)

4.3 Urbanisation

Urbanisation has gone much faster and reached larger proportions between 1800 and 1950 than at any previous time in history (David, 1955). Since that paper was written in 1955 the urbanisation has continued and the urban population is expected to increase by 72 % by 2050, from 3,63 billion in 2011 to 6,25 billion in 2050. However, the rate of population growth in urban population is declining both in developed and less developed regions. Table 1 illustrates that between 1950 and 1970 the average annual growth rate was 2,98 % in developed regions and 4,04 % in less developed regions, the average annual rate of change between 2030 and 2050 is expected to be 0,29 % in developed regions and 1,34 % in less developed regions (World Urbanization Prospect, 2011).

Table 1. Urban populations by development group, selected periods, 1950-2050

	Population (billions)					Average annual growth rate (%)			
Year	1950	1970	2011	2030	2050	1950-1970	1970-2011	2011-2030	2030-2050
World	0,75	1,35	3,63	4,98	6,25	2,98	2,41	1,66	1,13
Developed regions	0,44	0,67	0,96	1,06	1,13	2,09	0,89	0,52	0,29
Less developed regions	0,30	0,68	2,67	3,92	5,12	4,04	3,33	2,02	1,34

With an expected world population year 2050 of 9,31 billion compared with expected urban world population of 6,25 billion, around 67 % of the world's population is expected to live in urban areas (World Urbanization Prospect, 2011).

Approximately 40 % of carbon emissions can directly be associated with residential and commercial buildings globally (McGregor et al. 2013). With an increase of urbanisation around the world it is acknowledged that minimising emissions associated with urban areas presents one of the most urgent challenges of the 21st century. For the current, existing built environment it is of great importance to strive to become more energy and resource sufficient, less pollutant, and more self-reliant in balancing needs and consumption if conditions for a healthy and enduring human civilisation on Earth is to be fulfilled (Ecocity Builders, 2011).

What drives urbanisation is often described in terms of push and pull factors and are divided in economic, social and environmental aspects. Examples of economic push factors are agricultural failure, income variability, surplus labourers and loss of employment. Social push factors could be ethnic or other discrimination and displeasure with traditional lifestyle. Environmental push factors could be administrative displacement (e.g. in China, due to the construction of Three Gorges Dam, over a million people have been displaced (BBC, 2012)), drought or flood, resource depletion, loss of land. These are factors that push or force people from the rural land to urban areas. Pull factors, on the other hand, are attracting people to urban areas where economic pull factors could be job opportunities, prospects for higher income, improved housing and access to health care. Social pull factors could be educational opportunities, prospects of meeting new people, get closer to relatives and environmental pull factors could be a resource finding, e.g. mining findings (Gong, et al, 2012).

4.3.1 Urban Sprawl

One definition of urban sprawl is the tendency toward lower city densities as city footprints expand. It occurs in different forms; as low-density residential development at the edge of a city, as planned communities with their own downtowns and also as un-planned widening of the urban area due to houses popping up on formerly rural land (Nechyba & Walsh, 2004). Examples of urban sprawl related to planned communities are the so-called ABC-suburbs (ABC stands for Work, Home, Downtown) in Stockholm in 1950s (Stockholms läns museum).

Communities with high residential density have lower carbon intensity per person than communities with significant urban sprawl. Furthermore car-dependent communities at any size have higher carbon emissions per person than communities relying on effective transportation systems (McGregor et al, 2013). Since suburban sprawl is believed to have significantly contributed to increased vehicle use (Kahn, 2000), avoiding such sprawl could be handled by increasing the residential density and therefore increase proximity and connectivity and would make other modes of travel, such as transit and walking, more competitive with automobile travel (Frumkin et al. 2004).

4.4 The Eco City Concept

The Ecocity concept, developed by Richard Register, author and founder of Ecocity Builders discusses problems related to urban sprawl and car-dependence. He has coined the phrase “access by proximity” which suggests the proximity to important functions such as housing; work spaces; food, hardware, and clothing shops; educational facilities and places to socialise, are necessary to create ecologically healthy cities characterised by walkable centres, transit villages, discontinuous boulevards and agricultural land close by (Register, 2006). To describe cities as interconnected urban ecosystems, the IEFS illustrates 15 interdependent dimensions that can be seen in Figure 3.

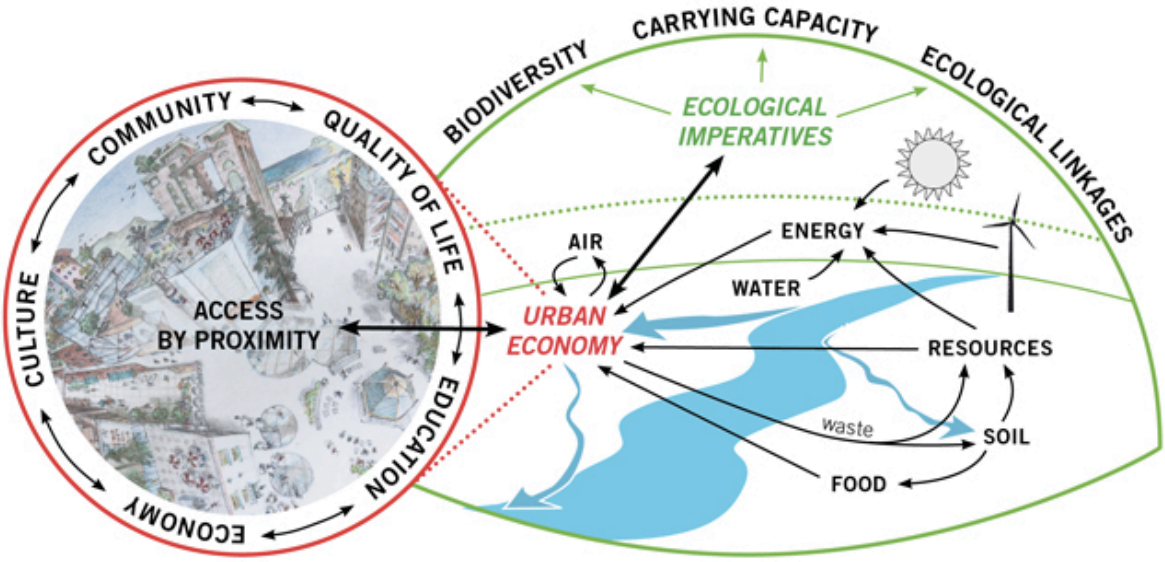

Figure 3. Urban Eco-system
(IEFS, 2014)

Another way of comprehending the interdependencies between the parts of a city system is the way Register does in his book *Ecocities – Rebuilding Cities in Balance with Nature*. He then describes the city as an organism. It could be seen as a metaphor for a holistic perspective when studying the city system, i.e. different parts of the organism (city) must be in balance with other parts in order to work properly (see Figure 4). The metaphor could also be interpreted as the necessity of the city to stay in balance with nature, since the organism has evolved from it and therefore is adapted to it.

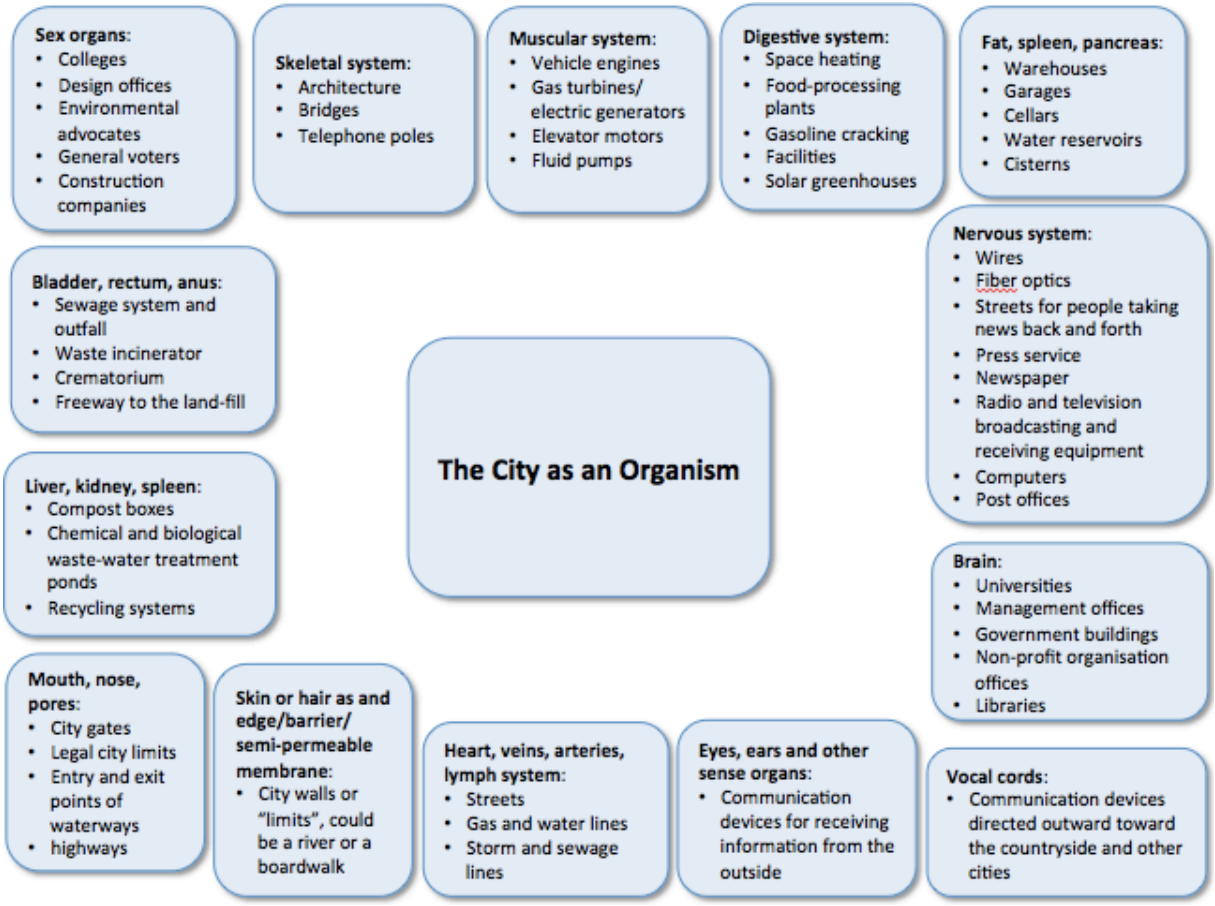

Figure 4. The City as an Organism
(Adapted from Register, 2006)

With the holistic perspective in mind, Register's interpretation is that a city should be adapted to stay within the means of the nature and therefore having a holistic approach when planning and constructing future areas.

