This paper is part of the Proceedings of the 11th International Conference
on Urban Regeneration and Sustainability (SC 2016)
www.witconferences.com

A sustainable city paradigm: criteria and indicators of efficiency

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Abstract

The debate on the sustainable city form has reached new horizons, and moved from theoretical perspectives and visions towards implication. This paper is a step towards reducing the gap between theory and practice. It aims to characterize a sustainable city paradigm as a framework through which the sustainable city can be visualized. This paper traces and reorganizes the different debates, scenarios, and visions concerning the sustainable city form in a framework entitled 'a sustainable city paradigm'. The paradigm consists of three proposed components; parameters, criteria and indicators. The paper is mainly focused on the characterization of the criteria and indicators of efficiency parameter as a major strand of sustainable city form. When the paradigm applied, the indicators resemble an instrument of criteria, and hence, efficiency's fulfillment. Once being characterized as a whole, the proposed paradigm is by no means a static model. Rather, it is a dynamic conceptual device to sensitize us to vision (out of many others) of what the sustainable city might become.
Keywords: sustainable city, sustainable city paradigm, efficiency.

1 Introduction

Global warming, air pollution, over population, the loss of brown fields and ozone layer depletion are some of the unavoidable consequences of invading the thresholds of environmental capacity [1–3]. Since man and the environment are two interdependent entities within a coherent system, a strong reaction to environmental crisis, and costs at the social and economical levels were also revealed; poverty, limited access to resources, intergroup tensions, population movement, institutional stress and breakdowns [3]. "Humanity cannot continue

to take the risks that will plague us for decades to come. There is only one Earth" [4, p. 9].

Researchers worldwide have reached an understanding that problems concerning humanity need to be identified at a global level, whereas manipulations and actions concerning solutions could be taken at the local one, and, subsequently, effective solutions could be guaranteed. As a result, a major shift in the field of sustainable city form took place; "the search for the ultimate sustainable urban form perhaps now needs to be reoriented to the search for a number or sustainable urban forms which response to [a] variety of existing settlement patterns and context" [5, p. 345]. Many researchers tried to approach this transformation by operationalizing the models of city form through setting down main principles, under which the characteristics of a sustainable city form could be categorized [3, 6–8].

This study is an attempt to investigate the concept of sustainable city form. In order to carry out this investigation the research traced, rearranged, and characterized debates concerning city form in a model entitled sustainable city paradigm. This investigation is considered to be an initial step in setting up and characterizing this paradigm. By using this methodology, the paper aims to characterize the sustainable city paradigm as a framework through which the sustainable city can be visualized. This paradigm consists of six main parameters: efficiency, responsibility, integrity, acceptability, liveliness and equity.

This paper will focus on the parameter 'efficiency' as a key issue of concern, out of many others, to those who search for sustainable city forms. Since cities are considered as the main consumers of energy, the question of energy efficiency of different types of city forms has been addressed by many researchers [9–13]. Emphasis is mainly placed on the reduction of energy consumed in buildings (whether in their construction stage or over their life time) and in transportation. Therefore, the search for efficient city form is of great importance. Being one strand of sustainable city thinking, issues related to efficiency of the city form need to be addressed and manipulated at the global and local level as well.

2 Cities and sustainability

In the light of the specific research conducted in this paper, the investigation of the efficiency of the sustainable city form, the most germane of research topics are: (1) a general review of studies on sustainable city; and (2) an investigation of efficiency and sustainable city.

2.1 Sustainable city

2.1.1 The evolution of sustainability

The first use of the word sustainability in connection with the environment was in 1980 in a publication of the International Union for the Conservation of Nature (IUCN) entitled 'World Conservation Strategy'. Nevertheless, this publication has limited impact on government policy. This gap has been overcome by the publications of the World Commission on Environment and Development, which

were sponsored by the United Nations like 'Our Common Future' or 'The Brundtland Report' in 1987 [14]. The concept of sustainability was central to Our Common Future's findings.

