Article

A Conceptual Model for Assessing the Relationship between Urban Morphology and Sustainable Urban Form

Abdollah Mobaraki * and Beser Oktay Vehbi

Department of Architecture, Eastern Mediterranean University, Famagusta 99628, North Cyprus, Turkey; beser.oktay@emu.edu.tr

* Correspondence: abdollah.mobaraki@emu.edu.tr; Tel.: +90-533-887-1400

Abstract: The built environment witnessed rapid transformation after the industrial revolution. This transformation came along with some negativities, which gave rise to the concept of sustainability in urban form. In this regard, the current study aimed to assess and validate the reciprocal relationship between urban morphology and sustainable urban form. This study proposes a conceptual model which integrates and presents the holistic correlation between sustainable urban form and urban morphology, by using qualitative grounded theory as the research methodology. The model was developed by introducing analytical tools to evaluate sustainability, along with integrating typomorphology and the concept of scale hierarchy. The findings of this study reveal that every single component of sustainable urban form interacts significantly with the typomorphology approach. Consequently, the outcomes help urban planners to get more informed decisions about the geometric analysis of urban morphology from a sustainability point of view.

Keywords: urban morphology; sustainable urban form; typomorphology; concept of scale hierarchy

Citation: Mobaraki, A.; Oktay Vehbi, B. A Conceptual Model for Assessing the Relationship between Urban Morphology and Sustainable Urban Form. *Sustainability* **2022**, *14*, 2884. <https://doi.org/10.3390/su14052884>

Academic Editor: Francesco Tajani

Received: 4 January 2022

Accepted: 16 February 2022

Published: 2 March 2022

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Copyright: © 2022 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

The emergence of the notion of sustainable development has created a platform to enable a public debate on the form of cities to take place [1]. It has subsequently motivated researchers, decision-makers, and urban planners in related disciplines to seek sustainable forms of development that are beneficial for the built environment. Considering this fact, morphological analysis of urban tissue reveals the logic of urban transformation, urban morphology can thus be a valuable implement to achieve sustainable urban form [2,3]. Although much research has been carried out on the topic of “urban sustainability” and “urban morphology”, there seems to be a substantial gap in the study of the mutual relationship between the two [4–8]. This study tries to focus on the relations between urban morphology (UM) and a sustainable urban form (SUF). Accordingly, this study aims to propose a model to evaluate the relationship between SUF and UM. The analytical tools derived from this relationship can be used as an assessment technique.

Since the issue of the urban context is a continuous multi-layered process, it is vital to formulate a defined scale hierarchy to streamline the process of the assessment. A strong spatial hierarchy is significant to determine the contribution between the important aspects of urban structure and the analytical tools of the research. Accordingly, the study introduces a spatially hierarchal structure, by integrating typomorphology and the concept of scale hierarchy concerning Kropf's taxonomy [6].

Therefore, the following research question has been considered as the main concern of the research.

- What is the relationship between urban morphology (UM) and sustainable urban form (SUF)?

Accordingly, the issues about the main principles of SUF also how to develop an assessment method to evaluate the relationship among UM and SUF in different scale hierarchies for more sustainable outcomes could be addressed as sub-questions.

Regarding the concern of originality, it needs to mention that this study comprises three substantive stages:

- The first stage of the study has considered sustainable urban form and contributes analytical tools as the analysis process.
- Parallel to the process, the second stage introduces urban morphology approaches for evaluating SUF, which are limited in focus to a typo-morphological approach. Moreover, this part develops a classification framework by synthesizing the approach in scale hierarchy theory as the input process.
- Eventually, the conceptual model is investigated by synthesizing the findings to evaluate the relationship through integrated methodology as the output process. Additionally, the study has been discussed appropriate tools and techniques as the methodological framework for applying the model in context.

The outcomes of this study are important for urban planners to assess the built environment from a sustainability perspective when considering the morphology of a city.

2. Method and Data

This study, based on the existing literature, will use qualitative grounded theory as the research methodology, to assess the relationship between SUF and UM. Initially, this study developed analytical tools by integrating the indicators of SUF and morphological layers to evaluate sustainability in an urban context.

Since the typological process has its roots in the fields of architecture and urbanism, the study will focus on the typo-morphology approach as the most appropriate assessment method. In this study, the integration of typo-morphology, based on Kropf's taxonomy [6] and the theory of scale hierarchy, has been used to provide a framework and a clear distinction between built environments by proposing a hierarchal structure. In consequence, this framework will facilitate to evaluate SUF in any urban context. In the next step, a conceptual model is represented by synthesizing specific methods to evaluate the relationship between SUF and UM. The model reveals the level of contribution of each proposed hierarchal structure in terms of analytical tools, and the proposed model can also be utilized for all sustainable urban types to derive a high level of sustainability. In addition, the study has discussed the suitable tools and techniques through a methodological process for applying the model in an urban context. Figure 1 illustrates the research process to show and explain the structure of the study briefly.

Figure 1. Framework of the research (developed by Authors).

3. Literature Review

After World War II, the industrial revolution was unanimously embraced since it presented a global development that stretched and impacted numerous interwoven networks of dimensions such as sociocultural, religious, political, and economic [9,10]. Consequently, rapid industrialization and urbanization started to develop yet adverse effects on the built environment such as climate change, overuse of energy, pollution, and overpopulated urban centers [11]. As the numerous problems started to ascend, the notion of urban sustainability became the only alternative [1,12–14]. In 1987, the imperative phrase of safeguarding resources for future generations in the “Brundtland Report” promoted the notion of “sustainable development” [15]. The focus of “sustainable development” is considering the provision of current requirements without jeopardizing offspring in meeting their requirements as next generation.

As Silva [13] states, urban form is a “spatial pattern” of individual activities at a defined time. Accordingly, sustainable urbanism improves not only people’s living standards but also their safety [16]; however, it is confirmed that various urban structures may have different levels of sustainability [9,17]. There is also evidence to show that there is no single sustainable urban model acceptable in all circumstances [18]. The accessible data describe sustainability as a flourishing means of achieving equilibrium between environmental health, financial growth, and social equity. Therefore, this study attempts to formulate a framework to achieve an SUF. Since urban morphology provides a strong assessment tool for evaluating the built environment; this study used urban morphology as the base to achieve SUF. Consequently, the study conducts principles of SUF and UM to find out the relation.

3.1. Principles of Sustainable Urban Form (SUF)

Sustainable urbanism is required to be equipped with energy generation [19] and governance, water generation, waste management, design, engineering, architecture, equipment for sustainable construction and management of housing. Sustainable urban form, ideas, or principles are created and classified as: Greening, Mixed Land Uses, Sustainable Transport/Accessibility, Density, Passive Solar Design, Diversity, Permeability, Compactness, Legibility, and Imageability [1,20]. Each of these indicators has been considered to achieve sustainable urbanism (Figure 2).