In addition to the illustrations, the Ecocity Builders and the International Ecocity Advisory Committee have adapted a working definition of what an Ecocity is:

"An Ecocity is a human settlement modelled on the self-sustaining resilient structure and function of natural ecosystems. The Ecocity seeks to provide healthy abundance to its inhabitants without consuming more renewable resources than it replaces in its bioregion. It seeks to function without producing more waste than it can assimilate or recycle for new uses or than nature can dilute and absorb harmlessly, and without being toxic to itself or neighbouring ecosystems. Its inhabitants' ecological impacts reflect

planetary fundamental principles of fairness, justice, reasonable equity and consensus at ample levels of happiness." (Ecocity Builders, 2010)

In a global survey from 2011, 178 Ecocities were presented. As shown in Figure 5, the cities are spread around the globe although a concentration to Europe and Asia is observed. Also, on these continents certain countries have higher project-intensity; in Europe, France and United Kingdom are dominating in terms of number of projects. In Asia, especially China, but also India and Japan have plenty of Ecocity projects (Joss, 2011). China, which has had exchange with Swedish authorities and consultants when planning for projects such as Caofeidian and Wuxi (Caofeidian is associated to the Symbio City approach is studied in section 5.3.1), stated in its 12th five-year plan that sustainable city development and urban green technologies are key components when it comes to facing the Chinese environmental challenges (Growth analysis, 2014). China is currently planning for around 250 Ecocities (Stoltz & Shafqat, 2014).

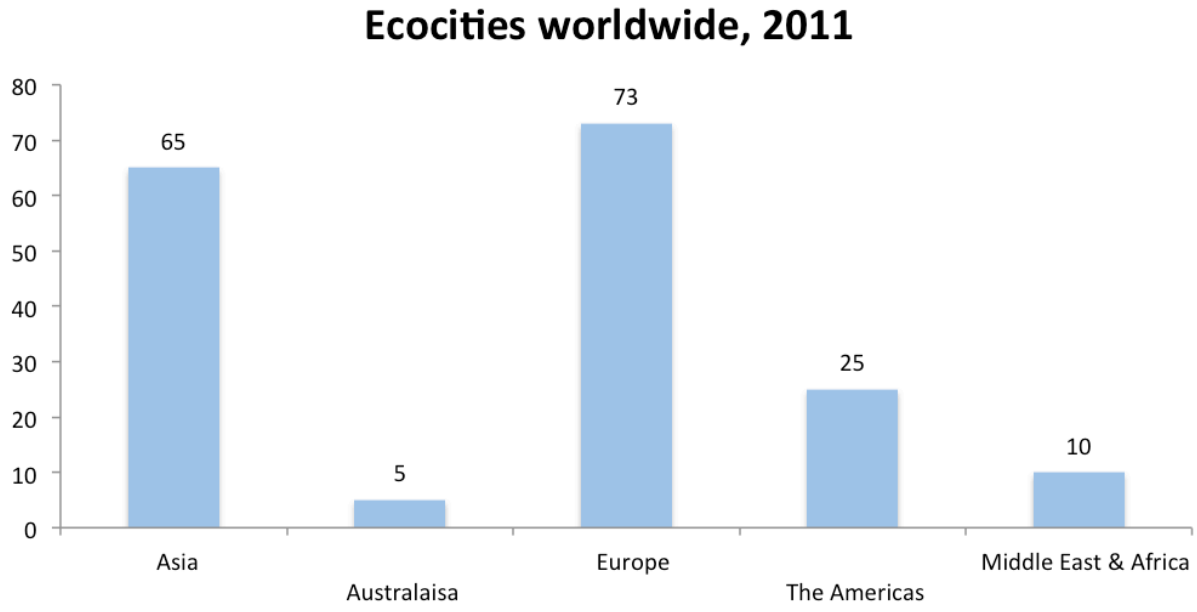

Figure 5, Ecocities, a global survey
(Joss, 2011)

In Figure 5, The Americas includes South, Central and North America and the Ecocities are mainly located in USA. Australaisa contains both New Zeeland and Australia. Cities, counted as Ecocities in Figure 5, are of different scales, not necessarily focusing on same issues and some projects are still in their phase of implementation (Joss, 2011).

4.5 Systems approach

To summarise the problems and possible actions that are necessary to be taken in order to face climate change, urbanisation, urban sprawl and the sustainability issues, it should be recognised that sustainable urban areas are a valuable part when trying to mitigate the impact caused by human activities. When observing a city, it is essential to have the system thinking right from start until the end to avoid negative outcomes. This is to locate synergies and to make the most rational decisions. McGregor et al. (2013) exemplifies this, when a community used the IRM-application after they had proposed strategies without using a holistic approach. In addition to the benefit of the original efficiency strategy that the city had, it showed that, among other synergies, electric vehicle strategies yielded in a 3 % carbon reduction, 10 % parking reduction and 6 % increase in energy demand, thus showing that interdependencies play an important role when making decisions.

4.5.1 Defining a system

The term ”system” has been more frequently used throughout the past decades. In the book *System – att tänka over samhälle och teknik* (2002) Lars Ingelstam answers the question “what is a system?” by pointing out common characteristics for systems;

- A system consists of some sort of *components* and *interconnections* between these.
- There should be a reasoning of why some specific components and their relations are chosen to form the system; they shall form an *entirety.*
- To distinguish the system from the rest of the world; a system boundary is applied. However, this does not imply the fact that the outer part is not regarded.
- The outer part is referred to as the surrounding or ambient. The interdependency between the system and the surrounding is equally essential for the system analysis as it is for the clarifying of the system itself.

4.5.2 Traditional analysis

The traditional analysis focuses on the separation of individual pieces of what is being studied, which could be comprehended if looking into the definition of the word “analysis” that originates from the meaning “to break into constituent parts” (Aronson, 1996). West Churchman exemplifies the traditional analysis in his book *The Systems Approach* (1968) by listing the problems of the world today. He claims that in theory we are able to resolve these with modern technology, the issue is that if one component is treated first, and most likely is wanted to be solved fast and efficient, it is firstly later on that it is proclaimed that the approach was ineffective and may have caused either a circle where the result ended up being solved insufficiently and/or that other parts, sub-systems, were affected by the decision thus changing the initial outline for the other parts. The conclusion drawn from the example is that the interconnections play an important role when making decisions based on resolving a specific problem.

4.5.3 System thinking

System thinking has its roots in the field of system dynamics, founded by MIT professor Jay Forrester in 1956. The fundamental difference between traditional and system approach, is that the system thinking focuses on how the studied object interacts with other constituents of the system of which it is a part. Consequentially this means that instead of isolating smaller parts, the system thinking expands its view to consider larger numbers and interactions complemented to the original issue, i.e. holistic thinking (Aronson, 1996). However, it is not feasible for a complex system or problem to spend loads of time to design all subsystems and their connections. If a satisfactory standard is set when taking time, influence and other boundaries into account, the original problem will be easier to delimit so it eventually will reach a realistic solving methodology. If the system thinking takes its toll when estimating interactions, it may go too far away from the initial problem formulation. Sometimes the systems can be far too complicated for our intellectual and rational power to understand, thus overcomplicating a solving method that may not result in better outcomes or as quoted "When you postpone thinking about something too long, then it may not be possible to think about it adequately at all." (Churchman, 1968)

Many important problems that plague us today are complex and involve multiple actors. Furthermore they are, in some manner, the outcome of past actions that were taken to alleviate them. By embracing the system thinking and apply it on these problems, it will give the ability to deal with them more effectively and raise our holistic thinking to the level at which we create solutions that are more feasible to us, even in situations marked by great complexity (Aronson, 1996).

5. Models and Concepts

Since there are uncertainties regarding the definition of the base-concepts that an Ecocity relies on, it has resulted in a lot of different interpretations of what a sustainable city should encompass. In table 2, a listing of terms, models, and concepts, all deriving from the same initial thought; creating and/or describing a sustainable, holistic urban area are presented. It should be added that the objectives differ due to different scales and focus areas.

Table 2. Description of models and concepts

Term	Comment
BREEAM Communities	A way to improve, measure and certify the social, environmental and economic sustainability of large-scale development plans (BREEAM, 2012)
Carbon Neutral City	Strives to reach zero net emissions‡ in the city (Joss, 2011)
Compact City	Is related to Eco City thinking when it comes to avoiding urban sprawl and private car use by increasing residential density (Joss, 2011)
Eco City	A collective name to describe a city scale project that is environmental friendly, existing as well as non-existing cities (Ecocity Builders, 2011; Joss, 2011)
Eco District	Designed to help cities and urban development practitioners to be more successful by working together. Focuses on community collaboration, integrated communication and management (EcoDistrict Framework, 2014)
Eco Industrial Park	Aims to attract high-tech and/or green industries with a mix of residents. Often part of an ambition of creating local economies away from polluting industries. (Joss, 2011)
Eco Municipality	Where the local authority is guided by a values related to environmental and social sustainability in its policy making (Joss, 2011)
Eco Region	An Ecoregion occupies an even larger area than the previous “Eco-terms”. Includes clusters of cities and villages and their close-in open natural environments. Is characterised by consistent climate and population of species (Ecocity Builders, 2011)

‡ Zero net emissions is when energy demanded is met by renewable energy supplied.

