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New approach addressing sustainability in urban areas using sustainable city models

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New approach addressing sustainability in urban areas using sustainable city models

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A brief analysis of the environmental, social and economic paradigm of today's cities, allows a simple conclusion to be reached: current cities are not sustainable. Considering this, it is very important to study the causes of city problems and to develop city models implementing sustainability practices. There are a limited number of studies developing sustainable city models, but in the scientific community there is an even greater lack of studies about the rehabilitation of current cities to implement these models. This work emerges with the objective of analysing how it is possible to implement sustainability practices in cities through the development of a sustainable city model and an urban rehabilitation plan. The development of sustainable city models is a very complex topic and the analysis of the literature shows that it is necessary to consider the relation between environmental and social aspects in the development of sustainable cities, while taking special care when considering the economic issues. It was also concluded that sustainable city models and rehabilitation plans should be subject to sustainability assessments and should consider the active participation of the city inhabitants. In fact, a city can only be sustainable if its population is in harmony with the city model and we can only assess results by predicting and measuring performance levels.

Keywords: sustainable cities; urban rehabilitation; sustainable city models

1. Introduction

Our planet has been suffering profound changes since the industrial revolution. Due to these changes, the world faces serious problems in the beginning of the twenty-first century at environmental, social and economic levels. These problems are caused mainly by the conjugation of three main factors: population growth, excessive resources consumption and increase in pollution (of air, water and earth). The construction sector is responsible for a significant amount of these negative impacts on the planet, being associated with the extraction of about 24% of the raw materials, and the consumption of almost 40% of the energy consumed, in Europe [1], producing 35% of the gases contributing to global warming [2]. The sector also produces 22% of all wastes in Europe [3] and 40% of all wastes at a global scale [4]. These environmental impacts combined with the high importance at social and economic levels show that the construction sector is not sustainable. This fact is even more notorious when shifting from the building scale to the city scale.

It is commonly recognised that today's cities are unsustainable. The World Wildlife Fund, in collaboration with the Global Footprint Network indicates the concept of environmental footprint as a suitable indicator to quantitatively assess the sustainability level of the planet and its cities. In this report, Europe has an ecological footprint of 4.72. This means that if the entire planet were to follow the lifestyle of the European inhabitants, 4.72 planets would be needed to meet the needs of the world population. The world average ecological footprint is 2.7 [5]. Jorgenson and Clark also conducted an analysis of the ecological footprint per capita of nations showing that society has already surpassed the carrying capacity of our planet [6]. Motesharrei argues that current trends could lead to the collapse of civilisation as we know it [7].

Since the 1990s, the application of the sustainable development concept in the construction sector has been considered as one of the main solutions to solve environmental problems and the concept of sustainable construction has emerged. Aiming to contribute to the implementation of this concept, Building Sustainability Assessment (BSA) methodologies have been developed since then. BREEAM (Building Research Establishment Environmental Assessment Method) was the first environmental assessment method for buildings and was developed in the UK by researchers from BRE (Building Research Establishment) during 1988 [8]. Shortly after, in 1996, three important BSA tools were launched: the American LEED (Leadership in Energy and Environmental Design) established by the US Green Building Council [9]; the SBTool (Sustainable Building Tool), developed by a team of stakeholders from more than 20 countries [10]; and the HQE (Haute Qualité Environnementale) developed in France [11].

Currently, there are dozens of BSA tools available on the market for assessing sustainability in construction. Some of these are adaptations of the SBTool methodology, such as SBTool PT developed in Portugal [12], SBTool

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CZ in the Czech Republic [13]; Protocol ITACA in Italy [14] and Verde in Spain [15]. These methodologies are recognised as a way to enhance the application of the concept of sustainable construction, improving the performance of buildings and setting good practices that minimise the environmental impact of buildings [16].