Principles of Sustainable Urban form ¹			
Principles	Factors	Principles	Factors
1. Compactness	a. Contiguity. ² b. Connectivity. ² c. Compact & varied. ³	7. Passive Solar Design	a. The urban density and angle of buildings. ^{12,14} b. Orientations, location, design, landscape & layout with the excellent use of microclimate circumstances & solar gain. ^{13,14,15}
2. Sustainable Transport /Accessibility	a. Scale fitting to strolling, cycling, & proficient open vehicle. ⁴ b. Energized social collaboration. ⁴		a. Green space potential to make a positive contribution to metropolitan agendas. ¹⁶ b. Support biodiversity through the preservation urban natural surroundings. ¹⁷ c. Improve the picture of the urban territory. ^{16,17,18} d. Improvement of the urban picture & personal satisfaction. ^{16,17,18}
3. Density	a. The proportion of individuals or residential part to total parts. ^{5,6}	8. Greening	a. Recognize and organize physical & spatial feature of the environment. ^{19,20} b. Create mental maps in the mind of the wayfarer. ^{11,20,21}
4. Mixed Land Uses	a. Reducing the distance of transport between operations. ⁷ b. The variety of functional land use & transportation-related activities. ^{8,9}	9. Legibility	a. physical elements; as place, appearance. ¹⁹ b. Cultural elements; as significance, connections. ^{14,19,21}
5. Diversity	a. The social variety. ^{10,11} b. Attractive urban highlights, including: building densities, family unit sizes, ages, societies. ^{11,21}	10. Imageability	
6. Permeability	a. alternative paths from one stage to another. ^{4,21} b. Clear vision and choices. ^{4,21}		

1. Jabareen, 2006 [1]
2. Wheeler, 2000 [21]
3. Dumreicher et al., 2000 [22]
4. Hillman, 1996 [23]
5. Carl, 2000 [24]

6. Walker and Rees, 1997 [25]
8. Alberti, 2000 [26]
9. Van & Senior, 2000 [27]
10. Jacobs, 1961 [28]
11. Turner & Murray, 2001 [29]

12. Thomas, 2003 [30]
13. Owens, 1992 [31]
14. Barry & Chorley 2009 [32]
15. Yannis, 1998 [33]
16. Swanwick, et al., 2003 [34]

17. Gilbert, 2012 [35]
18. DoE, 1996 [36]
19. Ding, 2013 [5]
20. Arthur & Passini, 1992 [37]
21. McGlynn et. al, 2013 [38]

Figure 2. Sustainable urban form and its various design concepts (developed by Authors) [1,5,21–38].

The notion of SUF has been extensively discussed and is still under discussion. Alternatives include the compact city [39], decentralized concentration, remote new settlements [40] and multi-centric cities [17,41]. Jabareen [1] defines four types of SUF based on distinct design values; these sustainable urban types are Eco-City, Compact City, Urban Containment, and Neo-traditional Development.

As Silva [13] notes, the entire idea of the urban form depends upon three factors which are the arrangement, appearance, and functionality of the buildings and structures. Fast-growing cities, on the other hand, are exposed to non-sustainable building plans and developments that lead to the exhaustion of resources and infrastructure. These are the consequences of the ‘boom’ in the construction sector, which requires and demands excessive resources. The invasion of rural areas for building purposes leads to deforestation, which involves the removal of thousands of hectares of trees, which also requires the construction of extensive transportation infrastructures. Furthermore, the growth of urbanism may also destroy the identity of urban areas, which are supporting specific types of lifestyle and culture. Thus, SUF is one of the methods that can provide safe growth and change without compromising natural sources or affecting social identity and culture [31].

Oliveira [3] stated the city has a multilayer system that analyzes the relationships of the physical and spatial aspects through four primary morphological layers of urban form which are: plot, buildings, street, and open space. Tadi et al. [42] gathered sustainable urban principles, including the primary layer of the systematic interpretation of the morphological methods of the city. The integration of the keys, such as analytical tools, creates a relationship between the different layers to improve the performance of the whole system (Figure 3). Designers can use the keys whilst observing the process of design to analyze the context and the current condition and critical functionality of a city, before interfering.

Figure 3. Integration of morphological layers and indicators of SUF to create analytical tools (developed by Authors).

As it is shown in Figure 3, these analytical tools which have been developed based on [25,26] comprise intensity (Density and Compactness), proximity (Sustainable Transport, Mixed Land Use), permeability, (imageability, legibility), Efficiency (greening, passive solar design), Accessibility (sustainable transport) and Diversity (legibility, mixed land use).

According to Jabareen [1], there are general standards for developing SUF, which are related to the principles of SUF and morphological layers. From this point of view, it is essential to find out the relations among these concepts to formulate analytical tools for assessing sustainability in an urban context. The analytical tools are related to all the indicators of urban form, sustainable urban types, and the dimensions of SUF. The relationship between each factor of the analytical tools and each principle of SUF has been demonstrated in Figure 4. From this point of view, the combination is finding a connection amongst the global factors and design principles of SUF to devise analytical tools for sustainability in the urban form, related to all the indicators of urban form, sustainable urban types, and dimensions of SUF.

Figure 4. The relationship between analytical tools and the principle of SUF (developed by Authors) [1,5,21,22,24–28,31,33,37,38,43–64].

3.2. Urban Morphology

According to Conzen [60] “Urban morphology” (UM) is expressed as the study of the formation of the built environment and the process of changes related to the spatial study of urban structures, land use, construction, open spaces, and road patterns. In this regard, Cowan [65] stated that UM is “the study of urban form” and identified four broad approaches to UM namely: 1. Historico-geographical; 2. Typo-morphological; 3. Spatial-analytical; 4. Configurational. UM and SUF holds different meanings for urban planners and designers, especially in developing cities. Accordingly, morphological studies can be divided into four groups considering various disciplines as geography, architecture, science, and philosophy. In respect of urban geography, the Conzeniana school of thought acts as a representation of ideas [66]. Caniggian School plays an important role in the discipline of architecture. Bill Hillier’s Spatial Syntax explores the morphology of the city from a whole new perspective in the mathematical character that is related to power and science [67]. The philosophy of Henri Lefebvre (1901–1991) states that the urban area is not a neutral entity, it has a social existence and has designated areas to demonstrate or identify its society or culture (Figure 5).

Figure 5. The genealogy of study in UM (adapted from Sima & Zhang, 2009).

The approaches to typo-morphology can be said to have arisen from an urban and architectural perspective as well as historical-geographic and environmental analytical methods, which are derived from the geography sector [68,69]. Because the typo-morphological (typological process) has its roots in the fields of architecture and urbanism, the study will focus on typo-morphological approach. Hence, the historical-geographical and spatial-analytical factors, which are from the field of geography, will be neglected. Furthermore, space or configurational syntax will not be used because it has a mathematical or scientific origin rather than an architectural one and because this study is focused on the field of architecture. Since geometric analysis is an integral part of UM, the current study will deal with this assessment to provide valuable information for analyzing the physical elements of urban environments (Figure 6).

Figure 6. The approaches for assessment of urban morphology in the relationship with SUF in the current study (developed by Authors).