EcoVillage/ EcoCommunity	Aims to achieve self-sufficient villages with cooperatives, healthy communities that help in the transition to a more sustainable future (Ecovillage, 2014)
Eco² City	Builds on the synergy between ecological and economical sustainability (Suzuki et al, 2010)
Garden City	Self-contained communities surrounded by parks with proportionate areas with residents, industries and agriculture (Zhou, N. Et al, 2012).
Livable city	Focuses on standard of living, in terms of wealth, comfort, material goods and necessities available for the socioeconomic classes in a city (Zhou et al, 2012).
Low Carbon City	The prefix carbon reflects to create low carbon economies, designed to mitigate climate impact (Joss, 2011)
Masdar City	Ecocity project in United Arab Emirates. It aims to serve as a clean-tech cluster for business and innovation, within the means of the environment. (Masdar City, 2014)
Net Zero Carbon Community	A community where energy demanded is met by renewable energy supplied (McGregor et al, 2013)
Oekestad	German translation of Eco City, often as part of Agenda 21 sustainability aspects (Joss, 2011)
Rethink City	A model speaking about the importance of holistic system thinking and the possible synergies within a system (Fryxell, 2012)
Slim City	Is an initiative to increase efficiency in city sectors, such as energy and transport. (Joss, 2011)
Smart City	A model with an efficient and widespread technological network that promotes dialogue between citizens and everyday objects (Di Carlo, 2013)
Smarter Cities	Focuses on "smart" solutions, giving leaders information to make better decisions, coordinate resources and processes to operate effectively (IBM, 2012)
Smart Energy City	Energy and resource efficient, moving towards zero GHG-emissions (Nielsen et al, 2013)
Smart Sustainable Cities	Relies heavily on ICT, meaning that it has the ability to provide ecological friendly

	and economically viable solutions for cities. Resembling to the three models above (Kondepudi, 2014)
Solar City	Renewable sources mainly from solar energy (Joss, 2011)
Sustainable Community	Synonymous with Ecocommunity (Joss, 2011)
Sustainable City	Synonymous with Ecocity (Joss, 2011)
SymbioCity	Promoting a holistic and integrated approach. Serve as a basis dialogue with cooperating partners regarding environmental system solutions with links to social and economic aspects (Ranhagen & Groth, 2012)
The Hammarby Model	A district in Stockholm that resulted into a model called "The Hammarby Model". Overall goal is to be "twice as good as the norm" which required innovative thinking regarding the construction (Stockholm Stad et al, 2007)
Transition Town	Aims to engage people on grass-root level to build local communities with social and environmental resilience (Joss, 2011)
Zero Carbon City	A city that has no GHG-emissions and only runs on energy from renewable sources (Joss, 2011)
Zero Energy City	Reduce current consumption and introduce renewable energy sources; trying to achieve local generation (Joss, 2011)

Even though the models and frameworks all derive from same initial thought – create a sustainable urban area – some of them have different ways and focus on how that can be managed. The Ecocity concept, described in section 4.4, focuses, unlike concepts with prefixes like smart and smarter, a lot more on the relation humans vis-à-vis nature and how that balance can be restored[§]. The holistic thinking is essential, but the human attitude towards nature, and the necessity of a symbiotic relationship between human and nature, seems to be guiding. Smart and smarter cities on the other hand rely much more on a high-technologic, innovative optimistic society where smart ICT solutions can mitigate human impact, towards a less pollutant and more sustainable living.

As seen in Table 2, many models, apart from resembling names, also share resembling descriptions. It would be possible to gather some models under a collective term, meaning that a term becomes an aggregation over a few other terms. Furthermore, some of the terms do not constitute a model of their own, but are rather theoretical descriptions of the concept of urban sustainable development models.

[§] In Ecocities –Rebuilding Cities in Balance with Nature, author Richard Register describes societies for more than 1000 years ago, for example Kogis of Colombia, Anasazi of Arizonas, New Mexico, Colorodo and Utah, as examples of humans living in symbiosis with nature (Register, 2006).

5.1 Choosing Models

When all 30 terms in table 2 has been described, it is possible to exclude the majority of these due to resemblance and lack of case studies. Eventually, it came down to a few more than the six models that will be further analysed in this section, but given the depth of analysis that is desirable and the width of the project, it was eligible to choose the following models and concepts, due to their recognition and reliability:

1. SymbioCity
2. Eco^{2}City
3. Smart City
4. Rethink Cities
5. BREEAM Communities
6. Hammarby Model

5.2.1 SymbioCity

The SCA-model aims to serve as a conceptual framework that is generic and can be applied flexibly to particular regions and urban contexts. It gives general guidelines and methods to support sustainable urban development procedures. Its main purposes are to:

- Serve as a basis dialogue with cooperating partners regarding environmental systems solutions with links to social and economic aspects.
- Promote a holistic and integrated approach.
- Serve as a basis for multi-disciplinary or sectorial reviews on all different levels of a city system.
- Contribute to the "Development of city-wide strategies" for short, medium and long-term improvements of urban areas.
- Enhance collaboration and sharing of experiences, primarily at local government level.

Figure 6 shows a more detailed description of environmental factors, subsystems and institutional factors that are elaborated in the SCA-model. In the centre, the most essential parts are presented; health, comfort, safety and life quality which are then followed by environmental factors that are linked to subsystems and finally reaching institutional factors.

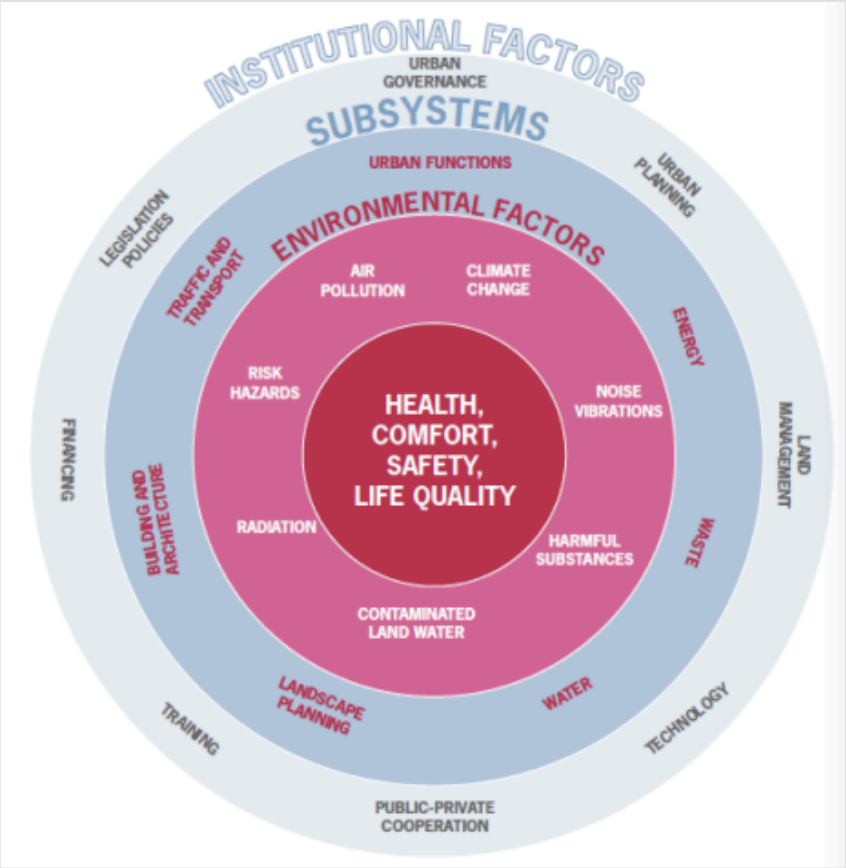

Figure 6. Base outline of the SCA-model
(Ranhagen & Groth, 2012)

The conceptual framework is divided into three parts, provided to urban developers primarily as a complement to an existing plan but could be applied as a model of its own. Furthermore the three parts all have underlying procedures that are shortly described (Ranhagen, 2010):

a) The Working Procedure

Define and organise the sustainable review

- Holistic analysis of urban areas on different scales: city/town-district or block level.
- Aimed at obtaining a more comprehensive picture of the environmental situation.

Make a diagnosis of the current situation

- SWOT-analysis on different urban scales.
- Problem-Sources-Causes (Problem tree)

Specify key issues and objectives

- Overall objectives should reflect the ambition of improving the environment in a long-term perspective.

Develop alternative proposals

- As the problems are often very complex, it is likely that there will be a number of alternative solutions
- Focus on the synergies between sub-systems.

- Prevention/Intervention and Mitigation.

Analyse anticipated, potential impacts

- The economic, social and environmental impact of alternative proposals and solutions should be studied in order to obtain a basis for choice, either of one alternative or the combination of several.

Choose a strategy for implementation and follow-up

- When the evaluation of alternative proposals has been set up, it will result in a recommendation of a preferred proposal and a further strategy for implementing this proposal in a short- and long-term perspective.
- The operation and maintenance phase is the longest period in the life of a city and its components, which make it necessary to systematically measure, evaluate and take steps for successive improvements of buildings, roads and green areas.

b) Subsystems

The SCA-model proposes these seven key subsystems to be regarded when planning and constructing a city. In table 3 the subsystems are listed followed each followed by a comment of advice (Ranhagen, 2010).

Table 3. Description of subsystems

	Comment
Urban structure and urban functions	Avoid urban sprawl and promote a high-density city to reduce transport-dependency. Promote efficient heating and cooling systems.
Landscape planning	Green areas working as carbon sinks.
Building design	Building design and insulation to reduce energy demand.
Traffic and transportation	Promotion of sustainable transportation – walking, cycling and public transport; green logistics; replacement of fossil fuels with renewable energy.
Energy	Increased energy efficiency, reduction of energy demand and fossil fuel dependency.
Waste management	Reduce, reuse, recycle, recover; use waste as a resource and minimise GHG emissions
Water management	Minimise energy needed for water management essentially leading to reduction of GHG emissions.

c) Institutional Factors

An effective institutional framework is essential to promote sustainable urban development and improve the urban environment. In the SCA-model the following key aspects are to be considered (Ranhagen, 2010):

Urban governance and capacity building

- Management of financial, economic, technical, organisational, human and other resources needed to improve the urban environment

Legislation and policies

- Powerful means for ensuring improvements
- Both on national and regional level

Spatial planning and land management

- Involves coordination of all types of land use in urban and rural areas.
- The interplay between urban and rural areas is crucial for sustainable urban development

Participatory processes

- Public participation in efforts to improve the environment.
- Informative and communicative roles between the public and municipality regarding planning, implementation and follow-up processes.

Financial resources and incentives

- Proper financing is essential when planning and implementing urban environmental improvement measures.
- Develop a realistic and optimum financing plan

Private sector participation

- On-going cooperation between planning authorities and the private sector.
- Incentives for businesses to become involved in urban transformation and possibly provide expertise and innovative, products and systems.