The more recent impetus for the concept of sustainability has been the Earth Summit in Rio de Janeiro in 1992 [3]. Its Proceedings have been published in a document entitled Agenda 21; a program designed to accelerate the implementation of sustainable development on an international basis, and can be seen as both a blue print and an action plan for sustainable development [15, 16]. The second United Nations world conference on human settlements 'Habitat II: the City Summit' in Istanbul in 1996, concentrated on a global agenda for cooperation by acknowledging the direct and vital contribution that productive and sustainable cities can make to social and economic advancement. The argument embodied three points: Sustainable cities are fundamental to social and economic development, environmental degradation obstructs the development contribution of cities, and finally, environmental deterioration is not inevitable [3, 17].

A simple way to conceptualize sustainability is to visualize a three-legged stool. The legs of the stool represent the economic, environmental and social impacts of a project. Equal emphasis should be placed on each of the legs, once applying this model, so that the design is balanced and the stool remains stable. Many people distort the definition of sustainability, by placing more emphasis on one of the three pillars [3, 15, 18]. Sustainability is a philosophy rather than a design technique – which can be applied to many different aspects of life. Sustainability may, thus, be viewed as a set of working principles that can be applied to a myriad of situations [3]. However, for the purpose of this paper, sustainability can be viewed as a framework through which change towards the welfare of community s social and economic systems can be managed and directed, yet with respect and in coherence with the environmental system.

2.1.2 Sustainable development

A generally accepted definition of this concept, which revolute from the Brundtland reports 'Our Common Future'; "Sustainable development is the development that meets the needs of the present generation without compromising the ability of the future generations to meet their own needs" [14, p. 43]. The general acceptance of this definition of sustainable development is largely due to its vagueness, and the fact that it means different things to different people as it depends on the person's point of view of the potential of technological progress and the regenerative capacity of the environment, in addition to views on equity and welfare [13]. However, according to Moughtin [1], this definition stresses three main points: development, need, and future generations.

Development should not be confused with growth. Growth is a physical quantitative expansion of economic system, while development is a qualitative concept concerned with the improvement and progress in cultural, social and economic dimensions [19]. Needs are related to the idea of distribution of resources. Also they vary a great deal according to social and economic differences [2]. The last point stressed in the definition is future generations, which introduced the idea of inter-generation equity. "We have not inherited the

earth from our parents, we have borrowed it from our children" [1 , p. 5]. In other words, despite the common assumptions, responsibility to future generations does not imply sustainability, even if this were not true, responsibility as a value cannot justify sustainable policies. Equity among generations implies similar conditions of life in each generation.

2.1.3 Sustainable city form

A sustainable city is viewed as a city where achievements in social, economic and physical development are made to last. It has a lasting supply of the natural resources on which its development depends (using them only at a level of sustainable field). It also maintains a lasting security from environmental hazards which may threaten development achievements [11, 20]. All the previous debates reveal the difficulty of defining the sustainable city, as there are as many definitions of a sustainable city as there are groups attempting to attain it [3]. However, for the purpose of this paper, the sustainable city is viewed as a city in the state of continuous dynamic balance seeking among its environmental, social, and economic attributes. It assures continuity with the past, yet it adapts to accommodate change. A key issue for achieving such a city is to find the city form which best serves its essence [5].

There is a strong link between city form and sustainable development, yet, it is not simple and straight forward [21]. It is also now widely accepted that the form of a city can affect its sustainability; and that a relationship exists between the shape, size, density and uses of a city, on the one hand and its sustainability, on the other, but the exact nature of this relationship is lacking consensus. It will be beneficial, first, to clarify what a sustainable city form might be. Williams *et al*. [22, p.4] considered a form to be sustainable if "it enables the city to function within its natural; md man-made carrying capacities; is 'user-friendly' for its occupants; and promotes social equity. The criteria that it should come about through inclusive decision making processes are also included." However, Moughtin [1] illustrates that lots of debate took place and a number of theoretical forms have been suggested for a sustainable city. The first is the compact high-density city. At another extreme are proposals for low density decentralized urban areas. A third school of thought suggests urban form based on policies for 'decentralized concentration'. The fourth theoretical position develops the concept of the sustainable city region extending the ideas of Howard and the Garden City movement.

