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Review Article

Urban Sustainability Concepts and Their Implications on Urban Form

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Abstract: Since the middle of the 1980s, there has been a demand for urban centres to be more sustainable. City planners and administrators have had to lean towards the various city sustainability concepts in their schemes. The concept of “sustainable city” which became prominent as a progenitor for the others can still be deployed as the basis for most of the newer concepts. More recent concepts like “smart city” and “resilient city” have their essence in high technology and socio-environmental ideals that relate more with post-modern living. The urban form which is the most physical entity in the city is always evolving. The implementation of these concepts are likely to impact on the urban form in a way that may alter its organic or planned evolution. This study is a bibliometric survey of 5 of the urban sustainability concepts and their relevance in urban morphology. The paper analyses the core issues in each of the concepts and relates them to the aspects of the urban form they are more likely to alter with a view of how such effects may determine the morphology. The five city sustainability concepts for this research are easily the most common with reference to SCI and SSCI databases and are therefore more relevant to current research. They are sustainable city, smart city, eco-city, low carbon city and green city. Green city and eco city may result in less compact urban forms while the rest are explicitly supportive of more compact urban forms.

Keywords: Smart City, Sustainable City, Urban Form, Urban Morphology

1. Introduction

Urban morphology attracts a diverse field of disciplines. This diversity is an indication of how complex the understanding of urban form can be. Comprehensive research and review of the urban form have been carried out previously [1-4]. The objective of this research is to examine the likely outcome of implementing some ideals in environmental sustainability on urban morphology. In human-environmental studies, the environment is either resilient or will change when human activity is impacted on it. In changing, it may change temporarily or assume a fresh threshold [5].

The intention of the sustainability concepts is to change the existing pattern of relationship between the city and humans so that humans change their attitude up to a point where the urban form assumes a new threshold in morphological balance. Such changes are intended to be of benefit to both man and the environment in the long term. While the people living in the city will have improved productivity and quality of life. The urban form is ultimately supposed to be more resilient to negative impacts and sustain itself by these concepts.

Resilience in this context is the urban form's ability to withstand both external and internal disturbances without altering its equilibrium through renewal, self-reorganization

and development [6-10]. Morphological resilience has been discussed at length in other realms of sustainability [11-12]. Evolutionary resilience, Engineering resilience and Ecological resilience were analyzed in some other discourses [13-19]

The behavioral and structural changes proposed by the urban sustainability concepts are closely related and a lot of parallels can be drawn among them. The nomenclature changes from place to place and in time. The proponents of the theories are clustered mostly in North America, Europe and South East Asia. The rest of the world, and the originators all align and implement the relevant concepts in their pilot project cities and urban renewal schemes. While the sustainability concepts address all aspects of urban life, including physical, economic, social and environmental, the urban form itself is limited to just the ecological and physical aspects of the environment.

The urban form is a product of the geographical, topological, economic, technological and social interactions in a complex mix within the city that may be cumbersome to decipher. Over time, this complex system attains an equilibrium. The urban form continues to adapt itself via consistent changes based on human interaction and natural events. In this context, when a series of fundamental adjustments are being proposed, the spatial consistency, the resilience, the adaptability and physical form are challenged. In new cities, the concept of city sustainability may be entrenched and maintained as one of the building blocks of the emerging urban form. In older cities that have come into the domain of city upgrade schemes, the

impact of the new concepts will be more evident. The application of the scheme will test the resilience and adaptability of the existing urban form. The far reaching effects of the implementation can be simulated over time to determine how relevant they are.

2. Methodology

A comprehensive list of sustainable city concepts was generated from De Jong *et al* [18]. The list is based on sustainable city terms obtained from research into the data bases of Science Citations Index [SCI] and that of Social Science Citations Index [SSCI]. These are the most common referrals for bibliometric searches. Of all the terms presented by De Jong *et al* [18], five were selected for the purpose of this study. They are “Sustainable City”, “Green City”, “Smart City”, “Low-Carbon City” and “Eco City”. The other less cited concepts like “Resilient City”, “Ubiquitous City”, “Knowledge City” and “Livable City” among others were not investigated for the study. They are all in some way or the other linked with the first five that were selected and all have their roots in “Sustainable City” but may be closely associated with other four concepts in specifications.

Each urban sustainability concept is briefly analyzed to expose the central tenets of the concept as proposed by the school that evolved the concept. The thought forms and what could possibly have informed such thinking are mentioned with respect to the city form.