However, some researchers are sceptical about the application and some concepts used in BSA tools. The main criticisms are related to the efficiency of these methods in the assessment of sustainability and their effectiveness in improving the built environment [17,18]. One of the issues is based on the fact that these methods do not take into account the relationship between the buildings and the carrying capacity of the environment, since the assessment is performed by comparing the building's performance to benchmarks. These benchmarks are normally obtained based on the average performance of normal buildings and high performance buildings. The average performance of normal buildings is normally defined as the performance of buildings using current construction techniques (low performance). This may result in the assignment of sustainability levels that are not in line with reality because new buildings are normally slightly better than conventional buildings, therefore always getting high performance levels when compared to these benchmarks. In sustainability assessments the attribution of A and A + ratings is common. Nevertheless these buildings may be unsustainable when compared to the carrying capacity of the environment in which they operate [18].

Another common criticism is that these methodologies only assess the buildings when they should evaluate the entire set of buildings and infrastructures at a broader scale. In fact, a building does not operate as an isolated element but as an element that interacts with its surroundings within an urban area. The scientific community is beginning to absorb this idea and there are some emerging studies that argue that sustainability should be considered at the city level [19].

Taking this into account, recent initiatives have emerged to assess sustainability in urban planning. In 2008 BRE launched BREEAM Communities [20] for the evaluation of small enterprises and urban settlements. This methodology has already been updated in 2012. In 2009 LEED also launched a module for urban planning called LEED for Neighborhood Development [9]. Association International Initiative for a Sustainable Built Environment (iiSBE) International convened a working group composed of urban technicians from various countries (Urban assessment working group) and is also developing a tool for the same purpose, SCTool (Sustainable Communities Tool) [21].

There are some studies that define sustainability criteria that cities or communities should satisfy, but there is still much work to do in the definition of sustainable city models and how to implement these models in today's cities. Considering this important research gap, this work aims to analyse the processes and stages needed to transform today's cities into sustainable cities.

2. Insights from the state of the art

2.1. *Sustainability in today's cities*

With a growing world population and its continuous migration to cities, the modern city needs for energy, food, water and other materials have increased dramatically and are suppressed almost exclusively through importation, usually at great distances. This growing dependency of goods across borders puts the environment and life support systems on earth at risk [22]. In fact, the culture of importation and exportation fostered by globalisation and the current consumerism model completely neglects the environment and is unfavourable to society. The increasing dependence of urban societies on foreign goods causes a decrease in local production capacity and consequently causes social and economic dependency. The loss of local power in cities and countries allows the well-being of the communities to be placed in the hands of a small number of companies and people who often have no understanding or respect for the environment, the community and its cultural interests, and the local economy [23].

The companies of the construction sector are an example of this problem, because they have no economic incentive in the consideration of environmental and social aspects in their business [24]. Taking this into account, there is the promotion of an excessive consumerism in favour of the economic performance of these companies [25], resulting in an unsustainable built environment, especially considering the environment [26]. The large volume of construction in the last 30 years was economically advantageous for construction companies, especially those that were linked to public works. However, due to excessive construction, a housing bubble triggered the 2008 economic crisis. Eurostat data (Figure 1) clearly show that in Europe 27, the construction sector had a continuous and uninterrupted growth until 2008 [27].

For example, according to the results of the Portuguese 2011 census, the city of Braga, with 125,000 inhabitants, has an oversupply of about 19,000 dwellings (70,000 houses) in relation to the number of families (51,000 families). In Portugal there are 45% more households than families [28]. This shows that housing has not increased as a consequence of population growth that occurred in the cities, countering the theory of supply and demand. Amado supports this conclusion stating that in Portugal, the boom of urban expansion was regulated with insufficient and inadequate legislative principles, which led to a territorial organisation without rules and planning