The most significant of the debates concerning the sustainable city form is the debate on the compact city as the closest to the ethos of sustainable development. According to Jenks *et al*. [5, p. 5], a sustainable city "must be of a form and with compactness that encourage social interaction." Hillman [23] sets several elements that can be met in the compact city. These elements include; settlement patterns and housing forms with low energy requirements, diversity of land uses, public facilities and adequate open spaces at a scale and location which reduce the need for motorized travel, transportation strategies which give priority to walking and, cycling and promote public transport use [24, 25]. However, the most important benefit is that compacting cities promotes social equity, as services and

facilities are provided locally within walking distance to most of its inhabitants [5].

2.2 Efficiency and sustainable city form

Several main issues could be discussed under the umbrella of sustainable city form. However, efficiency resembles a key parameter discussed by many researchers and a key issue related to the sustainable city agenda [3, 8, 21, 26]. The question of energy efficiency of different types of urban forms has been addressed by many researches [3, 9, 21]. Building industry and transport are considered to be the main consumers of energy. Energy in the building industry is consumed in two different ways: energy capital and energy revenue. Energy capital is the energy used to construct both buildings and urban infrastructure, while energy revenue refers to the energy consumed throughout the lifetime of a building [5]. Therefore, this paper reviews the main issues that contribute to the efficiency of the built form which are: (1) conservation, (2) building materials, (3) building design, and (4) transport.

2.2.1 Conservation

Conservation is considered as the main priority of a development philosophy which takes sustainability on the top of its agenda. "Do not build unless it is absolutely necessary; other ways of meeting needs" [1, p. 18]. The reason for giving such priority to conservation is the pursuit of policies and the avoidance of community disruption. Conservation includes extending, adaptive re-use and finding new uses for existing buildings; of which go in harmony with its character and context [1, 10]. The decision of whether to conserve or demolish is neither easy nor straightforward, and many important and complicated issues should be considered beforehand. "Existing structures embody quantities of energy capital, their demolition usually means the loss of that capital, unless some of the material can be re-used, usually in a low grade capacity as hardcore or landfill.

An existing building however, may require energy capital inputs in terms of maintenance new equipment and insulation, or it may consume costly energy revenue to keep an outworn structure operation. Any new structure; replacing an old building requires energy capital for demolition and energy capital for its building. A resulting super-insulated new building served by passive or solar heating may, however, use little or no energy revenue from non-renewable sources.

2.2.2 Building materials

Building from the earth evokes the least damage to the environment. It is close to the building site, and when no longer required, it decomposes naturally returning to where it came from 'earth' [1]. Building contributes to the damaging of the environment in different ways; using non-renewable energy evolved in extraction, refining and fabricating of building materials, together with their transportation to the site, and in the construction process itself. The selection of building material with the least damaging impact on the environment is complex [10]. First, there is the need to consider the direct impact on the environment. Second, the energy

content of each material needs to be considered as it resembles an important signifier of the amount of pollution involved in its manufacturing. The third and most complex impact is the manner in which the material is being used within a building.

Energy content; the amount of energy used in manufacturing a material, is one of the paramount issues that should be considered. Moughtin [1] classifies building materials into three groups according to energy content; low, medium and high energy. The closer the material to its natural form, the lower its energy content will be. Therefore, the lower energy involved in manufacturing the material, the lesser polluting impact on the environment it will have. For economic dimensions, low energy materials (sand and gravel) are used in bulk, while higher energy materials (steel or plastic) are used in small quantities [1]. One more important aspect to consider is the energy involved in the transportation of the materials to the place of manufacturing, and then, to the building site. The closer the materials to the site the leaser energy and cost will be consumed.