Typo-Morphological Approach

Typo-morphological research has been used as a planning instrument throughout architectural history. The work of the Krier brothers [70] and Aldo Rossi [71] has been quite fruitful, especially in the context of the metropolitan fabric form, housing, and open spaces. As well as in respect to socioeconomic procedures. Typo-morphological surveys

use construction information to define the city's physical shape and the method of human habitat accumulation, which helps gain knowledge of the city's three-dimensional structure and its fundamental development mechanism. As Moudon [72] notes: *"typo-morphology provides a working definition of room and sort of construction, and acts as a wealthy starting point for learning the essence of building design, its connection with the town, and the community in which it occurs"*. Typo-morphological surveys are therefore not only useful for analyzing current cities or urban areas, but also for building the theoretical basis for urban design planning [73]. The methods derived from the studies carried out by the Italian architect Saverio Muratori, and further established by his disciples, Gianfranco Caniggia and Gian Luigi Maffei, are highly significant. The typological method focuses on the hypothesis that, by evaluating construction as the operational unit of an assessment, altering trends in urban form can then be better understood. This means that the typo-morphological approach, when applied to individual buildings and towns, considers using the geometrical analysis method. The components constitute the construction products for individual buildings, the construction of components conforms to the walls and the organization of the buildings. For cities, the area is comparable to that of morphological analysis, i.e., housing, urban tissues, and the various types of arrangement of urban tissues in a region or district [72,74]. Geographical scientists generally adopt the morphological classification, but architects tend to adopt the typo-morphological classification.

4. Methodology and Development of Conceptual Framework

The issue of urban formation as a dynamic process poses a challenge to current contexts and designers by taking into account the past in order to create the future. The urban formation is an ever-changing system and a continuous process in which many numbers of functional and geometric connections can be displayed at different levels or scales [75]. The morphological analysis of the urban fabric permits us to gain a logical understanding of their formation and transformation. Thus, the analysis assists us to design with authentic awareness and interventions within the process of change. Therefore, this study aims to streamline this complex system by expanding the concept of scale and hierarchy that are bound to each other. The concept must be discussed in terms of the relationships between spaces of different dimensions. In this case, the scale hierarchy is crucial because it affects the accuracy of the outcomes.

The urban morphology approach analyzes the built environment based on four main elements of the morphological layer in the study: buildings, streets, open spaces, and plots/lots. Moreover, the urban form can be understood from the perspective of four different levels or scales, which are commonly recognized. They are, namely: the region, the city, the street/block, and the building/lot [72]. The physical form describes the layers of the cities and the process of the accumulation of built environments, which helps in the definition of the city's three-dimensional structure and the process of city formation (Figure 7). Therefore, this approach is not only suitable for the analysis of existing cities, but also for developing the theoretical base for urban design practice, since it has influenced urban development [73].

In the following part, the authors integrate the research design that proposes morphological dimensions for assessing SUF. The integrations will be based on two main combinations, the first is analytical tools by the integration between morphological layers and SUF principles, and the second is scale hierarchy and typo-morphology. The second combination will control the scale hierarchy of any case study when it is going to be evaluated and shows the effect of the scale hierarchy on the accuracy of the results. Finally, the findings will provide the experts with a tool to evaluate any part of the urban level starting from building to city scale, and permit them to assess the sustainability within the selected context.

type and elementary cells, respectively. More specifically, the base type is defined as a single room dwelling of five or six square meters, comprising a single space enclosed by a floor, four load-bearing walls, and a roof in which a door is located for access [74].

b. The Mid (Meso-scale) refers to the issue of urban tissue, which includes the following:

1. The Lots: The lot is defined as, 'the area built upon, together with the pertinent area'. The element that links built spaces to open spaces is the land lot or parcel, the primary cell of the urban fabric [38].

2. The pertinent strip: This is defined as a route that structurally and relationally shape the surroundings. The built area is the association of several identified built elements such as street, route, and embedded buildings [31].

3. The Built Route: The built routes are planned to provide connections between places as well as accessibility to construction sites. The city blocks are delineated by the well-connected routes since the connecting built routes can shape urban form [74].

4. The Block: The structure of a block is a basic structure of the urban pattern, and the block's geometric makeup is the defining factor of the form of the urban area. Kropf [81] pointed out that street dimensions depend on the length of a block.

5. Infill/Base Tissue: According to [74], this refers to the matrix route, described as an arrangement of particular parts and, such as the base type, also refers to a position in the typological process. Infill tissue is another term used in connection with the issue of the various types of urban tissue; it is the starting point from which a tissue evolves.

6. Node: A node is defined as any path crossing and a pole as the end/beginning of a path [74].

c. Major (Macro-scale) refers to the 'urban organism', which is categorized into two elements:

1. The first is described as urban life, which refers to the totality of localized urban activities related to the functional structure of cities.

2. The second is distinct from the urban frame, which refers to the sum of spaces corresponding to the locality, concerning the functional and spatial urban structure [81].

Hence, the importance of combining scale hierarchy with a typo-morphology approach to delineate the content in the Minor scale and the meaning in the Major scale. Consequently, this combination will influence the accuracy of evaluating sustainability in the selected case study, according to the scale level (Figure 8).

4.2. Integrated Synthesis and Formulating the Model

The first part of the theoretical framework of the study attempts to consider the global principles of SUF. Afterward, the authors, through literature (mainly Tadi et al. [42] and Manesh, et al. [58]), introduce the analytical tools of research for evaluating SUF. It was applied as an analytical process to reveal the relationship between morphological layers of a city and the design principles of SUF. In addition, the analysis has been carried out using urban morphology as a field of inquiry focusing on typo-morphology as an architectural and urbanism approach. Thereafter, the approach synthesizes in scale hierarchy based on Kropf's taxonomy [6] in order to develop spatially hierarchal structure as inputs data. Based on the above information, the model for evaluating the relationship between SUF and UM has been developed. The authors developed the model and considered the most valid indicators and the factors based on theoretical framework analysis. The model has been divided into three stages:

1. *Input (Identification) stage*: it includes the morphological classification based on the hierarchy concept, and scale of the case study, which is starting from town as Macro-scale and ending with building patterns as Micro-scale, sorting streets, and plot patterns as meso-scale. The model will focus on the architectural morphological approach, which is the typo-morphology approach, and it classifies the urban area into town, buildings, and systems organization. In this part, the input will involve the indicators of the urban form approaches sorted according to the concept of the scale commencing with the Micro-scale,

followed by the middle-scale, and completing with the Macro-scale. Each of these scale stages has its characteristics to be tested through input data, such as materials, building types, and structures on the Micro-scale. Similarly, in respect of the meso-scale stage, which involves lots, pertinent strips, built routes, etc., and in the final Macro-scale stage, the characteristics will include urban organisms. These levels will be harmonized with the urban morphology classification framework, based on the scale. For example, 'The Approach of Buildings System', which is one of the urban morphology classifications that includes buildings' level details, will be involved in a Micro-scale or Minor level stage. The same process applies to other approaches; for example, the Approach of the Plots System, and the Approach of the Streets System will be involved in the meso-scale or middle-level stages. Whereas, again, the approach of the Streets System, the approach of the Urban Tissue stage, and the approach of the Natural Context will be involved at a Macro-scale or significant level stage.

2. *The Analysis process (Evaluation) stage*: this part will include the analysis of the input data considering interrelations with the principles of the SUF and the level of the relationships with the factors of the typo-morphology approach and their influences on or contribution to the achievement of the sustainability. All these factors are under the concept of the scale of the selected sample study. The absence, presence, or lack of contribution of the indicators in the first (Input) stage will be tested in this stage. The Analytical stage is demonstrated in Table 1 and Supplement Table S1; at this stage, the most weighted indicators will be evaluated according to their contribution, which depends significantly on the scale of the case study.

