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Sustainable urban morphology emergence via complex adaptive system analysis: sustainable design in existing context

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Abstract

How to plan and design new elements in the city context in a way that the new elements improve the entire neighborhood energy performance and its sustainability is the main question to be discussed in this paper. In order to achieve this goal, different urban morphological factors, which have great influence on energy consumption of the city as a single entity, are investigated as based on complexity analysis. In this analysis, the urban morphology is considered as the microscopic emergence of the city element's transformation in time. Much research has been carried out regarding sustainable buildings and the energy performance of single edifices; however, there are few studies which have been carried out with consideration of the cities as a single unit. Ultimately, the aim of this paper is to elucidate a novel method to design a new urban element, architectural project for instance, towards achieving a sustainable urban form.

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Keywords: urban morphology; sustainable urban design; complex adaptive system

1. Introduction

How best to design and introduce new elements into an existing context, in one hand, and achieve an energy sustainable pattern for planning new cities, in the other hand, are rising concerns of planners and designers nowadays. Numerous researches have been carried out with focus on these two fields separately. The ability to bridge these two issues and answer them both regarding energy aspect of the sustainability

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is the core investigation of this article. Much research has been done in different urban sciences with the consideration of the city as a complex system (CS) but there is little research on the energy aspect of the cities considered as a complex system and a single entity. CS is a system composed of many heterogeneous agents, which are nonlinearly interconnected, while the final emergence of the system is completely different than the individual element's performance. The CS can be an economic system, social structure, computer or automobiles, for instances. Here, the energy aspect of city forms and the effect of urban morphology on energy consumption are under discussion with consideration of the cities as a complex system, and within the context of this paper, particularly a complex adaptive system. The complex Adaptive System (CAS) is a specific type of complex system with some key differing features. CAS has the ability to learn and adapt from past conditions that it has encountered. Thanks to this feature, CAS evolution is more advanced with respect to the CS. Due to its capacity to learn from the past experiences, CAS continuously adapts itself to new constraints and circumstances, resulting in a better performance therefore, the effect of urban form on the energy performance of the city as single entity via complex system analysis has been investigated. This paper aims to elucidate an approach to design a new element in to an existing context in an energy sustainable way.

Three main divisions of this paper

Part A	City as a Complex Adaptive System
Part B	Energy performances of the city as a single complex entity
Part C	Example for Exiample

1.1. Methodology

This paper is comprised of three different parts, followed by a conclusion at the end of each part. These conclusions assist for better comprehension of each part, whilst they also bond these three main parts of the article together.

In the first division, the City as a Complex Adaptive System (Part A), is introduced through its main characteristic features. How to consider cities as a complex adaptive system and how they form their morphology via complex adaptation is discussed afterwards. The main CAS features under discussion in the first part include the Agents, Subsystems, Algorithmic Relation, Dynamic and Adaptive feature from Exogenous Constraints and finally Transformation.

The second division, Energy performance of the city as a single complex entity (Part B), depicts energy performance of the city as a single unit, comprised of different heterogeneous elements, and how these single agents affect the final energy balance of the entire city. Thereafter, new energy performance of the city due to new morphological changes in the city is investigated. Urban morphology effects on solar gaining, thermodynamic performance, density, wind effect and ventilation are the main keywords investigated in the second part.

The third division, Example for Exiample (Part C), is a simplified case study, carried out on the Exiample blocks in Barcelona, Spain. This case study represents how a single building can improve the energy performance of other buildings in one neighborhood block, as well as the entire neighborhood on a larger scale.

2. City as a Complex Adaptive System (Part A)

The Complex Adaptive System (CAS) is a particular case of the complex system with the ability to

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