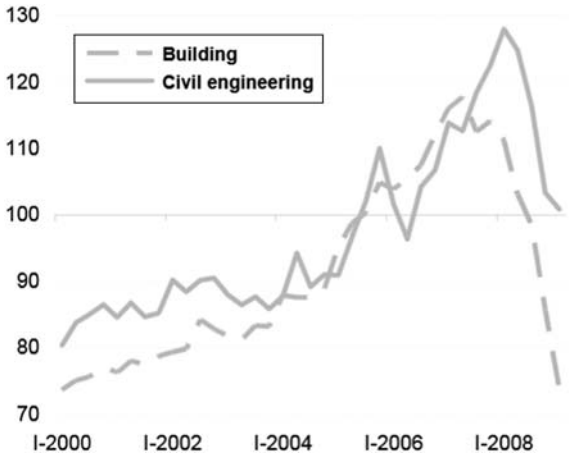

Figure 1. New construction in Europe 27 (EU-27) separated by building and engineering works (2005 = 100%).

[29]. This conclusion can easily be extrapolated to other regions and countries. Barbosa *et al.* demonstrated this fact with a mathematical analysis of the assessment methods currently used in municipal regulations and in Building Sustainability Assessment Tools such as the Gross Floor Area Index and Implantation Area Index, which do not provide adequate results and can promote unsustainable practices [30].

Regarding the serious problem of overbuilding, there is also a set of problems related to the way of life of urban populations which make cities unsustainable. Taking into account the present economic model of consumerism in today's society, there is a huge unnecessary consumption of materials and products that results in an excessive extraction of raw materials and production of waste, when compared to values of rural populations. Considering that the materials' life cycle is not a closed loop, since many waste products end up in landfills, implementation of sustainable development in cities and in society is a big problem to be solved.

Air pollution and noise in urban areas are also factors that degrade the quality of life in cities. These problems are often forced by the imbalanced urban development and increased mobility needs and traffic. There are some regulations to tackle these issues but they are often not complied with [31].

2.2. *Criteria for the development of sustainable cities*

Considering these problems in current cities, it is imperative to create guides and models of organisational planning of urban areas that can be followed and applied to cities to implement sustainable development [29]. Thus, it is crucial to define land-use policies taking into account sustainability criteria [32,33].

Most existing studies seem to agree and point to the concept of cities with tall buildings, high-density construction areas and minimisation of land occupation with small needs for materials and transport, as the solution for the development of sustainable cities [17,30,34–39]. Doughty and Hammond assert that a cluster of high-density buildings, providing they have a well-integrated network of infrastructures and transportation systems, can improve the energy efficiency of cities and reduce their environmental impacts [37]. Compact cities may have an important role to ensure the efficient use of resources in certain urban areas because they can be designed to improve the energy efficiency of the built environment, promote the use of public transport and non-polluting alternatives such as cycling and walking and further improve the reliability of waste recycling and reuse of materials and products. Dobbelsteen and de Wilde defend however that high-rise buildings should have a limit to the number of floors from which the environmental burden surpasses the gain in land-use efficiency [39].

There are other studies that consider different aspects for the design of sustainable cities. For example, Shan and Xingkuan consider aspects of aesthetics and art in buildings, but neglect aspects related to the environment, society and economy [40]. Huseynov, and Ramos and Rocha believe that cities must contain large green spaces to be considered sustainable [33,41]. Robertson refers to the importance of defining a multidisciplinary team in the design of a sustainable city [42]. Cho and Lee emphasise the importance of the satisfaction of the inhabitants in sustainable communities, mainly addressing the social component [34]. Mendes also believes that one aspect to consider is the quality of life of the population [43]. Bragança *et al.* consider the importance of the orientation of buildings due to the planning of public roads to reduce the energy consumption of cities [44]. Mitchell and Casalegno developed the concept of a sustainable city based in a highly efficient infrastructure system in order to reduce the environmental impacts associated with transportation and car dependence [45].