3. *The output (Decision) stage*: in this stage, all the previous principles and dimensions will be related to the global SUF as analytical tools. The validity of these factors will be tested in terms of their effects on the case studies. To examine the confidence and the validity of the suggested SUF, the analytical tools which are: intensity, proximity, efficiency, accessibility, diversity, and permeability will be applied to the case studies, based on the hierarchical scale of urban morphology which was explained in this study. Finally, the SUF types have been suggested for future studies to be evaluated based on these analytical tools and according to the three stages of the process of model development. Through these evaluations, the most effective SUF types will be evaluated (Figure 9).

4.3. The Evaluation Processes of the Relationship between UM and SUF

The primary objective of the procedure is to concentrate on the evaluation of morphological principles in SUF, through testing the analytical tools of the latter. Referring to the analytical tools of SUF each of them should be combined with the hierarchical typo-morphology approach, which is combined with the scale hierarchy (Figure 9), to test the validity of the contribution at five levels stated from strong contribution to non-contributed.

Consequently, the features of the relationship between UM (Typo-morphology approach) and the SUF (through analytical tools), have been recognized. This is by the amalgamation of all the discussions in this study classified, based on using the process of the typological approach in urban morphology, as shown in Table 1 and for more details see Supplement Table S1.

4.4. Methodology for Applying the Model

The description of the methodology will be implemented in this section to apply the proposed model for assessing the relationship between UM and SUF in urban contexts. To use the model, the following information is required:

- (1) The scale hierarchy of the study area (Micro, Meso, and Macro-scales).
- (2) Model of the study (evaluation of the weighting of the morphological indicators according to their contribution in sustainability), based on the contribution of each indicator.
- (3) The applied tools and techniques used in the proposed model (Site surveys, Observation, Customer Satisfaction Surveys, Opinion, and Social Analysis).

- (4) Identifying the sample size for a pilot survey.
- (5) Collected Data Analysis (Validity and Reliability), (Figure 10).

1. Moudon, 1994 [73]
2. Caniggia & Maffei, 2001 [75]
3. Muratori, 1959 [76]
4. Porter, 1982 [82]
5. Lange, 1997 [84]
6. Moughtin et al, 1995 [83]
7. Kropf, 2014 [79]
8. Kropf, 2017 [6]
9. Cömet, 2013 [85]
10. Scorza et al., 2021 [9]
11. Wheeler, 2000 [21]
12. Scheer, 2016 [42]
13. Gauthier & Gilliland, 2006 [86]
14. Filion & Hammond, 2003 [87]
15. Cataldi et al., 2002 [88]
16. Bhagwat & Devadas, 2020 [40]
17. Filomena et al., 2019 [39]
18. Conzen, 2004 [65]
19. Silva, 2015 [14]
20. Osmond, 2003 [89]
21. Sima et al., 2009 [67]
22. McGlynn et al, 2013 [38]
23. Shayesteh, 2013 [69]
24. Salat & Bourdic, 2012 [77]
25. Bourdic et al., 2012 [52]
26. Li, 2013 [90]
27. Gaic, 2015 [91]
28. Pattee, 1973 [78]
29. Maretti, 2014 [2]
30. Wu, 2008 [92]
31. Oshrieh & Valipour, 2019 [12]
32. Ding, 2013 [5]
33. Hall, 2008 [4]
34. Newman, 2003 [93]
35. Whitehand, 2001 [94]
36. Oliveira, 2016 [3]

Figure 8. Spatially hierarchical structure (SHS) in respect of the relationship between the scale hierarchy and typological process approach (Typo-Morphology) for the geometric assessment of urban morphology (developed by Authors) [2–6,9,12,14,21,38–40,42,52,65,67,69,73,75–79,82–94].

4.5. Mode of the Study

As already discussed, the main aim of the proposed model is to assess the relationship between UM and SUF to evaluate the level of sustainability in an urban context. As shown in Table 1, the evaluation is based on the contribution of each indicator to reach the level of sustainability in an urban area. Each of the indicators per resolution levels or scale (Micro, Meso, and Macro) will be weighted, based on its contributions, by using the analytical tools of the SUF. For example, in the 'Micro-Scale', building material has been contributed in three tools out of the six of the SUF analytical tools. This gives the indicator (3/6), which means a weighting of 50% in the contribution to the SUF. Rooms will not be evaluated in the model research because they are classified as internal factors. Moreover, for a more accurate evaluation, the weight of each indicator contribution can be classified into five levels with a specific number, for example, in 'Micro-Scale' of the typomorphology's indicator, building material with intensity is contributed because of the mass or volume of construction materials per unit area provide a crucial measure of intensity. Accordingly, the level contribution of each spatially hierarchical structure is evaluated in terms of the analytical tools to achieve SUF based on the morphology of a city (for more details, see Supplement Table S1).

1. Moudon, 1994 [73]
2. Caniggia & Maffei, 2001 [75]
3. Muratori, 1959 [76]
4. Kropf, 2017 [6]
5. Salat & Bourdic, 2012 [77]
6. Bourdic et al., 2012 [52]
7. Oliveira, 2016 [3]
8. Silva, Oliveira, 2017 [20]
9. Pattee, 1973 [78]
10. Kropf, 2014 [79]
11. Jabareen, 2006 [1]
12. McGlynn et al., 2013 [38]
13. Meenar et al., 2019 [43]
14. Bell et al., 2005 [48]
15. Arthur & Passini, 1992 [37]
16. Owens, 1992 [31]
17. Wheeler, 2002 [21]
18. Jacobs, 1961 [28]
19. Tadi, 2012 [58]
20. Burgess, 2000 [59]
21. Manesh et al., 2012 [60]
22. Beer et al., 2003 [61]
23. Jabareen, 2013 [62]
24. Krizek, 2003 [63]
25. Porta & Renne, 2005 [64]

Figure 9. The two main part of the study which contain three stages: input, analysis, and output (developed by Authors) [1,3,6,20,21,28,31,37,38,43,48,52,58–64,73,75–79].

Figure 10. The process to apply the proposed model in the context (developed by authors).

Table 1. The evaluation of the typo-morphological approach is based on spatially hierarchal structure (SHS) and analytical tools (developed by Authors).

	Spatially Hierarchal Structure	Intensity	Proximity	Efficiency	Accessibility	Diversity	Permeability
Building/Parcel Scale	Material	2	−2	2	0	2	−2
	Structure (form)	−2	−2	2	−2	1	−2
	Windows, Doors, Openings	−1	−2	2	2	−1	−2
	Room *						
Neighborhood/Plot Scale	Buildings	−1	2	2	1	2	1
	Plots	2	2	1	2	1	1
	Neighborhood/Local open space	2	2	−1	2	2	2
	Local street system	2	2	2	2	1	2
Block/District Scale	Plot series	2	2	2	2	2	1
	Blocks	1	1	2	1	2	0
	Arterial street and open spaces	2	0	2	0	2	1
City Scale	Infrastructure networks	−1	−2	2	2	−1	−1
	Highway roads	2	0	2	0	2	1
	Geographical characteristics (Topography, soil, climate, water body, biodiversity)	2	−1	1	2	2	2

➤ Evaluation of the weighting of the morphological indicators based on their contribution in sustainability:

(−2) Non-contributed

(−1) Weak contribution

(0) Neutral

(1) Regular contribution

(2) Strong contribution

* Room will be not evaluated in the research.