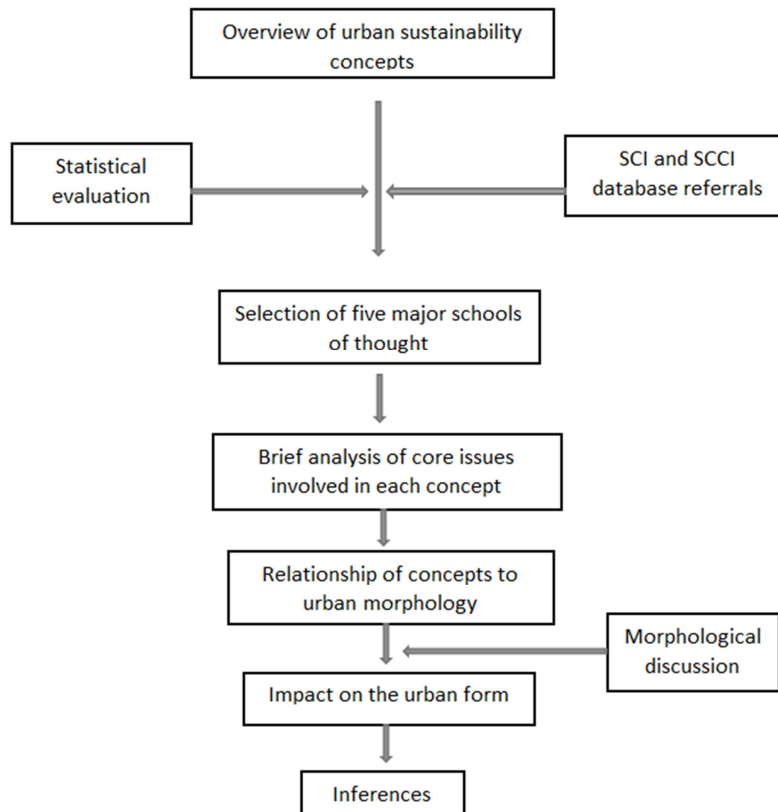


Figure 1. Methodological flow chart.

The five concepts are weighed against their effects on urban morphology under the following criteria.

- I. Sensitivity: This measures how responsive the urban form is expected to be when such concepts are applied in their context
- II. Resilience: The resilience of the urban form to natural impacts like earthquakes, flooding and other sudden changes in the elements is evaluated. Will the adoption of the concept make the urban form more resilient? There are three types of resilience. Evolutionary, Engineering and Ecological.
- III. Adaptability: Cities by their composition should adapt to changes from internal and external sources. The implementation of these concepts may increase how well these cities adapt themselves to changes.
- IV. Flexibility: The co-option of these concepts may make the urban form more flexible. Flexibility in this context may involve how well the urban form can be adapted to the changing needs of the inhabitants, the city is only good enough if it serves the purpose of the inhabitants.
- V. Spatial reorganization: A new concept may not fit into the existing spatial composition. There may be a need to alter the spatial order as the urban form blends with a new concept.

3. Descriptive Summary

Of all the concepts that are already in common use like sustainable city, smart city, eco city, resilient city, low carbon city, information city, knowledge city, ubiquitous city, green city and a host of others, the “sustainable city” and the “smart city” stand out as rallying points for underpinning all the other concepts. The three pillars of sustainability are economy, social welfare and the environment. While the “sustainable city” concept dwells evenly on the three pillars, the “smart city” is more concerned with the social and economic sustenance of the city with an added dimension of technology as a driving force for its objectives. De Jong et al [20] retrieved a total of 2145 articles from the SCI and SSCI databases. Of these articles on urban sustainability concepts, “sustainable city” had 461 articles while “smart city” had 887 articles published about the concepts. This research covered a 35year period from 1980 to 2015.

Table 1. Schedule of articles from sustainability concepts retrieved from SCI and SSCI databases.

S/N	Sustainability Concept	No of occurrences
1	Sustainable city	469
2	Smart city	887
3	Eco city	241
4	Low carbon city	199
5	Green city	110
6	Others	222

Source: Adapted from De Jong et al [20].

The five sustainability concepts received over 90% of the publications which makes them more relevant than the others.

3.1. Sustainable City

The concept of the “sustainable city” has its dominance in Western Europe and North America. It emerged in the late 1980s at the beginning of the sustainability era. This concept which is sometimes interchanged with “eco city” dwells more on environment and environmental impact of human activity like deforestation and environmental pollution.

At a higher level, it addresses transport, urban governance and energy conversation. After the Bruntland Commission [World Commission on Environment and Development, 1987] set out the basics on sustainability for the whole world, the scaling down of the concepts to that of efficient cities were laid out in subsequent writings [21-23].

Over time, there was a lull in writings about sustainable city as other concepts like “smart city” became more prominent. Since 2013 there has been a renewed awareness on the concept. This may be due to the difficulties that the other concepts which are more specific in their implementation pose to urban technocrats [24-25]. It may be easier to retain the core principles of the “sustainable city” concept to be able to achieve sustainable urbanization in reality.