Other authors developed assessment indicators and calculation methods to assess sustainability in urban areas. Silva and Mendes developed an assessment indicator for air quality and acoustic comfort in cities [31] and Silva et al. developed calculation methods for the assessment of urban mobility in cities [46]. Danko and Lourenço developed a set of indicators to assess the sustainability level of urban wastewater management systems [47]. Rosales [26] proposes a set of indicators taking into account a variety of elements such as the metabolism of the city, the level of self-sufficiency, city vulnerability, the certainty of land tenure, safety, the quality of habitat and others.

Nevertheless, these studies did not seek, in a holistic approach, to define the criteria that cities should fulfil to be considered sustainable, focusing only in some aspects. This

neglects the complexity of the interrelationship and interdependence of the various issues that must be addressed together in the development of sustainable cities.

2.3. Sustainability assessment in the development of sustainable city models

Rosales asserts that the definition of sustainable city should take into account a holistic view of sustainability and highlights the importance of quantifying the sustainability levels by the assessment of several indicators [26]. In fact, the multidisciplinary approach to sustainability is recognised in studies dedicated to BSA tools, in which criteria are defined encompassing various aspects simultaneously. And these criteria can be adapted to the urban level for the development of sustainable urbanisations [48]. The evaluation of sustainability of urban environments is very important and Danko and Lourenço argue that sustainability assessment is the first logical step in the development of plans to improve sustainability in urban environments. A preliminary assessment of sustainability levels allows an efficiency of time and resources related to the complex tasks of data analysis and problem solving, which usually occur in such operations [47]. Taking this into account, some existing urban sustainability assessment tools define indicators for assessing the sustainability of urban environments. Tables 1 and 2 present the indicators used in BREEAM Communities [20] and LEED for Neighborhood Development [9], respectively. It can be verified that both methodologies consider several indicators or criteria in the sustainability assessment of urban areas. These indicators are inserted in categories, larger groups of indicators, to which they are related. These frameworks intend to provide holistic assessments and include most aspects that can be considered in urban planning and urban rehabilitation. Nevertheless, they follow different strategies confirming that there is still no consensus in the approach, aspects and calculation methods of these tools.

2.4. Economy and sustainability in cities

Some studies advocate that to consider a city sustainable, it must be self-sufficient in terms of energy, materials, food and water [23,24,50,51]. Grewal and Grewal define a self-sufficient city as one that is able to meet its basic needs without recurring to importation, working in a closed loop [23]. Grewal and Grewal also proved that a city can be totally independent in energy, using currently available technologies [23] and in food production, with the adoption of modern production technologies such as efficient vertical farming [24]. These authors express the importance of increasing the self-sufficiency of cities because this property boosts the efficiency and sustainability in resources usage, increasing the autonomy and economic resilience against the negative effects of the global economic crisis.

Table 1. Framework of BREEAM Communities 2012 [20].

GOVERNANCE	
GO 01 – Consultation plan	GO3 – Design review
GO 02 – Consultation and engagement	GO4 – Community management of facilities
SOCIAL AND ECONOMIC WELLBEING	
SE 01 – Economic impact	SE 10 – Adapting to climate change
SE 02 – Demographic needs and priorities	SE 11 – Green infrastructure
SE 03 – Flood risk assessment	SE 12 – Local parking
SE 04 – Noise pollution	SE 13 – Flood risk management
SE 05 – Housing provision	SE 14 – Local vernacular
SE 06 – Delivery of services, facilities and amenities	SE 15 – Inclusive design
SE 07 – Public realm	SE 16 – Light pollution
SE 08 – Microclimate	SE 17 – Labour and skills
SE 09 – Utilities	
RESOURCES AND ENERGY	
RE 01 – Energy strategy	RE 05 – Low impact materials
RE 02 – Existing buildings and infrastructure	RE 06 – Resource efficiency
RE 03 – Water strategy	RE 07 – Transport carbon emissions
RE 04 – Sustainable buildings	
LAND USE AND ECOLOGY	
LE 01 – Ecology strategy	LE 04 – Enhancement of ecological value
LE 02 – Land use	LE 05 – Landscape
LE 03 – Water pollution	LE 06 – Rainwater harvesting
TRANSPORT AND MOVEMENT	
TM 01 – Transport assessment	TM 04 – Access to public transport
TM 02 – Safe and appealing streets	TM 05 – Cycling facilities
TM 03 – Cycling network	TM 06 – Public transport facilities

Table 2. Framework of LEED for Neighborhood Development [49].