The method which might be used for structuring questionnaires could be based on Likert's scale. Likert's scale is a method for obtaining the evaluation with five or seven response items [95]. In this study, Likert's scale used from 'strongly contributory' to 'non-contributory' categories (Table 1). The difference in weighting depends on the scale hierarchy of an urban context.

The proposed model can be applied by planners and designers, within the context of their contribution, which relates to the scale of the selected case study. Additionally, the model offers an opportunity for planners to evaluate the context accurately.

5. The Applied Tools and Technique

To obtain reliable outcomes, a specific number of respondents, when considering the population of a selected context, should be found. Hence, Slovin's formula could be used to identify the sample size for such a study, with the margin of error of $\pm 5\%$ ($n = N / (1 + Ne^2)$) n = Number of samples— N = Total population— e = Error tolerance. The spatial hierarchy of the case study should be identified within the Macro, Meso, and Microscales. The indicators of each scale are determined, in Figure 10. Considering the

selected context, the SPSS (statistical package for social science) can be applied to analyze the collected data statistically to obtain more accurate results, especially when there is a large amount of input data. The privilege of the SPSS computer tool is that the data can be entered by the researcher from different sources, but should be appropriately arranged. Moreover, entering the data will make the statistical calculation process an easy one, since only a few fundamental steps are required to be considered for obtaining accurate results. The outputs from Spearman's Correlation coefficient (r_s) are arranged between -1 and $+1$ [95,96]. Moreover, descriptive statistical methods can be considered for examining the collected data. The validity can be achieved using SPSS, whilst the reliability can be achieved through the use of Chronbach's Alpha test. The proposed methodology can be described as the Inventory Mapping Technique (IMT).

According to the proposed model, the morphological analysis based on the three-scale of Micro, Meso, and Macro, demonstrated the effect of each level on sustainability, based on their specific elements within a morphological context. The model represents the interrelations between urban morphology and the principles of SUF. It suggests that global analytical tools are used as a guideline to test the SUF types based on urban morphology (Figure 11).

Figure 11. Urban morphology relationship with sustainable urban form model (developed by Authors) [1–8,12–15,17,20–29,31,33,35,37–40,42–44,48–65,67–69,73–79,82–95,97–109].

6. Conclusions

The study developed the model to demonstrate the interrelations between sustainability and urban morphology. The relationship exists and would create a sufficient framework to support sustainable urban form based on morphological classification. This study strived to focus on typo-morphological approaches as the limitation of the study which contributed by integrating the approach based on Kropf's taxonomy (2017) to scale hierarchy. This interpretation is thus presented as a rigorous hierarchical structure in order to ease the complicated assessment. Additionally, the analytical keys are designated in the analysis stage to reveal the relationship between the two. Thereafter, the morphological analysis based on the three-scale hierarchy (Micro, Meso, and Macro) derived evaluate the effect of each level on sustainability, based on their elements within the morphological context. On the other hand, the indicators of the SUF relationship with the three main sustainable aspects have been confirmed, based on the interrelations between the indicators and the sustainability dimension indicators in urbanism. The model is taken as a guideline to test the SUF types towards analytical tools based on urban morphology. As aforementioned, this study has also revealed that the seven main factors for evaluating sustainability in the urban form are intensity, proximity, efficiency, accessibility, diversity, and permeability, which are the primary organizational factors for urban spatial configuration in terms of sustainability.

This study reveals that assessment in the field of urban design and an attempt to upsurge the quality of the urban environment in terms of sustainability is critical. In this sense, the study has been collected the principles as well as indicators of UM and SUF (projected on the concept of scale hierarchy), through reviewing the related literature and the classified framework based on an analytical process to demonstrate the relations between these indicators.

The outcome put forward is that the SUF is directly related to the urban morphological scale. The originality of this study will enhance the knowledge base linked to urban planning and design in respect of the role of urban morphology in sustainable urban planning. For future studies, the study recommends that the assessment of the sustainable urban form can be evaluated by conducting other approaches related to urban morphology rather than the one dealt with in this paper, i.e., Typo-morphology, e.g., the Historico-geographical, Spatial-analytical, or Configurational approach. Additionally, a model can be designed for the regional scale to raise geographical aspects.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/su14052884/s1>.

Author Contributions: Conceptualization, A.M. and B.O.V.; methodology, A.M.; software, A.M.; validation, A.M. and B.O.V.; formal analysis, A.M.; investigation, A.M.; resources, A.M.; data curation, A.M.; writing—original draft preparation, A.M.; writing—review and editing, A.M. and B.O.V.; visualization, A.M.; supervision, B.O.V.; project administration, A.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Jabareen, Y.R. Sustainable urban forms: Their typologies, models, and concepts. *J. Plan. Educ. Res.* **2006**, *26*, 38–52. [[CrossRef](#)]
2. Mareto, M. Sustainable Urbanism: The role of urban morphology. *Urban Morphol.* **2014**, *18*, 163–174.
3. Oliveira, V. *Urban Morphology: An Introduction to the Study of the Physical Form of Cities*; Springer International Publishing: Cham, Switzerland, 2016. [[CrossRef](#)]