2.2.3 Building design

"A building should be constructed so as to minimize the need for fossil fuels to run it" [9, p.70]. Several factors contribute to the efficiency of a building; the location of the building in relation to the means of access; the geometry of the building envelope; and the relation of the building to its site. A building should be located in close proximity to the main movement routes and infrastructure systems, or within walking and cycling distance of important connected activities [1]. Buildings should be flexible to adapt to changing needs and different uses. Flexibility of a building should rely heavily on renewable sources of energy; passive solar heating, natural lighting and ventilation. A building envelope, which is comprised of the external wall and roof, together with the ground slabs, is the part of the building where heat loss is registered.

Buildings with the lowest ratio for the area of envelope to the area of usable floor prove to be more efficient in terms of saving both energy capital and energy revenue. Thus, buildings with storeys are considered to be more efficient, provided that they do not exceed three to four storeys. As for buildings' width, it is associated with the necessity of achieving a good natural light to all main rooms. As the best lit areas of a building are within four meters of its external walls, the optimum width of a building is between nine and thirteen meters wide [1].

"Buildings should be designed to work with climate and natural energy source" [9, p. 84]. Haughton and Hunter [11] illustrate that the layout and orientation of buildings can lead to energy savings of 12% through passive solar gain. In this term, traditional cities and buildings have a leading role; "Traditional communities have been aware of the importance of building in harmony with nature. The very idea of community comes from the sheltering of people together, whether to provide maximum areas of shade and cooler air between buildings, or to reduce the external surface area of the community as it faced the hostile weather" [9, p. 70].

2.2.4 Transport

Much of the energy consumption debate rests on transport issues [3, 21]. A sustainable urban transport should encourage walking and cycling over other means of transport. It should also reduce the need to travel. One more important issue is that it should promote and give priority to public transport over private transport [27, 28]. Haughton and Hunter [11] point out that the most energy efficient forms of travel are cycling, walking, buses, and rail with car rated last. The need to reduce travel by car has several reasons, the most important of which is economic, as travel is not a productive activity, but a cost directly incurred by the traveler, or indirectly incurred by the consumer through high prices. It is also important for environmental reasons, as travel is considered as the most consumer of energy and the main cause of pollution. Not everybody has access to a car, so it is likewise important for its social reasons [29].

As for public transport, Haughton and Hunter [11] illustrate that it has its implications for urban form, not just in the sense of creating stronger sub-centers within the city fabric, but also, encouraging linear development of cities along its routes. It appears, therefore, that the coordination between land use and transport planning is essential if car-dependence is to be reduced. Such coordination could achieve several advantages [10, p. 99]: (1) greater population densities tend to mean that more services can be supported at the neighborhood level; this encourages walking and cycling, (2) larger cities tend to be more contained in terms of jobs and services, which makes some journeys shorter, and in a better position to support public transport, and (3) centralization or activities at selected points within the city region encourages the use of public transport.

3 A sustainable city paradigm

The debate, mentioned above, concerning the sustainable city form had moved forward and two important shifts were accomplished. First, the shift from the singular model approach (the compact city) towards the multi-model approach. The second important shift is towards operationalizing the models [5, 22]. However, "concentrating only on theoretical models of the most sustainable forms is of little practical use" [22, p. 3]. Models are usually viewed as blue prints to be translated into reality, and hence, they would be better used in "a much softer, more flexible fashion. Rather than viewing models as specifications for a city, they are better employed as conceptual devises to sensitize us to different visions of what the sustainable city might become" [26, p. 9].

The paradigm characterized in this paper is a conceptual framework which is consists of three proposed components; parameters, criteria and indicators. Parameters can be identified as the main principles that resemble any plan coefficient or objective. They are used to assess derivation from course. Criteria, on the other hand, are statements reflecting the requirements for achieving an objective modified by wider participation and feedback. Criteria would identify the acceptable specifications. Finally, indicators may be viewed as the quantifiable data that characterize the evaluated subject and concept in terms of its compatibility with the criteria and parameters. They are means for the evaluation

of the criteria fulfillment, and a benchmark for performance [15]. Indicators provide a way to involve citizens in setting targets and for measuring success in reaching them [3, 8].