5.2.2 Eco^2 City

The Eco^2 City relies on the synergy and interdependence of ecological and economic sustainability, thus resulting in the name "Ecological Cities as Economic Cities". The Eco^2 City Initiative works through the application of analytical and operational framework that provides cities to systematically achieve positive results. It gives a point of departure and needs to be customised for a given context of a city. It has been shown that the four key principles that the initiative builds on are important for lasting success. Each principle is widely applicable and forms the foundation of the Eco^2 initiative (Suzuki et al, 2010):

a) A city based approach

Enables local authorities to lead the development process that gives consideration to specific circumstances, including the ecology. It is based on a bottom-up approach meaning that the local actions generate creative self-reliant solutions, contributing to the bigger parts of the society; such as regional, national and possibly global levels. Furthermore, the city-based approach recognises that cities are at the front lines for managing change and leading an integrated approach, since they are not only engines of economies but also responsible for the majority of resource consumption and harmful emissions. A city has some crucial instruments at their disposal, for example: approvals, taxes and fees. However, it is of great importance that the local government can cooperate with the national government, to be able to reach success. This is because the state level government often tend to circumscribe the city's legislative, administrative, and fiscal powers.

b) An expanded platform for collaborative design and decision-making
Accomplishes sustained synergy by coordinating and aligning the actions of stakeholders. The stakeholders consist of many different groups, e.g. the public sector, civil society groups and citizens, each influencing over how elements of the city are designed and managed. The Eco^2 initiative divides the city into three collaborative working groups, referred to as the three tiers: corporate, municipal, and regional. In addition the election cycle for local governments could make sustainable decision-making difficult and the Eco^2 pathway suggests that the collaboration between stakeholders could steer the efforts of all stakeholders toward a commonly agreed vision. The expanded platform of collaboration, in combination with a long-term planning framework, is more likely to increase the commitment of local governments to its long-term policies. Furthermore, if a greater proportion of many stakeholders participate in the decision-making it will be harder for a new council to reverse on going plans.

c) A one-system approach
Enables cities to realise the benefits on integration, i.e. having a holistic approach, by planning, designing, and managing the whole urban system by optimising its key subsystems. The idea of the one system approach resembles the system thinking, it seeks to reduce the complexity by understanding how the parts fit into the whole. The challenge lies in overcoming the institutional structures that prevent stakeholders from working as a team.

d) An investment framework that values sustainability and resiliency
Includes and accounts for lifecycle analysis, the value of all capital assets (manufactured, natural, human, and social) and a broader scope of risk assessments in decision-making. Decisions today are dominated by immediate capital costs, to achieve economic sustainability; the decision-making needs to be guided by a holistic perspective. This requires new accounting and assessment framework that allows cities to adopt a lifecycle perspective when making investments, and also enabling fair solutions to all of the stakeholders. Investing in sustainability and resilience will mitigate the future negative externalities that are caused by the short-term investments, which are to give a financial return at a fast pace. Instead the broadening of the scope and incorporation of indirect "difficult-to measure" risks should be taken into account more frequent to enable cities to be better prepared to unpredicted happenings that may occur over time.

In Figure 7, an illustration of the core team and sector advisers is presented. Each subsystem is linked into the middle marked with a "c" representing sector champions of each category. The sector champions have a larger network of experts and stakeholders but the idea is to emphasise collaboration between all sectors and make them work together as a team. The true test of the Eco^2 cities initiative will not be its ability to link cities to finance, but to facilitate the process to adapt and apply the four principles and eventually unlocking a city's full potential (Suzuki et al, 2010).

Figure 7. The Core Team and Sector Advisers
(Suzuki et al, 2010)

5.2.3 Smart City

The reliance on ICT and "smart" solutions are typical for smart city models. A strong connection to big assembling of data, innovative and high-technologic solutions is of essence in the common strive for a sustainable city. "Smart" can be defined as an implicit or explicit ambition to improve economic, social and environmental standards. The concept of smartness is strongly connected to technologically implementable solutions. (Kondepudi, 2014). Even though it exists studies that discuss the subject of smartness, a further analyse of those discussions will not be handled in this project.

A Smart Sustainable City, SSC, have the goal of enhancing the quality of its inhabitants across multiple dimensions. A "Smart City" is very resembling to the SSC-model. Broadly speaking, one core element that separates smart city models from other Ecocity definitions is its base outline relying on ICT in more or less every key aspect discussed in the frameworks. Kondepudi states in his assessment report *Overview and Role of ICT in Smart Sustainable Cities* that "ICT have an ability to provide eco-friendly and economically viable solutions for cities, especially as their populations start to increase rapidly." Furthermore he means that ICT acts as an enabler of more intelligent and efficient utilisation of resources, leading to cost and energy savings, improved quality of life and a reduced ecological footprint (Kondepudi, 2014).

GSMA is a multinational mobile operator and their perspective on the smart city is stated as: "A smart city makes extensive use of information and communications technologies, including mobile networks, to improve the quality of life of its citizens in a sustainable way. A smart city combines and shares disparate data sets captured by

intelligently connected infrastructure, people and vehicles, to generate new insights and provide ubiquitous services that enable citizens to access information about city services and move around easily, improve the efficiency of city operations, enhance security, fuel economic activity and increase resilience to natural disasters." (GSMA, 2013).

Boyd Cohen, is an urban and climate strategist that put up six key components for a smart city, each one having underlying systems with further explanations, (see Figure 8). These key components are: Smart Economy, Smart Mobility, Smart Environment, Smart People, Smart Living and Smart Governance

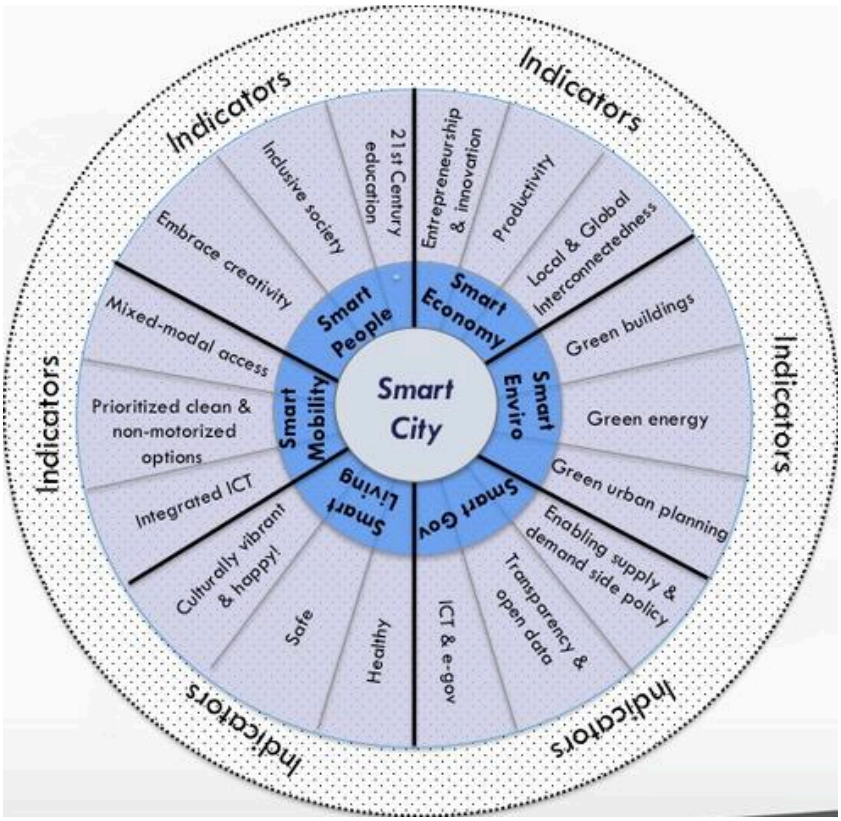

Figure 8. Smart Cities Wheel
(Cohen, 2012)

Another interpretation of key aspects in a smart city, is the eight subsystems that the SSC-model presents (Kondepudi, 2014), not having as many defined subsystems as the one Cohen, but with further explanations and examples of solutions connected to ICT:

- **Energy management**
  Smart energy management systems uses sensors, digital controls, advanced meters among other things to optimise grid operation and usage by keeping consumers and producers up-to-date to be able to deliver energy efficient solutions.
- **Building management**
  Smart building management systems can make intelligent modifications to improve energy usage, reduce wastage and make optimum usage of water.

- **Transportation & Mobility**
  Smart transportation management systems should use technology and collect information around mobility patterns. This method will provide city managers with information that facilitates investments towards infrastructure solutions and better functioning transportation services.
- **Waste Management**
  Smart waste management systems will empower implementation of a waste tracking system to monitor and control the movement of different kinds of waste. Furthermore it will take care of the sorting of waste, collect and share data from source to transportation to disposal of waste and connect larger waste management systems with local waste management service providers.
- **Water Management**
  Smart water management systems use and apply ICT to deliver solutions to provide access to clean water, manage demand and supply, and finally develop a pricing mechanism.
- **Healthcare**
  Smart healthcare management converts health related data into clinical and business insights. Organisations and cities work together on their health care data to secure communications and information sharing. The data provides doctors and health specialists with information to improve the productivity of service towards patients.
- **Education**
  The educational part is considered as one of the most crucial areas in smart city services, for adults as well as for children. Technology based solutions for students & teachers providing information to the community and finally up to city/country-level. There are many examples of benefits that come with ICT solutions on the educational platform. Intel has made a graphic illustration showing the value of ICT in educational contexts (Intel, 2012).
- **Physical Safety & Security**
  As cities become bigger and with an increasing number of inhabitants, the safety/security operations that are suggested is firstly to expand/update existing security technology such as video surveillance and secondly to adapt integration technologies that helps security agencies to communicate through smart technology.

5.2.4 Rethink Cities

Rethink Cities is an approach towards sustainable urban development, planned and formulated by FIDIC/EFCA, International/European Engineer Consulting Associations. In order to achieve sustainability FIDIC/EFCA and their Rethink Cities approach is encouraging a more holistic thinking where the three aspects cooperation, synergies and systems are fundamental. The building and constructing sector serve as an improving actor towards sustainability due to its deep experience and already holistic direction. The sector is also considered to be important in order to achieve synergies and improved methods and processes between different infrastructural supply systems in urban planning.

The "Rethink Cities" approach has identified ten possibilities to improve, in order to move towards sustainable urban development. These aspects are presented in Table 4, each followed by a brief comment describing suggestions of improvement. The "holistic approach" serve as an overlapping component valid for every other aspect (Fryxell, 2012).

Table 4. Ten possibilities to improve, Rethink Cities

	Comment
Urban functions – a holistic approach	A city should be regarded not just by its different components, but as a whole technical system where services, functions, support, maintenance and emissions are examined. Therefore the various urban functions all must relate to ecological, economic and social aspects.
Transportations	To decrease car use a large and well-structured public transportation system is necessary. Requirement of energy is correlated to residential density, land use and spatial structure of the built environment. Increasing urban density will shorten distances and therefore encourage walking and cycling.
Landscapes and biodiversity	The framework aims to restore a declining bio- and genetic diversity in cities. For a sustainable landscape planning it suggests: • Using natural design elements such as trees, plantation and gardening in the urban and human context. • Create green areas where wildlife can be left undisturbed. These can also be considered as lungs of the city. • Turn wasteland and former landfills into green areas and parks for recreation. • The microclimate should be taken into consideration when planning areas for housing and industry. That is to increase comfort level due to sun and wind exposure.
Building design	In order to save energy the Rethink approach focuses on energy efficient buildings, both new and existing, where design of walls, roofs and floors are the most important factors. Furthermore the framework stresses that the construction process could reduce building material waste by choosing materials with low environmental load and possibilities of reutilisation and recycling.
Energy "production", distribution and "use"	An important factor to reach sustainable energy supply is to decrease the energy demand. As mentioned above, energy saving buildings, industrial processes and transports are key factors to achieve a declining demand. To improve green energy supply, the Rethink City advocates fuel switching; coal to gas; natural gas to biogas; bioenergy instead of fossil fuel etc. Renewable energy resources such as solar-, wind- and hydropower are important components. An example of increasing energy efficiency is by installing district heating and cooling systems, instead of having private boilers for every household, where surplus heat could be

	recycled.
Water and sewage treatment	Technical solutions within buildings such as efficient taps, showers and dishwashers, together with behavioural factors are important to minimise fresh water use. Also alternative sources to supply non-potable and grey water must be considered, to enable reutilisation of water in areas where fresh water is not possible to obtain.
Waste treatment	With new techniques such as vacuum waste collection systems it is possible to reduce transportation otherwise related to waste management. The waste should be divided in different categories to simplify recycling, biogas production etc.
Information & communication technologies (ICT)	By including ICT-systems such as smart grids, cellular phones and satellite systems a more efficient energy usage is promoted. An example of this is sensor-based systems on streetlights.
Administrative methodologies	Governments, institutions and local authorities have a responsibility to make use of its legislative power regarding regulatory frameworks, tariffs, taxation programmes etc. to improve social, economic and environmental development.
Smart living	Information and knowledge regarding sustainability should constantly influence people to make smart decisions.