SMART LOCATION AND LINKAGE	
SLL 01 – Smart Location (Prerequisite)	SLL 08 – Access to Quality Transit
SLL 02 – Imperiled Species and Ecological Communities Conservation (Prerequisite)	SLL 09 – Bicycle Facilities
SLL 03 – Wetland and Water Body Conservation (Prerequisite)	SLL 10 – Housing and Jobs Proximity
SLL 04 – Agricultural Land Conservation (Prerequisite)	SLL 11 – Steep Slope Protection
SLL 05 – Floodplain Avoidance (Prerequisite)	SLL 12 – Site Design for Habitat or Wetland and Water Body Conservation
SLL 06 – Preferred Locations	SLL 13 – Restoration of Habitat or Wetlands and Water Bodies
SLL 07 – Brownfield Remediation	SLL 14 – Long-Term Conservation Management of Habitat or Wetlands and Water Bodies
NEIGHBORHOOD PATTERN AND DESIGN	
NPD 01 – Walkable Streets (Prerequisite)	NPD 10 – Transit Facilities
NPD 02 – Compact Development (Prerequisite)	NPD 11 – Transportation Demand Management
NPD 03 – Connected and Open Community (Prerequisite)	NPD 12 – Access to Civic and Public Space
NPD 04 – Walkable Streets	NPD 13 – Access to Recreation Facilities
NPD 05 – Compact Development	NPD 14 – Visitability and Universal Design
NPD 06 – Mixed-Use Neighborhoods	NPD 15 – Community Outreach and Involvement
NPD 07 – Housing Types and Affordability	NPD 16 – Local Food Production
NPD 08 – Reduced Parking Footprint	NPD 17 – Tree-Lined and Shaded Streetscapes
NPD 09 – Connected and Open Community	NPD 18 – Neighborhood Schools
GREEN INFRASTRUCTURE AND BUILDINGS	
GIB 01 – Certified Green Building (Prerequisite)	GIB 12 – Rainwater Management
GIB 02 – Minimum Building Energy Performance (Prerequisite)	GIB 13 – Heat Island Reduction
GIB 03 – Indoor Water Use Reduction (Prerequisite)	GIB 14 – Solar Orientation
GIB 04 – Construction Activity Pollution Prevention (Prerequisite)	GIB 15 – Renewable Energy Production
GIB 05 – Certified Green Buildings	GIB 16 – District Heating and Cooling
GIB 06 – Optimize Building Energy Performance	GIB 17 – Infrastructure Energy Efficiency
GIB 07 – Indoor Water Use Reduction	GIB 18 – Wastewater Management
GIB 08 – Outdoor Water Use Reduction	GIB 19 – Recycled and Reused Infrastructure
GIB 09 – Building Reuse	GIB 20 – Solid Waste Management
GIB 10 – Historic Resource Preservation and Adaptive Use	GIB 21 – Light Pollution Reduction
GIB 11 – Minimized Site Disturbance	
INNOVATION	
IN 01 – Innovation	
REGIONAL PRIORITY	
RP 01 – Regional priority	

Despite this, among some authors there is some criticism about the concept of self-sufficient cities, stating that it is a utopian concept [37,52]. They assert that sustainability is a desirable and attainable goal at the global scale, but do not agree that is achievable locally. However, they recognise that the causes of the problems of current cities are the excessive importation and unnecessary transportation of resources. Parkin considers that the implementation of sustainability in cities puts severe restrictions on the economic development of countries and companies and therefore can be considered impractical in the short or medium term, pointing to 2050 or after 2100 to achieve progress in the implementation of sustainability on the planet taking into account the current conditions [52].