Through the tracing of the different debates, viewpoints and visions related to sustainable city form mentioned above, the authors of this paper were able to characterize the sustainable city paradigm as a framework through which to visualize the sustainable city, and more important as a framework through which to test its applicability [30]. The Paradigm acts as a filter through which we can start to see what the sustainable city form of any city might look like. It is not a static model. To the contrary, it is a dynamic framework that is capable of adapting to changing needs. Feedback from the field is appreciated and adopted, and hence, the whole paradigm is in a state of continuous change to accomplish balance among its attributes (fig. 1).

As no single urban form can achieve all environmental, social and economic benefits [20], there are some discernible common threads that could be traced [5]. Therefore, the three components of the sustainable city paradigm are extracted and traced through these common threads and viewpoints emerging in debates concerning the issue of sustainable city form. Investigation is limited to one major theoretical area *which* is city form and two *minor* theoretical areas; street system and land use. Through the different debates concerning city form, street system and land use, authors of this paper were able to extract the different parameters of the paradigm in general, whereas a full characterization of the parameter 'efficiency' is presented in the next section. Fig. 2 illustrates the mechanism of the paradigm.

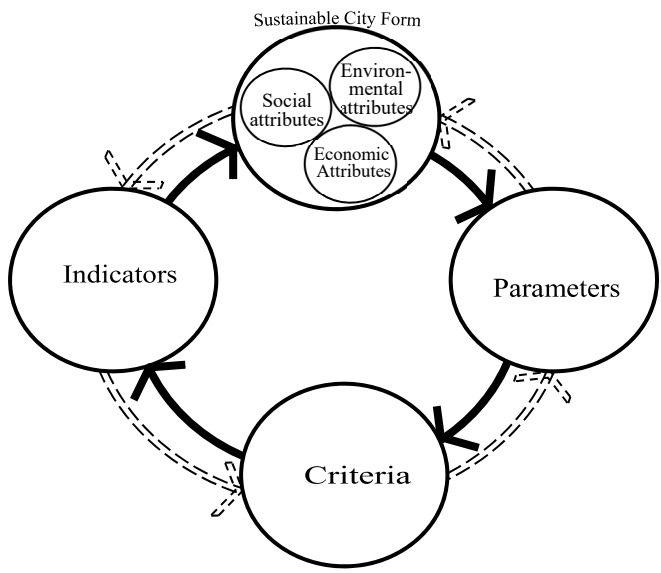

Figure 1: The dynamic nature of the sustainable city paradigm.