5.2.5 BREEAM Communities

"BREEAM Communities is a way to improve, measure and certify the social, environmental and economic sustainability of large-scale development plans by integrating sustainable design into the masterplanning process" (BREEAM.org). BREEAM has set a transparent framework that makes it easier for developers, professionals and decision makers in their common strive for a more sustainable living. BREEAM Communities has identified, defined, structured and weighted eight categories that are necessary in sustainable development. These are:

- Climate and energy
- Resources
- Transport
- Ecology
- Business
- Community
- Place Shaping
- Buildings

Each category seeks to mitigate the environmental, social and economic impact of a development project, and credits are given within these different categories according to their performance compared to defined sustainability objectives and planning policy requirements. In Table 5 each category is presented followed by a brief description of what the purpose is and also what issues the category covers. When the credits have been specified for each category they are summed up resulting in an overall score, which

is then converted to a grade on a scale of; Pass, Good, Very Good, Excellent and Outstanding (BREEAM for Communities: Stage 2, 2011).

Table 5. Subsystems handled in the BREEAM Communities Manual

Category	Description	Issues Covered
Climate and Energy	Reducing the proposed project's contribution to climate change whilst ensuring that developments are appropriately adapted to the impacts of present and future climate change	• Flood Management • Energy and Water Efficiency • Renewable Energy • Infrastructure • Passive Design Principles
Resources	Designing for the efficient use of resources including water, materials and waste in construction, operation and demolition, and minimising the life cycle impacts of materials chosen.	• Land Use and Remediation • Material Selection • Waste Management • Construction Management • Modern Methods of Construction
Transport	Addressing how people can get to the facilities and locations that they need; giving people choices other than private cars and encouraging walking and cycling for healthier lifestyles.	• Walkable Neighbourhoods • Cycle Networks • Provision of Public Transport • Green Travel Plans • Construction Transport
Ecology	Conserving the ecology living on and visiting the site and taking full opportunity for ecological enhancement within and around the development as well as on buildings,	• Maintaining/Enhancing Habitat • Green Corridors • Ground Pollution • Contaminated Land • Landscaping Schemes
Business	Providing opportunities for businesses to locate and serve both the locality and provide jobs for people living in and around the development.	• Inward Investment • Local Employment • Knowledge Sharing • Sustainable Charters
Community	Designing the development to support a vibrant new community that can integrate with surrounding areas, avoiding creating actual or perceived "gated" communities.	• Social Impact Assessment • Community Engagement • Sustainable Lifestyles • Facilities Management • Mixed of Use • Affordable Housing
Place Shaping	Provide a framework for the design of a "real place" with an identity that ensures that people can instinctively find their way around. Also ensuring that the new development draws from the local context and heritage.	• Site Selection • Defensible Space • Active Frontages • Green Space • Secured by Design • Housing Density
Buildings	Ensuring that the design of individual buildings contribute to the sustainability of the overall development through high environmental standards.	• BREEAM Buildings • Code for Sustainable Homes • Building refurbishment

In autumn 2012, an update of BREEAM Communities was launched. The new manual contains fewer detailed demands and descriptions in comparison with the previous one. It is less prescriptive, more flexible and integrates better with the planning process (BREEAM Communities, 2013). The sustainability aspect is divided in three steps (BREEAM Communities, Technical Manual, 2012):

Step 1. Establishing the principle of development: Assesses the issues and opportunities on the site and evaluates how the development will affect the community as a whole. All issues are mandatory because they are seen as fundamental principles that will have impact over decisions regarding the design of the development.

Step 2. Determining the layout of the development: At this point the local community may become more involved regarding the design of the project as the design team are planning for various options. Also project stakeholders, statutory consulters and planning authority are involved. One issue, 'GO 02 – Consultation and engagement' is mandatory.

Step 3. Designing the details: Depending on the size of the development, there may not be a clear distinction between Step 2 and Step 3. However, the final step focuses on the detailed design of the development. None of the issues in Step 3 are mandatory.

For both Step 2 and Step 3 the BREEAM Communities Assessor is working with the design team to determine which criteria that can be achieved under BREEAM Communities.

5.3 Case Studies

To discuss the models that has been analysed, a connected case to each model will here be presented, followed by a short discussion around issues that may occur when implementing a city project. Hammarby Sjöstad will also be handled, since it has led to the Hammarby Model that has become globally recognised for urban developers. At this point there are no cases directly linked to Rethink City, partially because it is a set of guidelines rather than a model and partially because it is relatively new, thus leaving it unhandled in this section.

5.3.1 Caofedian City

Caofeidian International Eco-City, also referred to as Tangshan Bay Eco-City, suffered from an earthquake in 1976 that levelled the city. When it was rebuilt, it was according to higher sustainable standards than most other Chinese towns. Thirty years after the natural disaster, an initiative was launched to consolidate the city as a pioneer for sustainable urban development. (Joss et al, 2011). This in combination with an approximate urban growth of 15 million persons per year in China resulted in the starting progress of Caofeidian Ecocity. The overall conceptual planning for the city began in 2007 and was carried out by Sweco in collaboration with many stakeholders in Tangshan and also the Embassy of Sweden in Beijing with its Center for Environmental Technology, CENTEC (Sweco, 2008).

When developing the conceptual plan and guideline targets for the city, Sweco utilised the SymbioCity approach and restricted it to suit local conditions. The sustainable guidelines that Sweco addressed are presented in Figure 9, each part having further explanations of what to achieve in order to reach the "Nine Themes of Planning" (Sweco, 2008) being:

1. Liveable city
2. Innovative city
3. Accessible city
4. Green and blue city
5. Climate neutral city
6. Resource efficient city
7. Flexible city
8. Beautiful city
9. Healthy city

Figure 9. The Nine Themes of Planning in Caofeidian City (Sweco, 2008)

Apart from the base parameters, 141 sustainable indicators for the Ecocity development were presented, including seven subsystems. However, the Tangshan side-stakeholders considered some parts to be too ambitious and too innovative for Chinese standards, claiming that the average Chinese citizen is not yet familiar with the sustainable thinking mind set and the targets were too risky and most likely to fail (Tillväxtanalys, 2014).

The Tangshan Bay project's first phase has been carried out with great involvement from Sweco, and the city is currently in an on-going progress and the real construction work, second phase, is due to be finished by 2020. The cooperation with Tangshan has been a central part of CENTEC's work and has included many high-level visits, conferences, ceremonies, company visits and meetings. The initial planning phase was successful from the Swedish companies point of view, but during the current second phase, new companies have taken place in the proceeding of the city project. This in combination of slow progress in the development and constant changes in the Tangshan management has led to conflicts of interests between the Swedish and Chinese sides. Furthermore, the Caofeidian Ecocity project has suffered from financing issues which for example has led to ordered consulting services, providing further suggestions for the city project, being left unhandled (Tillväxtanalys, 2014).

5.3.2 Curitiba

Curitiba is a city located in Brazil that shows that high costs not necessarily have to be the determining factor to ecological and economic development. Much of the success for the city may be attributed to the IPPUC, an independent public authority that manages areas as research, planning, implementation and supervision of urban plans. The master plan was formulated in the 1960s, thus making it easier to evaluate than other projects handled, since most of them are not fully completed. To describe the various innovative approaches that Curitiba has towards urban planning, seven major aspects will be presented (Suzuki et al, 2010):

Innovative land use planning
To be able to control the growing population, Curitiba committed to a master plan made in 1966 that directed urban growth along structural axes radiating from the city centre. Economic activities are concentrated along these axes, and at the same time the city centre was strengthen with high-density development. To avoid traffic in the city centre, mayoral administration transformed selected streets in the core of the city to car-prohibited areas, thus making the streets pedestrian friendly. This, in combination with the bus service system that reaches 90 % of the total city area, has led to more people coming to town, increasing the economic opportunities for local shops compared to streets with car traffic. (Suzuki et al, 2010)

The integrated public transportation system
Curitiba's bus system was developed as a part of the overall master plan whose basic objectives included expansion of the city along five structural axes, integrating land use and transport and protecting the traditional city centre. Curitiba's busways are viewed as a model bus rapid transit system with different types of buses, having different speed limits and number of bus stops (TRB, 2001).
When implemented, the estimated cost was US$3 million per kilometre which was much more affordable than alternative transportation systems, such as tram (US$8 – US$12 million per kilometre) or a subway (US$50 – US$100 million per kilometre). As a result of the bus system among other solutions, Curitiba's fuel usage is 30 % lower than Brazil's other major cities (Friberg, 2000). Out of all trips made in Curitiba, 45 % travel by bus, 27 % by foot, 22 % by private car and 5 % by bicycle. This has not only led to reduced car emissions and traffic congestion, but also time saving and enhancement of the economic activity (IPPUC, 2009).

Green area enhancement
To improve the quality of life for the citizens, Curitiba decided to improve its green areas, from the 1970s 1 square meter per person to 51,5 square meter per person by 2010. The trees, in the parks and along the streets, absorb carbon dioxide and the forest areas capture an estimated 140 tons per hectare, which helps mitigating climate impact. In addition, the shade from trees cool buildings, which decreases energy usage (IPPUC, 2009). This, in combination with a car-free centre has provided more bicycle paths along the streets and inside the parks. Instead of controlling water flow with concrete structures, Curitiba has created natural drainage systems. Riverbanks have been converted into parks where the overflow water can be absorbed in the soil and rivers and rainwater flooding may be held naturally in the lakes. The ecosystem is thus preserved naturally. (Suzuki et al, 2010).