However, some authors argue that to achieve sustainability goals, the problems that should be addressed are those related to the environment and its carrying capacity, as well as the population lifestyle while the economic aspects should not be considered [17,35,53]. Senbel *et al.* argue that ecology and the implications of human consumption patterns are two environmental aspects that are not well represented in metrics based on economic performance [17]. Lewis and Brabec agree stating that the key factor in the analysis of a pattern of urban planning in sustainability is actually quantifying its impact on the ecological systems [53]. Fresco points to the economic development as an obstacle to the achievement sustainability and considers that the current economic model is the main cause of problems in cities and in the world [51]. The circular city and society envisioned by Fresco promotes equality between citizens and since the existence of money can cause inequalities, Fresco has created a new system to replace the monetary system, often called a 'resource-based economy'. This system has gained particular notoriety and receptivity in recent years as a result of the financial collapse and publicity in social media. It becomes important to consider the social aspects of economic equality in the operation of cities and

communities. More and more, the economic aspects in the development of sustainable city models and rehabilitation plans should be aimed at promoting life quality to all inhabitants instead of promoting economic development of companies or local governments [7,50].

2.5. *Considering human behaviour in the development of sustainable cities*

Another research field that is very important and supported by a vast number of authors is that the development of sustainable cities must consider social issues and the willingness of inhabitants. Wener and Carmalt [36] claim that sustainable buildings and therefore sustainable cities should be designed to meet basic human needs, taking into account the psychological effects and behaviours of individuals. The success of a sustainable city model, based on a good technical and environmental performance, depends largely on the degree to which designers are able to understand and predict human behaviour and activities and their ability to use this knowledge to develop spaces that meet these needs [36]. Girardet's concept of a sustainable city is that the organisation of spaces should allow its citizens to meet their needs, improving the life quality without damaging the natural environment or the quality of life of neighbouring populations, present and future [54]. Robertson [42] and May [55] highlight the importance of considering the social aspects stating that given the complexity of the interactions between humans and the environment, solutions to environmental problems cannot be purely technical and therefore cannot be divorced from social, cultural and politic aspects. Ross goes further and says that if the current cities ever develop into sustainable cities, it will be due to social and political change and not due to technical improvements [56]. Fresco agrees and says that long ago there were technical means for the implementation of sustainability in cities and it is in the hands of citizens to act to implement sustainable practices [51]. Amado *et al.* highlight the importance of defining city models taking into account the wishes of the local population and conclude that public participation is mandatory during all stages of the organisation of the territory in order to ensure a proper relationship between the community and the proposed urban form [57]. Fonseca and Ramos also argue that inhabitants should be involved in the decision-making processes related to urban planning policies [58]. Taking this into account, it becomes necessary to predict human behaviour and to include social participation in the development of sustainable city models and rehabilitation plans.

2.6. *Existing sustainable city models*

Although there are many studies about the characteristics that cities must fulfil to be sustainable, there is a lack of studies in which there are proposed new models for sustainable cities. The first studies on models of urban planning in cities began in the nineteenth century with the expansion of industrialisation and increasing population migration to cities. In 1923 Burgess proposed the circular city model with concentric functional rings. This model was applied to the city of Chicago. It contains a strong industrial and business centre and concentric rings of residential areas of increasingly higher classes as the distance from the centre increases [59].

After the concept of Burgess, several models emerged throughout the twentieth century. For example the model of Hoyt in 1939, also known as the sectarian model and the model of Harris and Ullman in 1945, also known as the multi-core model (Figure 2) [60].