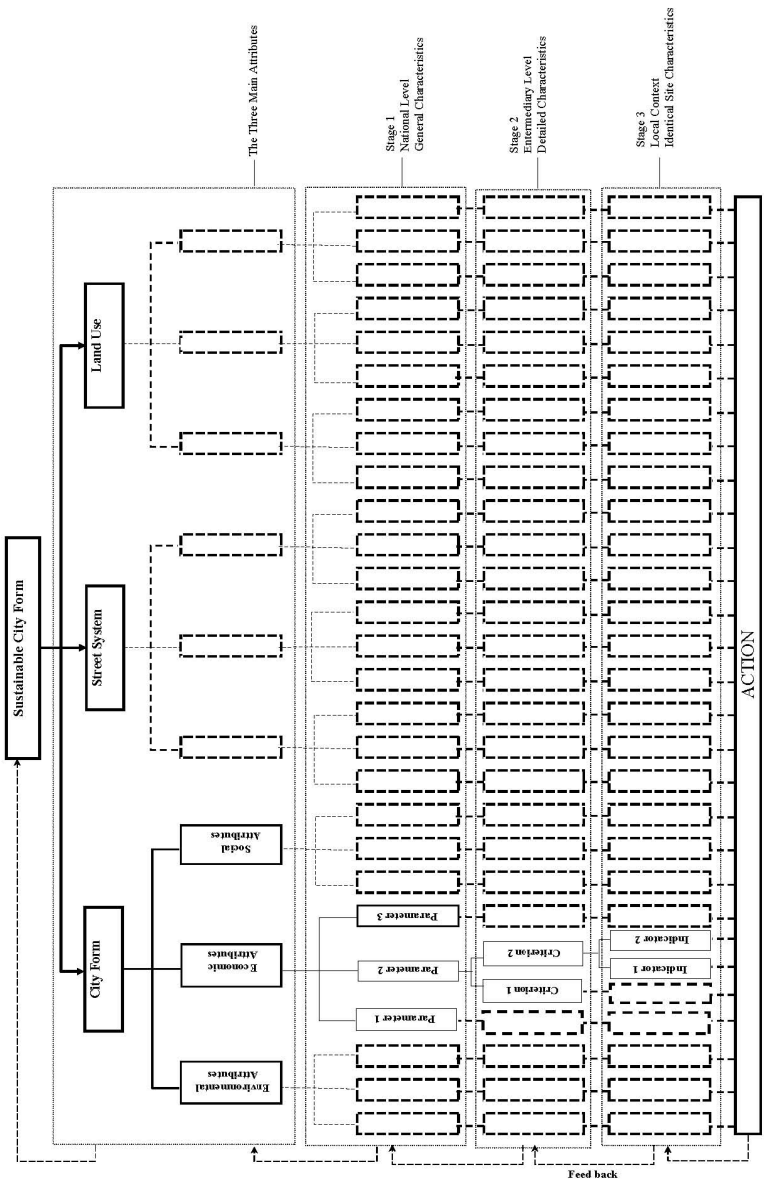

Figure 2: Conceptual diagram of the proposed sustainable city paradigm.

The main parameters of a sustainable city form categorized under three pillars; environmental, social and economic attributes of each area of concern to this paper [3, 8, 13, 28]. However, these attributes are highly connected and interrelated (for example one parameter could have environmental and economical attributes). A review of debates and viewpoints around the sustainable city form suggested that characteristics concerning sustainable city form categorized under six main parameters: efficiency, responsibility, integrity, acceptability, liveliness, and equity [3, 21, 31–34]. Efficiency is highly related to the reduction of energy consumed, either by buildings or by means of transport [1, 3, 5, 21, 22]. Responsibility, on the other hand, is related to resources saving and the prevention of pollution. Integrity has to do with the individuality of the city and harmony of the components [3, 7]. Acceptability is interrelated with the quality of life [7]. Liveliness links ecology with society based on the relation between people and the environment, contacts and diversity [3, 6, 20]. Finally, equity is understood as the fare distribution of resources, fair access to basic needs and services, and finally, participation [3, 20, 24].

The paradigm's components are categorized according to the environmental, economic and social attributes of each area of concern in this paper. The parameters, being the main general objectives of any plan, can be operated at the national level. As they resemble characterization of each of the parameters in order to facilitate their application, the criteria resemble an intermediary stage into the indicators, which ought to be dealt with and developed at the local context level. Resembling the specific applicable site characteristics, when indicators are implemented, feedback from the site is considered, and hence, modifications take place consequently from the indicator's level up to the city form's level.

4 The characterization of the criteria and indicators of efficiency

The development of a criteria and indicators of the efficient city form with respect to a local context and circumstances of any city is a major concern of this paper. Criteria are statements reflecting the requirements for achieving an objective. They are modified by wider participation and feedback [3, 6]. Therefore, each of the parameters analyzed into a number of descriptive statements, which resemble an intermediary stage into the indicators. These are the quantifiable data that characterize the evaluated subject and concept in terms of its compatibility with the criteria and parameters. They are means for performance [15]. The adoption of indicators could be of great importance since it has many advantages: (1) provide a way to involve citizens in setting targets and in measuring success in reaching them [3, 6], (2) resemble a feedback instrument for the fulfillment or accomplishment of expected results [3], (3) can be used as tools of allocation of the weakness in the functioning of community, and hence, support overcoming them and increase the quality of life [3, 6], and (4) help to better allocation of resources, both human and material [3, 13].