4. Hall, T. Bridging the gap: Applying urban morphology to successful planning practice. *Urban Morphol.* **2008**, *12*, 54–57.
5. Ding, W. Urban design needs urban morphology: A practitioner's viewpoint. *Urban Morphol.* **2013**, *17*, 120–123.
6. Kropf, K. *The Handbook of Urban Morphology*, 1st ed.; John Wiley & Sons: Hoboken, NJ, USA, 2017. [\[CrossRef\]](#)
7. Luu, H.T.; Rojas-Arias, J.C.; Laffly, D. The Impacts of Urban Morphology on Housing Indoor Thermal Condition in Hoi an City, Vietnam. *J. Contemp. Urban Aff.* **2021**, *5*, 183–196. [\[CrossRef\]](#)
8. Maretto, M.; Gherri, B.; Chiovitti, A.; Pitanti, G.; Scattino, F.; Boggio, N. Morphology and sustainability in the project of public spaces. *J. Public Space* **2020**, *5*, 23–44. [\[CrossRef\]](#)
9. Scorza, F.; Fortunato, G. Cyclable Cities: Building Feasible Scenario through Urban Space Morphology Assessment. *J. Urban Plan. Dev.* **2021**, *147*, 05021039. [\[CrossRef\]](#)
10. Frey, H. *Designing the City: Towards a More Sustainable Urban Form*, 3rd ed.; Taylor & Francis: New York, NY, USA, 2003. [\[CrossRef\]](#)
11. Kotharkar, R.; Pallapu, A.V.; Bahadure, P. Urban Cluster-Based Sustainability Assessment of an Indian City: Case of Nagpur. *J. Urban Plan. Dev.* **2019**, *145*, 04019018. [\[CrossRef\]](#)
12. Oshrieh, R.; Valipour, E. The Role of Urban Density and Morphology in the Air Pollution of Tehran Metropolitan. *J. Contemp. Urban Aff.* **2019**, *3*, 38–43. [\[CrossRef\]](#)
13. Girardet, H. *Creating Sustainable Cities*, 1st ed.; Resurgence Books: Totnes, UK, 1999. [\[CrossRef\]](#)
14. Silva, Q. The Analysis of Urban Form as an Assessment Tool of Sustainability. Master's Thesis, Instituto Superior Técnico, Lisbon, Portugal, 2015.
15. Dipeolu, A.A.; Akpa, O.M.; Fadamiro, A.J. Mitigating Environmental Sustainability Challenges and Enhancing Health in Urban Communities: The Multi-functionality of Green Infrastructure. *J. Contemp. Urban Aff.* **2020**, *4*, 33–46. [\[CrossRef\]](#)
16. Liu, W.; Bai, E.; Liu, L.; Wei, W. A framework of sustainable service supply chain management: A literature review and research agenda. *Sustainability* **2017**, *9*, 421. [\[CrossRef\]](#)
17. Cuthill, M. Strengthening the 'social' in sustainable development: Developing a conceptual framework for social sustainability in a rapid urban growth region in Australia. *Sustain. Dev.* **2010**, *18*, 362–373. [\[CrossRef\]](#)
18. Jenks, M.; Burton, E.; Williams, K. Compact cities and sustainability: An introduction. In *The Compact City: A Sustainable Urban Form?* 1st ed.; Jenks, M., Burton, E., Williams, K., Eds.; E&FN Spon: London, UK, 1996; pp. 11–12. [\[CrossRef\]](#)
19. Sammarco, C. The Substrate and Urban Transformation. Rome: The Formative Process of the Pompeo Theater Area. *J. Contemp. Urban Aff.* **2019**, *3*, 1–7. [\[CrossRef\]](#)
20. Silva, M.; Oliveira, V.; Leal, V. Urban form and energy demand: A review of energy-relevant urban attributes. *J. Plan. Lit.* **2017**, *32*, 346–365. [\[CrossRef\]](#)
21. Wheeler, S.M. Planning for metropolitan sustainability. *J. Plan. Educ. Res.* **2000**, *20*, 133–145. [\[CrossRef\]](#)
22. Dumreicher, H.; Levine, R.S.; Yanarella, E.J. The appropriate scale for "low energy": Theory and practice at the Westbahnhof. In *Architecture, City, Environment, Proceedings of the PLEA 2000*; Koen, S., Yannas, S., Eds.; James & James: London, UK, 2000; pp. 359–363.
23. Hillman, M. In favour of the compact city. In *The Compact City: A Sustainable Urban Form*, 1st ed.; Jenks, M., Burton, E., Williams, K., Eds.; E & FN Spon: New York, NY, USA, 1996; pp. 36–44. [\[CrossRef\]](#)
24. Carl, P. Urban density and block metabolism. In *Architecture, City, Environment: Proceedings of PLEA 2000*; Koen, S., Yannas, S., Eds.; James & James: London, UK, 2000; pp. 343–347.
25. Walker, L.A.; Rees, W.E. Urban Density and Ecological Footprints—An Analysis of Canadian Households. In *Eco-City Dimensions: Healthy Communities, Healthy Planet*; Roseland, M., Ed.; New Society Publishers: Gabriola Island, BC, Canada, 1997; pp. 96–112.
26. Alberti, M. Modeling the urban ecosystem: A conceptual framework. *Environ. Plan. B Plan. Des.* **2000**, *26*, 605–630. [\[CrossRef\]](#)
27. Van, U.P.; Senior, M. The contribution of mixed land uses to sustainable travel in cities. In *Achieving Sustainable Urban Form*, 1st ed.; Burton, E., Jenks, M., Williams, K., Eds.; E & FN Spon: London, UK, 2000; pp. 139–148.
28. Jacobs, J. *The Death and Life of Great American Cities*, 1st ed.; Vintage Book: New York, NY, USA, 1961. [\[CrossRef\]](#)
29. Turner, R.S.; Murray, M.S. Managing growth in a climate of urban diversity: South Florida's Eastward ho! Initiative. *J. Plan. Educ. Res.* **2001**, *20*, 308–328. [\[CrossRef\]](#)
30. Thomas, R. *Sustainable Urban Design: An Environmental Approach*, 1st ed.; Taylor & Francis: New York, NY, USA, 2009. [\[CrossRef\]](#)
31. Owens, S. Energy, Environmental Sustainability and Land-Use Planning. In *MJ Breheny Sustainable Development and Urban Form*; Breheny, M., Ed.; Pion: London, UK, 1992; pp. 79–105.
32. Barry, R.G.; Chorley, R.J. *Atmosphere, Weather and Climate*, 1st ed.; Routledge: London, UK, 2009. [\[CrossRef\]](#)
33. Yannas, S. Living with the city: Urban design and environmental sustainability. In *Environmentally Friendly Cities*; Eduardo, M., Yannas, S., Eds.; James & James: London, UK, 1998; pp. 41–48.
34. Swanwick, C.; Dunnett, N.; Woolley, H. Nature, role and value of green space in towns and cities: An overview. *Built Environ.* **2003**, *29*, 94–106. [\[CrossRef\]](#)
35. Gilbert, O. *The Ecology of Urban Habitats*; Springer Science & Business Media: Berlin/Heidelberg, Germany, 2012. [\[CrossRef\]](#)
36. DOE. *Greening the City: A Guide to Good Practice*; The Stationary Office: London, UK, 1996. [\[CrossRef\]](#)
37. Arthur, P.; Passini, R. *Wayfinding: People, Signs, and Architecture*; McGraw-Hill Book Co.: New York, NY, USA, 1992.
38. McGlynn, S.; Smith, G.; Alcock, A.; Murrain, P.; Bentley, I. *Responsive Environments: A Manual for Designers*; Architectural Press: New York, NY, USA; Elsevier: London, UK, 2013. [\[CrossRef\]](#)
39. Filomena, G.; Verstegen, J.A.; Manley, E. A computational approach to 'The Image of the City'. *Cities* **2019**, *89*, 14–25. [\[CrossRef\]](#)