3.2. Smart City

The “Smart City” is a concept that is more futuristic. It proposes the use of high level technological inputs for communication and information in the daily running of the city. It proposes that, such inputs make the governance of the city easier as the authorities have direct access to individuals. It also proposes that cost will be reduced due to interfacing of activities by technology. Transportation is minimized and the city can be more cohesive. Information and Communication Technology can be used to enhance contact between the citizen and the authorities, reduce costs, lower resources consumption and improve quality of urban services. The concept remains popular in the Europe and North America.

This concept maintains a delicate balance in the ecology, economy and social tripod legs of sustainability by using technology as an all-round brace to the whole frame. It predict a more prosperous future for all with high tech communities in an efficient environment [26-30].

3.3. Eco City

The “Eco City” concept has been popularized by Chinese theorists. It became popular in the 1990s but didn’t pick in prominence until the 2010s. It is suggested that this may be the resolve of the government of China to redress the toll on the environment by using the term “Ecological City” in its sustainability program. Hassan and Lee [31], Joss et al [32] and Wang et al [33] suggest that the rapid urbanization and the resultant projects and infrastructure which are of the mammoth proportions have led to the use of the term as propaganda by the Chinese government. It is a concept that aims to protect the ecological balance in the environment by reducing carbon waste and increasing population density of

parts of the city. This is expected to achieve more open areas in the city form. It aims to achieve all forms of sustainability by these efforts.

3.4. Low Carbon City

The “Low Carbon City” is a concept that dwells more on renewable energy in the running of the metropolis. It is a concept that is popular in the Middle East and China. Cities like Dongtan in China and Masdar City in Abu Dhabi are being developed to have no carbon foot prints. The Kyoto Protocol (1997) set out standards for the whole world on levels of carbon emission that are permissible to save the planet. The “Low Carbon City Concept” is a move into the more technical issues [34-38]. After the domination of urban sustainability discourse by the concept of “Sustainable City”, “Low Carbon City” concept is seen as a modernization of the

economic denomination to the “Sustainable City” concept. [39-40]

3.5. Green City

The “Green City” is a concept that dresses all other concepts in a green garb. The concept concentrates more on reducing the effects of global warming and reversing climate change manifestation. By offering a greener cityscape, the concept hopes to make all the other concepts more effective without the focus on items like cloud computing and heavy generation of data, “Green City” appears to be a less discussed offshoot of “Sustainable City” [41-42]. Less technologically inclined concepts like the elimination of “Urban Heat Islands” and promotion of “Urban Forest” in the maintenance of the geo-ecological balance are often discussed within the “Green City” community.

Table 2. Impact levels of urban sustainability concepts on the urban form.

Concepts		Sustainable city	Smart city	Eco city	Low-carbon city	Green city
Effects	Sensitivity	***	**	**	**	***
	Ecological resilience	***	**	***	***	**
	Evolutionary resilience	***	***	***	***	**
	Engineering resilience	**	***	**	***	**
	Adaptability	***	**	**	**	***
	Flexibility	**	***	***	*	***
	Spatial reorganization	***	***	**	*	*

Legend

- *..... Low level of impact.
- **Average level of impact.
- ***High level of impact.

4. Discussion

To be able to fully appreciate the extent to which these sustainability concepts can impact on the urban form, the present relationship between the urban planning by design technocrats and the essence of the theories must be well understood. There tends to be a disjoint between the ideals of the concepts and the pressing social needs of urbanized areas that may tend to conflict with what the sustainability concepts are striving to achieve. In the satellite new towns, some of these concepts are easier to achieve. In built up areas where the urban form has attained a long term equilibrium, the full application of the concept may not be achievable. In China, about 150 cities are now applying the smart technology for governance. The street lighting which is available in these cities are used as domain for the smart technology. In already existing scenarios, application of these concepts are always contingent and will only address a narrow angle out of the barrage of sustainability issues that face these cities. When reference is made to the spatial dimension, the design and sustenance of the built environment in recent times is concerned with the impact of climate change. The Intergovernmental Panel on Climate Change [IPCC] proposes that the redesign of commercial buildings and residential buildings should be able to reduce the projected greenhouse gas emitted into the environment by 29% in the year 2020 [43].

Other issues that come up in the discourse of the built environment are natural hazards [44], urban functions at a larger scale and energy consumption [45-46] and probably large scale terrorist attacks [47].

The concept of “sustainable city” which is the progenitor of all the other concepts is more in tune with the urban form than its offshoots. It is more spatial and ecological in its predisposition and tends to limit its technological dimension to energy conversation. The issues concerned with urban sprawl, environmental protection and communication efficiency all come together to address environmental issues like climate change and energy conversation from a more sedentary angle.