The sustainable city paradigm proposed in this paper characterizes the criteria and indicators of the efficient city form. It presents the common characteristics of

a city form which are related to: walkability, conserving and rehabilitating existing buildings, the use of local materials in construction along with using environmental friendly materials, and building design. It also presents the common characteristics of efficiency concerning street systems and land use. The paradigm indicated that a city form should promote and encourage walking, since walking is the most energy efficient form of travel [1, 5, 11]. This is both environmentally and economically efficient, as it minimizes pollution and noise, on the one hand, and is fuel efficient, on the other [3].

In hosting any new function, priority should be given to conserving and rehabilitating existing buildings, as replacing any structure requires energy capital for demolition and construction [1, 10]. Giving priority to conservation avoids community disruption and strengthens the bond between the community and its heritage [1, 3, 10]. The number of the rehabilitation projects is a strong signifier of tendency towards conservation.

Using local materials is both economically and environmentally efficient, as it reduces the need to transport the materials to the building site and, eventually, the energy and cost consumed [3, 21]. Using environmentally friendly materials; that is, with the least energy involved in manufacturing, reduces pollution and cost as well. Identifying building materials and their sources is a strong sign of locality, whereas the energy content of each building material is a sign and indicator of the degree to which the material could be considered environmentally friendly.

Buildings should be designed so us to consume the least non-renewable energy resources throughout its lifetime, and to work in harmony with both its site and microclimate. This could be achieved through building orientation, which enhances the ability of making use of natural daylight and ventilation, as well as building layout [11]. Another mechanism to reduce energy loss is through minimizing the building envelope. Along with building orientation and layout, the electrical energy consumed in the city could be a good indicator of harmony with the site and climate; the lesser energy consumed, the more efficient use of renewable sources in lighting and heating is and, hence, the more the building is environmentally and economically efficient.

Increasing densities, but not excessively, in the city is another point to be considered. This could be economically efficient as it means more services could be provided locally and therefore, reduce the need to travel [12, 23]. On the other hand, this factor could be socially efficient, as it tends to enhance the sense of community, and social equity among the inhabitants [12]. Researchers agree that densities should be located near nodal points, public transport, and the existing infrastructure [1, 11]. This is economically efficient as it reduces costs required in connecting buildings to services (electrical, water ...etc). Likewise, it is socially beneficial as it enhances the sense of community.

The common characteristics of efficiency, concerning street system, may include several points: encouraging walkability with its environmental, economic, and social benefits. Therefore, streets should be mainly oriented to host movement on foot [1, 5, 35, 36]. The second important point is encouraging travel by using public transport. This is environmentally efficient as it reduces pollution and noise. It is also economically efficient as it reduces energy consumption. On the

other hand, using public transport could enhance community spirit and the sense of equity [1, 5, 37].

There are two distinctive characteristics that ought to be prevailed concerning land use. The first is the encouragement of mixed-use developments; that is, a city that hosts a mix of housing, working, services, and entertaining facilities [11, 35]. The other important point, which interrelates with the previous one, is a reduction in the need to travel [1, 27, 34]. Both characteristics have environmental and economic benefits. The provision of mixed-uses reduces travel using fuel consumptive means of transport and, therefore, reduces pollution and is energy efficient. Socially, the provision of different land uses means a more contained community. Eventually, this enhances community spirit and social equity.

The common characteristics arc organized and summarized in Table 1 as the criteria and indicators of the efficient city form, street system, and land use.

5 Conclusion

The debate on the sustainable city form has reached new horizons. It moved from theoretical perspectives and visions towards implication. This paper is a step towards reducing the gap between theory and practice. It traces and reorganizes the different debates, scenarios, and visions concerning the sustainable city form in a framework entitled 'a sustainable city paradigm'. The paradigm consists of six parameters: efficiency, responsibility, integrity, acceptability, liveliness, and equity. The paper was mainly focused on the characterization of the criteria and indicators of efficiency parameter as a major strand of sustainable city form, although the whole parameters require lots of devotion and collaboration which is beyond the scope of this paper.