Despite the existence of these classic models of cities with circular forms, many existing cities evolved with a grid model, often organically and with some lack of planning. There was not a true effort throughout history to implement sustainability models in cities. In part this was due to economic constraints but also due to the fact that these models attempted to understand the expansion of cities by exploratory means, rather than to propose sustainability principles. In fact, the issues related to the carrying capacity of the planet and sustainability only began very recently, as stated before, long after the development of most of the cities of developed countries.

However, recently some initiatives emerged with the objective of designing and building sustainable cities. For

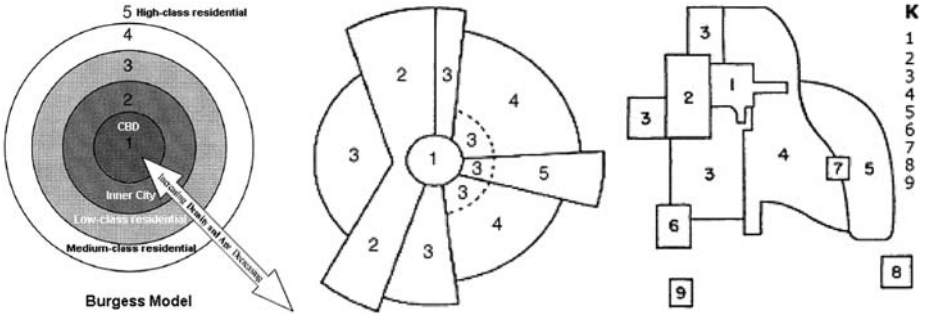

Figure 2. Burgess model (left) [59], Hoyt model (centre) [60] and Harris and Ullman model (right) [60] CBD = Central Business District.

example, Mendes proposes in his book 'The future of cities' the implementation of an innovative conceptual model of an incubator city, based on the implementation of five dimensions, the intellectual city, the innovative city, the connected city, the authentic city and the sustainable city [61]. Another example of a model that has raised notoriety in recent years is the one from Jacque Fresco, which idealises a circular city with functional concentric rings, through the application of the latest technology to protect the environment and improve the lifestyle of populations. The city model of Fresco (Figure 3a), designed for cities up to one million inhabitants, adopts a resource-based economy, in a model where all waste is recycled and all energy comes from renewable sources, with efficient management of materials and resources [51]. This model makes predictions about the implications in the lifestyle of inhabitants but bases its predicted performance in assumptions and not in quantifiable sustainability assessments. Another example of a sustainable city model is the EcotownZ project (Figure 3b), a model of an ecological city with 150,000 inhabitants, which follows the traditional urban forms and can be built using current technology. The creators of the model claim that the city offers the best of urban and rural environments simultaneously and they can completely eliminate traffic problems, promoting the use of public transport, cycling and walking [62]. Despite the existence of these models, there have been many critics of them, as the implementation of a city of this type may involve building a city from scratch, as it would be very difficult to adapt an existing city to this idealised model of sustainability.

2.7. *Urban rehabilitation examples*

Despite some examples of cities being built from scratch, mainly in Asia, most of the existing efforts in the implementation of sustainability measures in cities have been conducted through the urban rehabilitation of existing cities. A common example is the city of Stockholm, in Sweden, which was considered the first European Green City by the European Commission [63]. Also in Sweden, the cities of Göteborg and Hammarby Sjöstad are referred to as sustainable cities and have been subject to major rehabilitations through time. There are numerous private and public initiatives to implement sustainable principles and labels in cities, especially in northern Europe and particularly in the Scandinavian countries. As examples, it is possible to mention the cities of Bristol, Leicester and Middlesbrough in England, Nantes in France, Rotterdam in the Netherlands, Aalborg, Ballerup and Frederikshavn in Finland, Oslo in Norway, Copenhagen in Denmark, Vitoria-Gasteiz in the Basque Country and Frankfurt, Freiburg, Hamburg and Kronsberg, in Germany, among others [64].