“Smart City” is an all-encompassing concept that seeks to promote a monitored disposition towards energy conservation, efficient urban functioning and social services. It emphasis the maximization of individual and communal output. Higher productivity bolstered by strict technological support should definitely yield a better life for all. The concept appears to place human welfare far ahead of environmental consideration. Even where ecological issues are presented, they are not intended for the ecosystem as priority but rather for human sustenance. Of all the concepts being addressed, “Smart City” probably has the widest application as it goes beyond the environmental domain and addresses the political domain. It proposes to use its application to enhance governance. The system believes in real time feedback loops and assessments

so that issues are identified with the faster modern technological feedback systems and decisions are taken faster. The fact that the system relies on one-on-one information accesses between individuals, groups and relevant authorities also means that statutory decisions and opinions are communicated directly to those concerned without any interphases. The monitoring of progress of schemes being executed in the communities is real time which such a robust level of application. "Smart City" is easily the most acceptable of all the concepts. It also lends itself to new accretions by proponents and supporters of the theory.

The "Eco City" concept appears to be more of a response to prevailing circumstances than a firsthand generation of a series of thought processes to address a problem. The nomenclature which ties it directly to ecology and the Chinese origin are suggestive of a guided response to the skewed urban morphological processes of Industrial China. Heavy pollution, loss of species and the attainment of negative environmental thresholds in the industrialized city brought about a clamour for new cities that are eco-compliant. If a city is established on a more balanced ecological content only, other aspects of the urban form that support psycho-spatio-economic needs of the city may be hindered. It is quite possible that the proponents of the theory assume that the socio-economic problems that have been resolved in the older cities which have become ecological dysfunctional will not become issues in the new cities. It must be realized that the greater affinity for economic prosperity without a balancing act with all other aspects of development led to the serious ecological problem in the first instance. The application of the theory in urban renewal may be cumbersome for most of the cities that were heavily industrialized. The new cities may benefit from its applications. The term "Eco City" is used interchangeably with "Sustainable City" in many fields. This is the outcome of linking "Sustainable City" to the original concept of "sustainability" at the onset which came about in a bid to stem down global warming and climate change. It was believed that the disequilibrium of the eco system and air pollution by greenhouse gases was responsible for the phenomena. While sustainability at the onset dealt with global ecological issues, the concept of "Sustainable City" is an evolved application of the discourse in the domain of urbanization.

The 'Green City' is a concept that is linked to all the other concepts but advocates the greening of the environment as a very important index in urban sustainability achievement. It brings about serenity to the environment and helps to achieve the desired ecological balance from within the city. Endangered species of plants and animals are provided a sanctuary within the city. The romantic appeal of the countryside is brought back into the city. While such disposition to overromanticize the use of greenery in the city may be possible in new layouts, it may be at disparity with other concepts of modern day planning like densification and vertical development in city upgrade. Urban infill and the concept of the "Industrial City" may not easily adopt this

concept without limitations. It helps to eliminate the phenomenon of "Urban Heat Islands" because it advocates lower density development and dispersal. Such approaches in urbanization may not be very efficient in economic terms and ultimately energy consumption. Services tend to spread too. The "Green City" can be likened to the "Garden City". At the limits of the "Garden city" concept of Ebenezer Howard, the industrial city had to come up to address the economic imbalance in the theory. Modern adaptations of this theory can be seen in all the five concepts being considered.

Generally a compact urban form is looked at as preferable to the dispersed form which tends to use up more energy in the conservation discourse [39]. It is only the "Eco City" concept that is not explicitly supportive of the compact urban form concept. The fact that it dwells more on ecological balance and conscious elimination of noxious compounds from the environment predisposes it towards eco – sustainability. The economic aspect of sustainability which is the root of the compact urban form concept is not emphasized. The Green City is an adaptable concept that fits all the others and may be interpreted in application to actually support a compact urban form [48]. Whatever the composition of an urban form, it is likely to be enhanced for improved and more meaningful human habitation when any of the concepts are implemented on it.

5. Conclusion

This research has tried to project the urban sustainability concepts on the urban form. The performance of urban fabric when new schemes are implemented in the development process may be difficult to predict. The urban fabric itself is put up by socio-economic interactions within it. The ecological and environmental aspects of the city are also affected by new schemes. The results obtained from the investigation could be further broken down into the different aspects of urban design like street design, public spaces, landscape and building clusters. Other indicators of urban form like regularity, fractility, sky-view factor and confinement [49-52] were aggregated in the outlook of the study. The more general and intrinsic values inherent in the urban form like resilience and adaptability were used to define the urban form. Generally, the urban sustainability concepts are likely to have far reaching positive effects on the urban form if implementation is well adapted in different contexts.

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