The development of a criteria and indicators of the efficient city form with respect to a local context and circumstances of any city is a major concern of this paper. The results revealed that the characterized sustainable city paradigm is a framework through which to visualize the sustainable city, and more important it is a framework through which to test its applicability. However, the paradigm characterized is not a healing recipe or a blueprint, it is rather a flexible framework or a vision out of many others and thus, disputable. And, the prevailing deficiencies do not necessarily assure the validity or the criteria and indicators concerning efficiency, on the contrary, it argues more research to test their validity. It also stresses an important fact; the importance of policies and strategies other than those associated with urban form should not be overlooked.

This research provides an approach out of many others, to investigate the sustainable city form of any city. When it applied, the indicators resemble an instrument of criteria, and hence, efficiency's fulfillment. Once being characterized as a whole, it will be noticed that the paradigm is by no means a static model. To the contrary, it is a dynamic framework that is capable of adapting to changing needs. It provides planners and city officials with a flexible framework, a filter through which to visualize each city's own version of sustainability.

Table 1: The characterization of the sustainable city paradigm.

Area of concern	Criteria	Indicators	Attributes
City form	1. Reduce decentralization [1, 5, 11, 35].	1. The distance from center to periphery should encourage walkability [1, 11, 35, 37].	Environmental economic social
	2. Priority to conservation [1, 4, 10].	1. The number of rehabilitation projects [*].	
	3. The use of local materials [1, 10].	1. Building materials and their sources [*].	Environmental economic
	4. Environmentally friendly materials [1, 10].	1. Energy content of each material [1].	
	5. Passive solar gain [1, 10, 11]. 6. Renewable energy resources [1, 10]. 7. Accept responsive facades [10]. 8. Respect of micro-climate [1, 10] 9. Encourage the use of natural daylight [1,10]. 10. Encourage natural Ventilation [1, 10].	1. Building orientation [1, 10, 11]. 2. Buildings width (9-13 m) and levels (3-4 stories) [1]. 3. Electrical energy consumption per household [*].	Environmental economic
Continue City Form	11. Increase densities but not excessively to encourage compact forms [12, 23, 24, 37].	1. Density [*].	Economic social
	12. Density related to nodal Points/public transport [11].	1. The location of density [*].	
	13. Relate to existing infrastructure (utilities and roads) [1].	1. The location of density [*].	Economic
Street system	1. Design for pedestrian environmentally friendly transport, and increase accessibility for pedestrians and cyclists [1, 5, 11, 12].	1. The ratio of walking paths and bicycle lanes over the number of roads [*].	Environmental economic social

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Table 1: Continued.

Area of concern	Criteria	Indicators	Attributes
Street system	2. Recover road space for public use or public transport [1, 5, 9, 11, 12].	2. The ratio of public transport over the means of transports [*].	Environmental economic social
	3. Exclude non-essential traffic [*].	1. Congestion [*].	Environmental economic social
	4. Encourage route connectivity and permeability [*].	1. Accessibility from one place to another [*].	
	5. Hierarchy of routes [*].	1. Public, semi-public, semi-private, and private routes [*].	
	6. Reduce parking lots [46].	1. The number of parking lots [*].	
Land use	1. Encourage mixed-use developments [11, 37].	1. The ratio of working inhabitants in work places within the city [*]. 2. The ratio of houses and services over the total area [*].	Environmental economic social
	2. The need to travel [1, 5, 27].	1. The distance from center to periphery should encourage walkability [1, 35]. 2. Availability of main needs within the center [*]. 3. The location of density [*].	
	3. Development of brown field sites and avoid green field sites [35].	1. The location of new developments. [*] 2. The ratio of open spaces to built ones [*].	Environmental economic

Note: [*] The authors of this paper.

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www.witpress.com, ISSN 1743-3541 (on-line)

Acknowledgements

The author acknowledges the Deanship of Scientific Research, Jordan University of Science and Technology, Jordan, which funded the broader research upon which this paper is based. Thanks are due to a number of insightful anonymous reviewers who made valuable comments on earlier drafts of this paper.

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