Waste management
Curitiba has initiated several innovative waste management programs. Instead of relying on high technologic waste treatment facilities, the city depended on people's awareness around the growing amount of waste. With educational programs for the poor people and children, that teaches the importance of waste separation and environmental protection has increased recycling and decreased littering and waste growth. Furthermore, the city offers employment to the less fortunate population, e.g. homeless and poor, to participate in recycling and garbage separation programs (Suzuki et al, 2010).

Development of the industry
The economy in Curitiba was in the 1970s reliant on the service sector. In order to attract investors and boost employment, IPPUC decided to introduce manufacturing industries. After three decades the Industrial City of Curitiba has created about 50,000 jobs directly and 150,000 jobs among secondary industries. The industrial park has strict environmental regulations and polluting industries are not allowed. (Suzuki et al, 2010).

Social considerations
Even though Curitiba's economy is relatively developed compared to other Brazilian cities, many residents still live in slums. To prevent further segregation the city has adopted various social programs. For example, social incubators have been created to provide training and facilities for establishment for local business. Curitiba encourages a mix of income groups so neighbourhoods become inclusive. City services such as education, health, culture and social service facilities are distributed throughout the whole city, resulting in equal accessibility to all citizens regardless of income. (Suzuki et al, 2010).

Culture and heritage preservation
When the planning process was intact during the 1970s, 363 building were identified for preservation. However, since most of these buildings were located on private land, the managing of the preservation became difficult. After many ifs and buts some of the buildings remained the same, while revitalisation was made of 44 historical buildings. People now have easier to enjoy the urban cultural atmosphere since the city core was

transformed into pedestrian streets, facilitating the enjoyment of walking around in the city (Suzuki et al, 2010).

5.3.3 Charlotte, North Carolina

An example of a city that utilises the Smart City concept to achieve sustainability is Charlotte in North Carolina, USA. The introducing of the project took place in 2010 and the launching of the project started during autumn 2011. Its vision is to decrease energy usage by 20 % within five years. To achieve the target the city uses mobile networks and various ICT systems to roll out linked smart meters and energy displays in commercial buildings and also educate employees on how to save energy. The project also aims to: encourage sustainable behaviour among citizens, to improve the image of Charlotte, and mitigate peak energy-demand. The KPI's used for evaluation are: reduction in usage of environmental resources in each of the four project pillars (energy, water, air, waste) within five years, a quantitative analysis of energy reduction by a third party and to supervise citizens' awareness around environmental impacts (GSMA, 2013).

The sustainability profile that Charlotte is aiming for is carried out by a public-private partnership named Envision Charlotte. It was established as a non-profit organisation developed with leadership from the city of Charlotte, Bank of America, Duke Energy, Wells Fargo Bank and consultancy Intelligent Buildings along with other key community stakeholders (GSMA, 2012). An example of one of the trademarks established in Charlotte is "Smart Energy Now™". It is a program from one of the stakeholders, Duke Energy, which uses a digital grid infrastructure that keeps track of energy usage for participating buildings. This data includes information on real-time energy usage, load factors, historical trends and explains what the numbers actually provides. A striving goal is to contribute with a 5 % energy reduction only through behavioural change (Duke Energy, 2014).

By making the Envision Charlotte program defined in a very simple manner: reduction of the energy usage by 20 % by 2016 and the extension around consumer behaviour and awareness, the city believes that in the future it could expand its energy efficiency solutions beyond business parks and potentially apply the same technologies to other utility services, such as water provision (GSMA, 2013). Furthermore, the website for Envision Charlotte provides various programs encouraging the citizens to get involved in the proceeding of the project. In addition, the website provides information on the on-going process and sends newsletters frequently, keeping people updated and points out what the next steps in the project are (Envision Charlotte, 2014).

5.3.4 Castleward, United Kingdom

Castleward is a BREEAM Community certified community in Derby, England. The planning started in 2012 and it aims to create 800 new homes and 34,500 square feet of commercial space. It is planned in five phases, stretching over 15-20 years and the first masterplan phase was assessed and certified against the BREEAM Community sustainability standard. BREEAM Community became part of the community development when the private partner Compendium Living included it in its initial bid

and planning proposal. The development is a joint venture between Derby Council and Compendium Living.

The planning proposal as part of masterplan phase one recognises three key principles of the development: 1) Movement and Access; 2) Open Space; 3) Sustainability. The BREEAM Community framework was used when incorporating the sustainability principle with the two other principles.

The Castleward masterplan has received the score "Good" according to the earlier presented BREEAM Community evaluation tool (section 5.2.5).

Table 6 shows how the evaluation of the masterplan has been arranged and what factors and issues that has been covered, according to the BREEAM assessment. The second rightmost column shows what the available credits were and the far right one, what credits Casteward targeted (BREEAM 2011 Retail Assessment, 2011).

Table 6. BREEAM Assessment of Castleward, Derby

Criteria	Issue	Credits available	Credits targeted
Management	• Sustainable Procurement	8	4
	• Responsible Construction Practices	2	2
	• Construction Site Impacts	5	5
	• Stakeholders Participation	4	3
	• Life Cycle Cost and Service Life Planning	3	0
Health & Wellbeing	• Visual Comfort	4	2
	• Indoor Air Quality	4	0
	• Thermal Comfort	2	2
	• Water Quality	1	0
	• Acoustic Performance	2	2
	• Safety and Security	2	2
Energy	• Reduction of CO_2 Emissions	15	2
	• Energy Monitoring	2	2
	• External Lighting	1	1
	• Low and Zero Carbon Technology	5	1
	• Energy Efficient Equipment	2	2
Transport	• Public Transport Accessibility	5	5
	• Proximity to Amenities	1	1
	• Cyclist Facilities	0	0
	• Travel Plan	1	1
Water	• Water Consumption	5	3
	• Water Monitoring	1	0
	• Water Leak Detection and Prevention	2	0
	• Water Efficient Equipment	1	1
Materials	• Life Cycle Impact	5	3
	• Hard Landscaping and Boundary Protection	1	1
	• Responsible Sourcing of Materials	3	2
	• Insulation	2	2
	• Design for Robustness	1	0
Waste	• Construction Waste Management	4	3
	• Recycled Aggregates	1	0
	• Operational Waste	1	0

Land Use & Ecology	• Site Selection	2	1
	• Eco. Value of Site and Protection of Eco. Features	1	1
	• Mitigation Ecological Impact	2	2
	• Enhancing Site Ecology	3	0
	• Long Term Impact on Biodiversity	2	2
Pollution	• Impact of Refrigerants	3	2
	• NO_x Emissions	3	3
	• Surface Water Runoff	5	5
	• Reduction of Night Time Light Pollution	1	1
	• Noise Attenuation	1	1
Innovation	• Innovation	10	0

Summarising the credits given shows that Castleward received 70 out of a total of 129 credits. The credits within each area are given based on varying demands changing depending on which criteria that are considered.

5.3.5 Hammarby Sjöstad

Hammarby Sjöstad, which means, the city around Hammarby Lake, is an environmental on-going project located outside Stockholm inner city. In the 1980s the area was locating brown fields and semi-legal industries where toxic were dumped on the ground and directly in the water, which led to heavy pollution. During this time, politicians in Stockholm were discussing plans on hosting the Summer Olympic Games in 2004 and Hammarby Sjöstad was suggested as the site for the Olympic Village. This led to an application with the ambition of having a city district twice as good as the state-of-the-art technology available in the construction field (Pandis Iveroth et al, 2013).

A central aim of the environmental program of Hammarby Sjöstad was to close the material and energy cycles as much as possible. Due to earlier energy crises in the 1970s the city of Stockholm had already undertaken activities of sustainability, which were located in the southern parts of Stockholm and ready to be implemented as part of the Hammarby Sjöstad project. In 1996 the municipality contacted the three companies Stockholm Energi, Stockholm Vatten and Skafad that are responsible for near-located power plants, wastewater plants and waste recycling. These companies were asked to, in collaboration with each other, create an integrated sustainable environmental program for Hammarby Sjöstad. Companies' working in cooperation was quite unique for a district of this scale (In 2012 Hammarby Sjöstad sheltered 21000 habitants and the plan for the project is to reach a level of 28000 habitants (Hammarby Sjöstad, 2013)) and the ambitious goals of Hammarby Sjöstad was something new to these companies which eventually led to them being called eco-cycle companies. After some initial struggle and a neglected proposition, Stockholm municipality accepted a proposal suggesting a combination of already built infrastructure with new technical innovations such as a local wastewater treatment plant and a local storm-water treatment (Pandis Iveroth et al, 2013).

As a consequence of the eco-cycle companies, Hammarby Sjöstad identified its own eco-cycle involving energy, water & sewage and waste presented in Table 7 (Bergström et al, 2007).

Table 7. Hammarby Model's Eco-cycle

Energy	Water & Sewage	Waste
Combustible waste is converted into district heating and electricity	Water consumption is reduced through the use of eco-friendly installations, low flush toilets and air mixer taps	An automated waste disposal system with various deposit chutes, a block-based system of recycling rooms and an area-based environmental station system help the residents sort their waste
Biofuel from nature is converted into district heating and electricity	A pilot wastewater treatment plant has been built specifically for the area in order to evaluate new sewage treatment techniques	Organic waste is converted/digested into biosolids and used as fertiliser
Heat from treated wastewater is converted into district heating and district cooling	Digestion is used to extract biogas from the sewage sludge	Combustible waste is converted into district heating and electricity
Solar cells convert solar energy into electricity	The digested biosolids can be used for fertilisation	All recyclable material is sent for recycling: newspapers, glass, cardboard, metal, etc
Solar panels utilise solar energy to heat water	Rainwater from yards and roofs is drained into Hammarby Lake, rather than into the wastewater treatment plant	Hazardous waste is incinerated or recycled
Electricity must be a "Good Environmental Choice" product or equivalent	Rainwater from streets is treated locally using settling basins and then drained into Hammarby Lake, rather than being drained into the wastewater treatment plant	

The eco-cycle of Hammarby has also been described as the Hammarby Model (see Figure 10), where interconnections between subsystems in Table 7 are illustrated. It aims to create an optimised cyclical system where for example sewage is turned into biogas.