40. Bhagwat, J.M.; Devadas, V.A.R.U.V.E.L. Planning for a sustainable compact city: A way forward. *WIT Trans. Ecol. Env.* **2020**, *241*, 113–122.
41. Ghonimi, I.; Zamy, H. Towards Sustainable New Settlements in Egypt: Lessons Learned from a Comparison between Traditional and Modern Settlements in Greater Cairo Region–Egypt. *J. Sustain. Dev.* **2017**, *10*, 1–24. [\[CrossRef\]](#)
42. Scheer, B.C. The epistemology of urban morphology. *Urban Morphol.* **2016**, *19*, 117–134.
43. Meenar, M.; Afzalan, N.; Hajrasouliha, A. Analyzing Lynch's city imageability in the digital age. *J. Plan. Educ. Res.* **2019**, 1–13. [\[CrossRef\]](#)
44. Hough, M. *Cities and Natural Process: A Basis for Sustainability*; Routledge: New York, NY, USA, 1995. [\[CrossRef\]](#)
45. Dieleman, F.; Wegener, M. Compact city and urban sprawl. *Built Environ.* **2004**, *30*, 308–323. [\[CrossRef\]](#)
46. Forsyth, A.; Crewe, K. New visions for suburbia: Reassessing aesthetics and place-making in modernism, imageability and new urbanism. *J. Urban Des.* **2009**, *14*, 415–438. [\[CrossRef\]](#)
47. Rising, H.H. The image of the water city. *J. Urban Des.* **2019**, *24*, 424–442. [\[CrossRef\]](#)
48. Bell, S.; Blom, D.; Rautamäki, M.; Castel-Branco, C.; Simson, A.; Olsen, I.A. Design of urban forests. In *Urban Forests and Trees*; Konijnendijk, C., Nilsson, K., Randrup, T., Schipperijn, J., Eds.; Springer: Berlin/Heidelberg, Germany, 2005; pp. 149–186. [\[CrossRef\]](#)
49. Beatley, T. *Green Urbanism: Learning from European Cities*; Island Press: Washington, DC, USA, 2012. [\[CrossRef\]](#)
50. Ahmed, K.G. Designing sustainable urban social housing in the United Arab Emirates. *Sustainability* **2017**, *9*, 1413. [\[CrossRef\]](#)
51. Longley, P.A.; Mesev, V. On the measurement and generalization of urban form. *Environ. Plan. A* **2000**, *32*, 473–488. [\[CrossRef\]](#)
52. Bourdic, L.; Salat, S.; Nowacki, C. Assessing cities: A new system of cross-scale spatial indicators. *Build. Res. Inf.* **2012**, *40*, 592–605. [\[CrossRef\]](#)
53. Marshall, S. *Streets and Patterns*, 1st ed.; Spoon Press: Prague, Czech Republic; Taylor & Francis Group: London, UK, 2005. [\[CrossRef\]](#)
54. Nasar, J.L. Does neotraditional development build community? *J. Plan. Educ. Res.* **2003**, *23*, 58–68. [\[CrossRef\]](#)
55. Williams, K.; Burton, E.; Jenks, M. Achieving the compact city through intensification: An acceptable option. In *The Compact City: A Sustainable Urban Form*, 1st ed.; Jenks, M., Burton, E., Williams, K., Eds.; E & FN Spon: New York, NY, USA, 1996; pp. 83–96. [\[CrossRef\]](#)
56. Talen, E.; Ellis, C. Beyond relativism: Reclaiming the search for good city form. *J. Plan. Educ. Res.* **2002**, *22*, 36–49. [\[CrossRef\]](#)
57. Van der Ryn, S.; Cowan, S. An introduction to ecological design. In *The Ecological Design and Planning Reader*, 1st ed.; Ndubisi, F.O., Ed.; Island Press: Washington, DC, USA, 2014; pp. 191–202. [\[CrossRef\]](#)
58. Tadi, M.; Vahabzadeh Manesh, S.; Mohammad Zadeh, M.H. Urban Morphology, Environmental Performances, and Energy Use: Neighborhood transformation in Rio de Janeiro via IMM. *J. Archit. Eng. Technol.* **2017**, *5*, 1–7. [\[CrossRef\]](#)
59. Burgess, R. The compact city debate: A global perspective. In *Compact Cities: Sustainable Urban Forms for Developing Countries*, 1st ed.; Burgess, R., Jenks, M., Eds.; Routledge: London, UK, 2000; pp. 9–24. [\[CrossRef\]](#)
60. Manesh, V.; Tadi, M.; Zanni, F. Integrated Sustainable Urban Design: Neighbourhood design proceeded by sustainable urban morphology emergence. *WIT Trans. Ecol. Environ.* **2012**, *155*, 631–642. [\[CrossRef\]](#)
61. Beer, A.R.; Delshamar, T.; Schildwacht, P. A changing understanding of the role of greenspace in high-density housing: A European perspective. *Built Environ.* **2003**, *29*, 132–143. [\[CrossRef\]](#)
62. Jabareen, Y. Planning the resilient city: Concepts and strategies for coping with climate change and environmental risk. *Cities* **2013**, *31*, 220–229. [\[CrossRef\]](#)
63. Krizek, K.J. Operationalizing neighborhood accessibility for land use-travel behavior research and regional modeling. *J. Plan. Educ. Res.* **2003**, *22*, 270–287. [\[CrossRef\]](#)
64. Porta, S.; Renne, J.L. Linking urban design to sustainability: Formal indicators of social urban sustainability field research in Perth, Western Australia. *Urban Des. Int.* **2005**, *10*, 51–64. [\[CrossRef\]](#)
65. Conzen, M.R. *Thinking about Urban Form: Papers on Urban Morphology, 1932–1998*; Peter Lang AG, Internationaler Verlag der Wissenschaften: Lausanne, Switzerland, 2004.
66. Cowan, R. *The Dictionary of Urbanism*; Streetwise Press: Tisbury, UK, 2005. [\[CrossRef\]](#)
67. Sima, Y.; Zhang, D. Comparative precedents on the study of urban morphology. In Proceedings of the 7th International Space Syntax Symposium, Stockholm, Sweden, 8–11 June 2009; KTH: Stockholm, Sweden, 2009.
68. Hillier, B. Spatial sustainability in cities: Organic patterns and sustainable forms. In *Royal Institute of Technology, Proceedings of the 7th International Space Syntax Symposium*; Daniel Koch, D., Marcus, L., Steen, J., Eds.; KTH: Stockholm, Sweden, 2009. Available online: <https://discovery.ucl.ac.uk/id/eprint/18538/1/18538.pdf> (accessed on 9 August 2020).
69. Shayesteh, H. Typo-Morphological Approach to Housing Transformation in Tehran. Doctoral Dissertation, UCL (University College London), London, UK, 2013.
70. Carpio-Pinedo, J.; Ramírez, G.; Montes, S.; Lamiquiz, P.J. New urban forms, diversity, and computational design: Exploring the open block. *J. Urban Plan. Dev.* **2020**, *146*, 04020002. [\[CrossRef\]](#)
71. Krier, L. *Architecture: Choice or Fate*; Andreas Papadakis: Windsor, UK, 1998.
72. Rossi, A. *The Architecture of the City*; The MIT Press: Cambridge, MA, USA; London, UK, 1982.
73. Moudon, A.V. Getting to Know the Built Landscape: Typomorphology. In *Ordering Space: Types in Architecture and Design*; Franck, K.A., Franck, K.A., Schneekloth, L.H., Eds.; Van Nostrand Reinhold: New York, NY, USA, 1994; pp. 289–314.