However, these examples do not follow a long term sustainable city model as the target for their urban rehabilitation. In these cities, there are efforts towards sustainability, which is commendable, but it can be argued that these efforts do not encompass all aspects of sustainability holistically and are not enough since they are not coordinated. The title of 'sustainable city' may be assigned improperly since there is the promotion of some individual measures, recognisably good for the implementation of sustainability, but the cities are not really sustainable as a whole.

Despite these recent cases (twenty-first century), there are much older examples such as the case of Paul Glover's plan to transform the city of Los Angeles (which is usually considered unsustainable) into a sustainable city. The plan includes changes to the technical design and in social, political and economic levels over 20 years in order to become a sustainable city [65]. However, Glover's plan was never implemented and ended up only as a proposal. The city of Los Angeles has evolved a lot since then and has greatly increased its environmental impact, being a case study in water importation at great distances. This poorly planned growth has occurred in many cities around the world, in which there are technical means to implement improvements to make them more sustainable but, in most cases, a lack of financial ability and/or political willingness to embark on these kinds of plans. It is therefore very important to study and develop sustainable city models and ways to implement these models through the rehabilitation of existing cities.

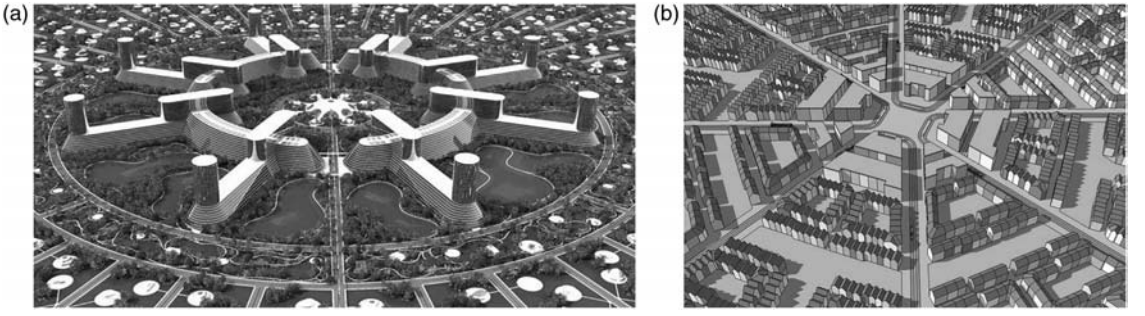

Figure 3. Examples of sustainable city models: a) Fresco model [51] and b) EcotownZ model [62].

3. Conclusions

The development of sustainable cities is a very complex subject. However it is urgent to act at this level to mitigate the environmental and social problems that are present in today's cities and societies around the world. It is argued that it is necessary to rehabilitate cities, mainly in historical centres. Nevertheless, rehabilitation should be done in a manner that follows predefined objectives in the form of a sustainable city model. To develop a sustainable city model, environmental and social aspects must be balanced, while being especially careful in dealing with economic issues.

It is important to note that the development of a sustainable city should be subject to sustainability assessment. Only with the use of quantifiable indicators is it possible to objectively address the performance levels and to compare holistically different models and decide on the implementation of the best solutions. These indicators should correspond to a set of criteria that cities should fulfil to be considered sustainable.

Moreover, a city can only be sustainable if the population is in harmony with its operational model, since the behaviour of a community is determinant on the performance level that can be achieved. Taking into account that in the design of a sustainable city, the operation of the communities should be considered, such as consumption patterns and lifestyle of the population, the opinions of the population must be predicted and studied in the design of a sustainable city. Thus, the design of a sustainable city model bounces off the strictly technical subject and addresses axiological issues related to the individual and collective willingness of people.

Finally, it is necessary to take into account that considering the state of development of most cities, it is difficult to implement some models of sustainability. In fact, many cities are implementing sustainability measures while disregarding sustainable city models. However, these measures have proven to be insufficient for implementation of sustainability in a holistic approach. Therefore it becomes necessary to study urban rehabilitation plans for long-term implementation of sustainable city models.

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