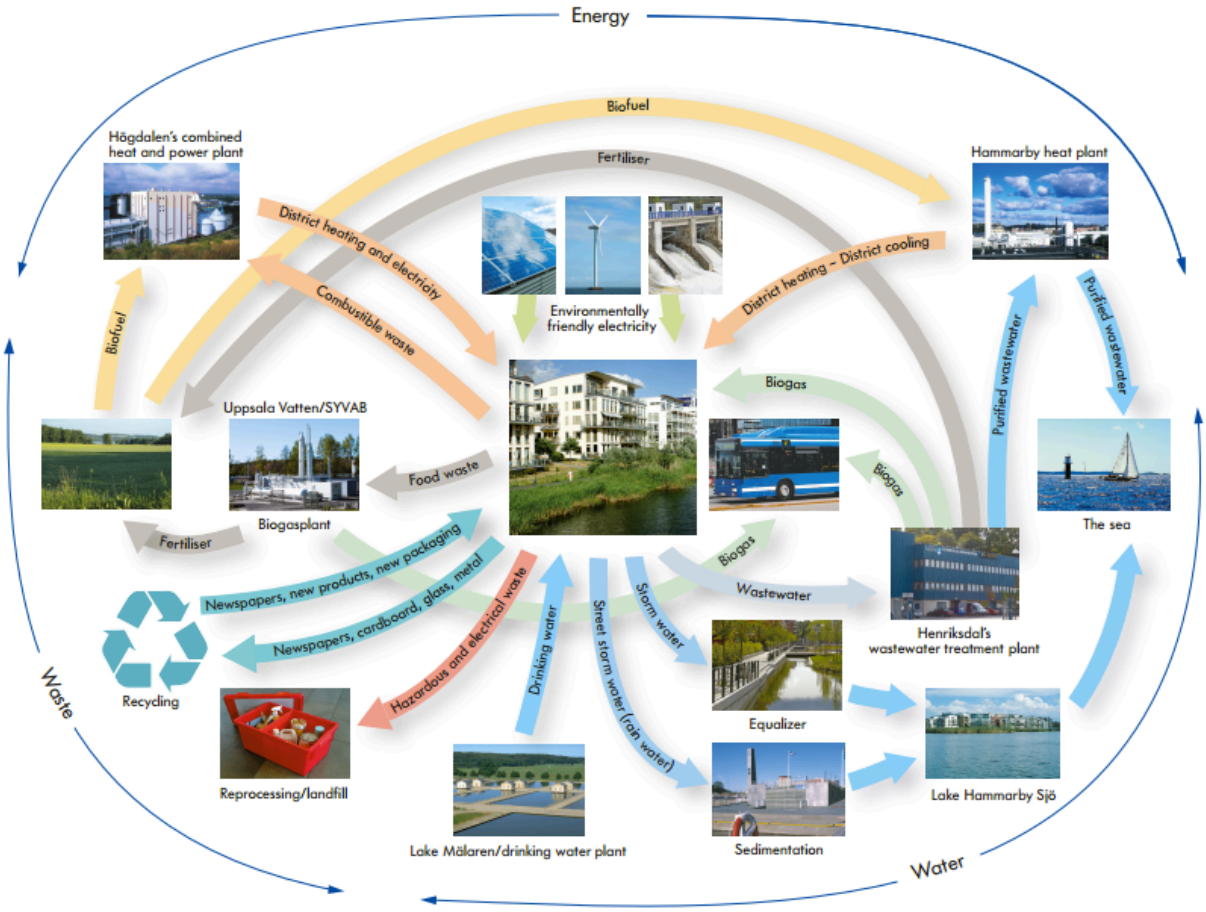

Figure 10. The Hammarby Model
(Bergström et al, 2007)

The Hammarby Model has however been criticised for showing an "ideal image" regarding how well the eco-cycle is closed; the actual flows of energy, material and waste are not consistent with the original plan. Furthermore, the energy "consumption" for apartments is almost twice as high as the initial goals. The "consumption" is however slightly lower than Swedish average, but since the households in Hammarby Sjöstad are relatively spatial and shelters few habitants, the energy "consumption" per capita becomes higher than Swedish average (Wangel, 2013).

6. Comparison and evaluation

For this part the models will be linked to their corresponding case that have been presented in previous sections. An evaluation of the models and cases will be made given the four criteria (holistic approach, adaptability, interconnections of subsystems and working procedure) that were chosen in the methodology, aiming to keep an objective perspective; i.e. stating what the models encompasses within the criteria, and also analyse the potential problems and successes that has occurred in the city projects.

6.1 SymbioCity (Caofeidian City)

As the SCA-model states in their own report, it should work as a complement rather than replace existing regulatory frameworks and policies (Ranhagen, 2010). By stating this, it emphasises the fact that it is more of an eye-opener to potential interconnections, synergies, and a suggestion on working procedures and involvement from public and private sectors etc. all in combination willing to provide future urban planners a structure when concretising complex city systems. However, since it is very descriptive in many aspects, it stands pretty well on its own as a master plan.

The framework stresses that it does not have a depth in socio-cultural and economic dimensions of development. The primary focus relies on ecological factors, but with an ultimate goal to reach high "quality of life". But apart from pointing out energy system dimensions, the framework is in fact extended by considering some dimensions in the social and economic areas (Ranhagen & Groth, 2012). It has a great width in the energy sustainability area, as well as it is easy to follow the framework's descriptive step-by-step working procedure, providing great flexibility since it discusses various aspects and has alternative proposals, making it concrete and holistic regarding environmental sustainability.

However, when comparing its practical use in the Caofeidian project where Sweco suggested 141 sustainable indicators to be regarded, a conflict of interest was revealed with the local authorities, claiming it was too ambitious for the soon-to-be residents. The Swedish-Chinese collaboration in Caofeidian city has encountered cultural clashes, which has led to project delays. The Chinese authorities are in great need of foreign knowledge in order to absorb information regarding sustainability and advanced technology but are not yet as environmentally guided as for example Sweden. For many local Chinese governments low price is still the most crucial factor when choosing project proposals (Tillväxtanalys, 2014).

The detailed SCA-model in combination with the cultural clash may lead to projects being delayed or left out due to absence of agreement. A parallel drawn to Churchman's phrase (1968) "When you postpone thinking about something too long, then it may not be possible to think about it adequately at all." is applicable in this situation where the promoting of a holistic approach, and not missing out on any synergy, eventually made it too complex for the city to execute various parts of the initial plan. Even though the framework has a well defined working procedure and many intensions and plans on how to link subsystems with each other to achieve maximum potential and not overlook potential synergies, the case of Caofeidian City shows that in practice the economic aspect and project-team are just as crucial as the master plan methodology.

6.2 Eco^2 City (Curitiba)

The Eco^2 City initiative strives to help cities in developing countries achieve greater ecological and economic sustainability. Although, this model incorporates some social aspects, the main objective relies on the synergy and interdependence of ecological and economic sustainability. In the report written by Suzuki et al. (2010) it is stated that a paradigm shift is needed to be able to handle the powerful wave of urbanisation (see section 4.3) while continuing to manage the existing built stock. This shift should, according to Suzuki et al, base on systematic learning from global best practices, i.e. benchmarking successful solutions.

Furthermore, the authors of the report Eco^2 Cities claim that if a city finds an appropriate strategy it is possible to economically improve its resource efficiency, while simultaneously reducing pollution and unnecessary waste. By doing so a chain reaction is intact, the less polluted environment leads to higher quality of life for the citizens, and creates an enduring culture of sustainability (Suzuki et al, 2014).

The concept has put up four key principles that were found to be essential for lasting success. By presenting these four aspects, a concrete way of the working process is structured and is easy to comprehend for urban developers. In its practical use in Curitiba, the strong city-based approach that the framework promotes, has worked out well. Also the continuous inclusive approach towards the poor inhabitants, which are offered education and employment related to sustainable urban development, has created a common vision for the population as a whole to strive for a well functioning, long prosperous living.

Although the city of Curitiba has had a positive outcome, it does not necessarily mean that the framework is better of than others. The framework relies heavily on that synergies will be achieved through economic and ecological standards, thus not entirely including the holistic approach, both for the good and the bad. It is positive in the sense that it is defined in a concise manner, and takes a niche position for less developed regions (Suzkui et al, 2010), but could be too excluding in some aspects not considering as many subsystems as for example the SymbioCity framework. Another aspect is that the project of Curitiba has been developed through several decades and is easier to evaluate due to the time-lapse and completed work so far, which has made it possible to get access of quantitative results.

6.3 Smart City (Charlotte)

The message that the smart city models aims to deliver to leaders and policy makers at different levels, is to work “smarter”. The somewhat sketchy definition of the term “smart” has, more or less, the same meaning in the various reports covering the concept. The master plan is to achieve energy efficiency and enhance economic value by collecting big amounts of data from all possible sectors, e.g. transportation, healthcare, water utilisation, by using high-technologic, sensor-based systems that facilitates visibility for local authorities to make better decisions, anticipate problems and coordinate resources and processes to operate effectively.

In the IBM – Smarter Cities report (2012) it is stated that the framework provides strategic analysis tools to identify the most valuable actions for city leaders in order to become a smart city. The smart city concept aims to include the three sustainability factors, but its reliance on ICT and an expanded, interconnected, infrastructure tilts the focus towards ecological and cost efficient (economic) solutions. Furthermore, it could be excluding for less developed regions, where the technological standard is at a lower level and an expansion of high-technologic solutions would be of high cost, not necessarily in the longer perspective but at least in near-future. On the other hand, one could promote leapfrogging (the idea of developing regions to learn from the experiences in industrialised countries regarding technological change and environmental impacts and solutions) for undeveloped cities, where the ICT could be a part of the concept of creating a sustainable living according to smart city models. It would require large infrastructural investments that are of risk, but possibly yield an enhancement of economic value in the long run.

In Charlotte, North Carolina, it has been acknowledged that by engaging inhabitants and companies in keeping track of their energy utilisation with ICT-systems and commonly striving for the strict defined goal, reducing energy usage by 20 % within a five year time-lapse, the city can easily visualise and quantify the on-going process results with the implemented smart meters. The Envision Charlotte program continuously encourages its citizens to participate in educational programs regarding environmental sustainability and energy efficiency. By educating and engaging organisations and citizens in the city, and facilitating the evaluation of the project in its on-going progress by using tracking instruments, Envision Charlotte has managed to reduce energy demand and by extension the awareness of its citizens regarding environmental issues and are on good track of reaching the goal. Apart from the main objective the city seeks to extend energy efficiency solutions by potentially applying same technologies to other utility services in the future and in combination with this strengthen the image of the city (GSMA, 2013).

6.4 Rethink Cities

Since the Rethink Cities concept is relatively new, 2012, and is more of a way of thinking than an assessment tool or model, there are no directly associated cases to it, as for the other frameworks. The Rethink City model is different from other models in the sense that it deeply analyses the upcoming problems regarding climate change, urbanisation and so forth in their report, providing readers with data and puts awareness in focus. Fryxell states that the framework has a holistic approach handling economic, ecological as well as social development.