74. Carmona, M.; Heath, T.; Oc, T.; Tiesdell, S. *Public Places, Urban Spaces: The Dimensions of Urban Design*, 3rd ed.; Routledge: New York, NY, USA, 2021. [\[CrossRef\]](#)
75. Caniggia, G.; Maffei, G.L. *Architectural Composition and Building Typology: Interpreting Basic Building*; Alinea Editrice: Firenze, Italy, 2001.
76. Muratori, S. *Studies for an Operative Urban History of Venice*; State Polygraphic Institute: Rome, Italy, 1959.
77. Salat, S.; Bourdic, L. Urban Complexity, Scale Hierarchy, Energy Efficiency and Economic Value Creation. In *The Sustainable City VII: Urban Regeneration and Sustainability*; WIT Press: Boston, MA, USA, 2012; Volume 155, pp. 97–107. [\[CrossRef\]](#)
78. Pattee, E. (Ed.) *Hierarchy Theory: The Challenge of Complex Systems*; George Braziller: New York, NY, USA, 1973. [\[CrossRef\]](#)
79. Kropf, K. Urban tissue and the character of towns. *Urban Des. Int.* **2014**, *1*, 247–263. [\[CrossRef\]](#)
80. Thom, A.S. Momentum, mass, and heat exchange of plant communities. *Veg. Atmos.* **1975**, *1*, 57–109.
81. Salem, B.; Lino, J.A.; Simons, J. A framework for responsive environments. In *European Conference on Ambient Intelligence, Proceedings of the 13th European Conference, Malaga, Spain, 26–28 April 2017*; Braun, A., Wichert, R., Mana, A., Eds.; Springer International Publishing: Cham, Switzerland, 2017; pp. 263–277. [\[CrossRef\]](#)
82. Porter, T. *Colour Outside*, 1st ed.; Architectural Press: London, UK, 1982.
83. Moughtin, J.C.; Oc, T.; Tiesdell, S. *Urban Design: Ornament and Decoration*, 1st ed.; Betterworth and Heinmann: Oxford, UK, 1995.
84. Lange, B. *The Colour of Copenhagen*; Royal Danish Academy of Fine Arts, School of Architecture Publishers: Copenhagen, Denmark, 1997.
85. Cömert, N.Z. Testing an Integrated Methodology for Urban Typo-Morphological Analysis on Famagusta and Ludlow. Doctoral Dissertation, Eastern Mediterranean University, Famagusta, Turkey, 2013. Available online: <http://hdl.handle.net/11129/656> (accessed on 28 August 2019).
86. Gauthier, P.; Gilliland, J. Mapping urban morphology: A classification scheme for interpreting contributions to the study of urban form. *Urban Morphol.* **2006**, *10*, 41–50.
87. Fillion, P.; Hammond, K. Neighbourhood land use and performance: The evolution of neighbourhood morphology over the 20th century. *Environ. Plan. B Plan. Des.* **2003**, *30*, 271–296. [\[CrossRef\]](#)
88. Cataldi, G.; Maffei, G.L.; Vaccaro, P. Saverio Muratori and the Italian school of planning typology. *Urban Morphol.* **2002**, *6*, 3–14.
89. Osmond, P. Micro-scale analysis of urban form: Towards a sustainability toolkit. In *The Planned City*; International Seminar on Urban Form: Trani, Italy, 2003; pp. 320–325.
90. Li, Y. A Typo-Morphological Enquiry into the Evolution of Residential Architecture and Urban Tissues of the Guangfunan Area of Guangzhou, China. Doctoral Dissertation, Concordia University, Montreal, QC, Canada, 2013. Available online: https://spectrum.library.concordia.ca/977412/1/Li_MSc_F2013.pdf (accessed on 19 July 2019).
91. Gajic, R. Urban morphology as a tool for exploring the land use in residential areas: Example of New Belgrade. *Spatium* **2015**, *2015*, 76–83. [\[CrossRef\]](#)
92. Wu, J. Toward a landscape ecology of cities: Beyond buildings, trees, and urban forests. In *Ecology, Planning, and Management of Urban Forests*; Carreiro, M.M., Song, Y., Wu, J., Eds.; Springer: New York, NY, USA, 2008; pp. 10–28. [\[CrossRef\]](#)
93. Newman, P.W. *Cities as Sustainable Ecosystems: Principles and Practices*; Island Press: Washington, DC, USA, 2003. Available online: <https://parfikh.files.wordpress.com/2012/01/cities-as-sustainable-ecosystem.pdf> (accessed on 2 June 2020).
94. Whitehand, J.W. British urban morphology: The Conzenion tradition. *Urban Morphol.* **2001**, *5*, 103–109. Available online: <http://www.urbanform.org/pdf/whitehand2001.pdf> (accessed on 4 April 2019).
95. Chyung, S.Y.; Roberts, K.; Swanson, I.; Hankinson, A. Evidence-based survey design: The use of a midpoint on the Likert scale. *Perform. Improv.* **2017**, *56*, 15–23. [\[CrossRef\]](#)
96. Spearman, C. The proof and measurement of association between two things. *Am. J. Psychol.* **1904**, *15*, 72–101. [\[CrossRef\]](#)
97. Conzen, M.P. How cities internalize their former urban fringes: A cross-cultural comparison. *Urban Morphol.* **2009**, *13*, 29–54. Available online: http://www.urbanform.org/online_unlimited/pdf2009/200913_29.pdf (accessed on 23 May 2020).
98. Lobo, J.; Bettencourt, L.M.; Strumsky, D.; West, G.B. Urban scaling and the production function for cities. *PLoS ONE* **2013**, *8*, e58407. [\[CrossRef\]](#)
99. Hopwood, B.; Mellor, M.; O'Brien, G. Sustainable development: Mapping different approaches. *Sustain. Dev.* **2005**, *13*, 38–52. [\[CrossRef\]](#)
100. Dempsey, N.; Bramley, G.; Power, S.; Brown, C. The social dimension of sustainable development: Defining urban social sustainability. *Sustain. Dev.* **2011**, *19*, 289–300. [\[CrossRef\]](#)
101. Leccese, M.; McCormick, K. (Eds.) Charter of the new urbanism. *Bull. Sci. Technol. Soc.* **2000**, *20*, 339–341. [\[CrossRef\]](#)
102. Nelson, A.C.; Pendall, R.; Dawkins, C.J.; Knaap, G.J. *The Link between Growth Management and Housing Affordability: The Academic Evidence*. Growth Management and Affordable Housing: Do They Conflict. 2002, pp. 117–158. Available online: <https://www.brookings.edu/wp-content/uploads/2016/06/growthmang.pdf> (accessed on 19 September 2020).
103. Gillham, O. *The Limitless City: A Primer on the Urban Sprawl Debate*; Island Press: Washington, DC, USA, 2002.
104. Newman, P.W.; Kenworthy, J.R. Gasoline consumption and cities: A comparison of US cities with a global survey. *J. Am. Plan. Assoc.* **1989**, *55*, 24–37. [\[CrossRef\]](#)
105. Morris, A.E.J. *History of Urban Form before the Industrial Revolution*, 3rd ed.; Routledge: London, UK, 2013. [\[CrossRef\]](#)
106. Roelofs, J. Building and designing with nature: Urban design. In *Sustainable Cities*; Satterthwaite, D., Ed.; Earthscan: London, UK, 1999; pp. 234–250.

107. Boonstra, C. Sustainable housing: The Dutch experience. In *Sustainable Housing: Principles and Practice*; Edwards, B., Turrent, D., Eds.; Taylor & Francis Group; E & FN Spon: New York, NY, USA, 2000; pp. 79–87. Available online: http://students.aiu.edu/submissions/profiles/resources/onlineBook/u4M3j6_Sustainable_Housing_Principles_and_Practice.pdf (accessed on 27 July 2020).
108. Paulson, B. Toward global sustainable community: A view from Wisconsin. In *Sustainable Global Communities in the Information Age: Visions from Futures Studies*; Yamaguchi, K., Ed.; Praeger Publishers: Westport, CT, USA, 1997; pp. 103–113.
109. Todd, N.J.; Todd, J. *From Eco-Cities to Living Machines: Principles of Ecological Design*; North Atlantic Books: Berkeley, CA, USA, 1994.