Furthermore, he stresses that the cooperation, synergies and systems are the three key features in order to achieve sustainability at the urban level. With the ten underlying aspects, presented in table 4, it is explained what possible actions there is to take towards unsustainable behaviours. It is more descriptive and gives examples and evidence of environmental solutions rather than having an actual working plan. It does not consider different contexts such as topography, scalability and economic resources as much as other existing frameworks, thus leaving it to be more of an educative complement to a prior existing planning framework rather than a model of its own. (Fryxell, 2012)

6.5 BREEAM Communities (Castleward)

As BREEAM themselves states on their website, the BREEAM Communities is a way to improve, measure and certify sustainable development plans by integrating sustainable design in the initial planning process. This means that the framework partially is provided in the planning phase of a project, supporting with expertise regarding sustainable design and partially appears for the evaluation of the project, using the evaluation of the eight categories and respective underlying criteria, from which a city is rated and provided a certificate and perhaps enables marketing of the city as a green, sustainable city.

A difference with the BREEAM Communities framework is that it is the organisation itself that works closely in the starting phase with the project leaders of the city and in collaboration comes up with a suitable urban development. The framework handles a width of areas and undertakes the fact that it might not always be possible to cover all issues at the beginning. The areas consist mainly of energy systems but include aspects as "stakeholder participation" and include some economic values and a few social aspects. Its assessment tool is also well recognised around the globe and makes the certificate a reliable source of evaluating a project, even though a quantification does not necessarily categorise and consider all constituents of a city. For example, the case of Castleward received the grade "Good" but was just below the next level "Very Good" which could be misleading for a third party when simply looking at the rating. However, if a more detailed analyse is carried out it is possible to highlight areas where projects are doing well and bad from looking at the underlying aspects scores.

6.6 Hammarby Model (Hammarby Sjöstad)

In the case of Hammarby, the development of the model emerged from the vision and central aims of the environmental program created for the district, which roughly can be described as making the material and energy cycles as closed as possible and that the district should be twice as good as standard districts during that time. (Pandis Iveroth, 2013). The model focuses a lot on integrated infrastructural systems aiming to minimize metabolic flows and has provided concrete solutions of how it can be implemented. The interconnections of subsystems have been extensively applied in the district as illustrated in Figure 8; for example the excess heat from the wastewater is utilised to produce district heat that in return is used to heat up the apartments in the area.

By promoting the closed, cyclic and environmental-friendly model in combination with the sustainability profile that it has proclaimed, the concept has been recognised in urban development circuits. It is good that the ideal image and framework has led to a global recognition, making foreign urban planners believe in succeeding even though city projects involves large investments edged by uncertainty. The Hammarby Model has also, for the record, been a great inspiration for the SymbioCity approach (Tillväxtanalys, 2014).

However, Hammarby Sjöstad has been criticised for its overambitious energy-standards, where an annual 60 kilowatt-hours per square metre was the initial goal but a recent in-depth study of 50 apartments shows that the average is almost twice as large, 115

kilowatt-hours per square metre annually. It is below the Swedish average on 140 kilowatt-hours per square metre, but with low residential density shows that the per capita energy use is better in areas with smaller apartments or bigger families, thus leading to sharp criticism regarding the “twice as good as the norm” and environmental profile that Hammarby Sjöstad claims to have. Furthermore, the high investment costs that are necessary to undertake for the creation of the area has led to high rents, raising questions around social sustainability of districts resembling to Hammarby Sjöstad (Wangel, 2013).

6.7 Matrix

To summarise the comparison and evaluation of the models and case studies, a matrix is put up to provide the reader with a short descriptive explanation regarding the four criteria, divided into: holistic approach, interconnections of subsystems, adaptability and working procedure in Table 8.

Table 8. Comparison of models in a matrix

	Holistic Approach	Interconnections of subsystems	Adaptability	Working Procedure
SymbioCity	Focus on ecological factors, but includes economic and social aspects.	A thorough base that stresses the importance of finding synergies between subsystems	States that it can be applied flexibly and gives general guidelines and methods to support sustainable urban development.	One of its three key aspects is named "working procedure" and has an easy step-by-step manual to work from.
Eco² City	Focuses on the synergy between ecological and economic sustainability with some including social aspects.	"The one-system approach" explains the value of planning, designing and managing interconnections to understand how parts fit into the whole.	Has stated a niche towards less developed regions. Provides a point of departure and needs to be customised for the context of a city project.	Focus on strong leadership along with coordinating and aligning actions of all stakeholders. Sharing of information regarding decisions and the possibility to affect decisions from the public is encouraged.
Smart City	Reliance on ICT-solutions towards ecological and economic efficiency.	Big collecting of data and information aiming to allocate all interconnections of subsystems.	Relies on advanced technology, which could be out of price range or hard to implement for less developed or poor regions.	Depending on what smart city model to evaluate, the working procedure differs slightly. Relies on making "smart" innovative decisions and collecting large amounts of information and data.
BREEAM Communities	Considers a range of aspects within social, economic and environmental sectors.	Has put up a list of subsystems that are considered depending on a project's prerequisites.	Chooses areas to cover in collaboration with project developers to suit local conditions.	Helps in the initial planning and designing process, then leaving the local developers to carry out the project, to later on serve as an evaluation tool.
Rethink City	The criterion "The holistic approach" serve as an overlapping component valid for criteria within, especially the environmental sector.	Stresses the importance of interconnections. Is however not very deeply formulated.	Hard to evaluate, since there is not a clearly formulated idea of implementation and no directly linked case to the framework.	The building sector should serve as an improving actor towards sustainability and is considered to be of great importance
Hammarby Model	Holistic approach primarily within the environmental sector.	Strong interconnection between, energy, waste and water sectors.	Was derived from the case of Hammarby Sjöstad, and has been discussed that the cost of the project has led to high rents, thus only making it affordable for more wealthy residents.	Since the model relies on the case of Hammarby Sjöstad it exemplifies the working procedure from its own experiences.

7. Discussion and Conclusion

The outcome of the report is, as stated in the introduction chapter, a delimited and summarised way of evaluation of the models that were further analysed. The uncertainties regarding definitions of sustainability, what aspects to consider when referring to sustainable urban development models, and even what is being considered as a model or simply a concept for promoting sustainability has delimited the depth of analysis. The list of uncertainties could be made longer, but since these are working definitions and tools it might not be possible to concretise arguments and recommendations in a concise and summarised way due to the complexity and scale of the subject. Instead, one should consider the fact that the subject is getting more attention and being widely recognised in the striving for a future where sustainability is promoted, in developed as well as less developed regions. There are also questions raised on how aggressive and how soon actions need to be applied to face a growing global population and increasing affect on the environment. Less pollutant and more energy effective urban areas are a part of this, but questions still remain if actions are going in a slow pace or are not applied aggressively enough to not compromise future generations needs.

Models have their own way of presenting urban sustainable development. There are differences in focus areas, depth of description and adaptability, but all originating from the same initial thought with different interpretations on how to form sustainable urban areas. Every model mentions the importance of integrated planning and designing, i.e. having a holistic approach, and that interdependencies and synergies are of great importance. The SymbioCity approach, Smart Cities model, Eco^2 City and the Hammarby Model all have a thorough base and could be applied in the planning, initiating and follow-up process whereas Rethink City is, as stated, a supplementary sustainable thinking framework and finally the BREEAM Community is a model that enters in the planning process and eventually returns as an assessment tool of the project.

Even though it is hard to point out aspects in models and frameworks that makes them “good” or “bad”, since most of them are complementary to a basic idea of the development of a city, for existing as well as non-existing cities, it is possible to draw conclusions of some key aspects that seem to be essential in order to succeed. Some lessons learned in the case of Curitiba, which can be considered to have a positive outcome, is the performance from the mayors and IPPUC whom have showed great leadership and continuity in the proceeding of the project. Furthermore, the environmental education of all society groups - with focus on including the less fortunate population – a clear provision of information that affects the project, in combination with public awareness and participation in city programs has all been crucial factors to facilitate the advancement of reaching established goals. These factors are also recognisable in Charlotte, North Carolina where citizen participation is promoted and seems to be an inevitable factor for the shift towards sustainability living possible. In Hammarby Sjöstad interconnections of subsystems has been implemented successfully but, as discussed in the previous section, the energy-targets set for buildings are far above the project target. The collaboration between the three Swedish companies (Stockholm Energi, Stockholm Vatten, Skafad) has turned out well. Even though Glashusett (Glashusett, 2014) gives lectures in sustainable, the educational component of reaching out to the local residents seems to be lacking in order to achieve

even better results. In Caofeidian city, the collaboration between the Swedish and the Chinese has come to a point where cultural differences, delayed payments and lack of active participation from the Swedish institutions after the initial phase has led to progress delay. Since the city does not carry any residents for the moment, there are uncertainties regarding public awareness and participation. This in combination with the large scale of the project makes it more ambitious and simultaneously riskier than the other city projects evaluated. Lastly, in Castleward the planning was carried out in collaboration with BREEAM employees and has also been evaluated according to the evaluation tool provided by BREEAM. It makes it easier for the community to address weak spots, after getting the rating, and authorities knows where more effort is needed in order to achieve a higher rating in the future.

To summarise the conclusions drawn from the cases, it shows that even though a model such as the SCA-approach has a width of areas covered and a well-defined framework, it does not necessarily mean that it ensures successful outcomes. It may strengthen its credibility and it is applicable in many contexts but for models such as Eco^2 City and Smart City the city projects has turned out to be better at least for now. Caofeidian City may reach better results in the future when the project is finished and better assessments can be made, but as stated it has suffered from financial issues, conflicts of interests and project delays.

Strong leadership, a clear objective that is realistic given the budget, in combination with private and public participation and awareness all seems to be components to reach success. An easy-to-follow, descriptive framework may facilitate the process for planning, implementing and evaluating a city project but a close collaboration is essential to reach maximum potential. Finally an effective economic resource use where decisions are made through the application of synergies, long-term perspective in mind and clear compromises so that conflict of interest is avoided are all parts of reaching ecological, economic and social sustainability in urban development.

7.1 Future Work

For coming bachelor science projects in the sustainable urban development area, it is suggested to delimit more to investigate a single model or project further and make a deeper analysis than this project has provided. Apart from that, an interesting thought would be to compare the original idea of an Ecocity – to live in harmony within the means of the environment, relying heavily on human awareness and scarceness of natural resources – with the Smart cities that promotes an innovative, high-technologic society where the awareness centres from quantitative collecting of information and data. It would also be a qualitative study, and since the subject includes social and economic aspects it would be of interest on how other programs, such as economic and political science programs, interpret their perspective on sustainable urban development.

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