

**SUSTAINABILITY ASSESSMENT OF COMPACT-CITY
DEVELOPMENT USING GEODESIGN APPROACH**

AHMED ABDULHAFEDH OWaid

UNIVERSITI TEKNOLOGI MALAYSIA

SUSTAINABILITY ASSESSMENT OF COMPACT-CITY DEVELOPMENT
USING GEODESIGN APPROACH

AHMED ABDULHAFEDH OWAID

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ABSTRACT

Improving and evaluation of development plans is an essential to ensure a better planning and design practice. Compact city development is an urban design and planning concept that is noted to be very useful to ensure sustainability and overcome environmental, economic and social problems caused by urban sprawl. However, the outcomes and impacts of compact city development are not clear if using the conventional spatial analysis methods for evaluation. This study intends to improve and advance the process and methodology of assessing compact city development taking benefit from the new emerging concept of GeoDesign. This study is carried out in the city center of Johor Bahru, the capital city of the State of Johor, Malaysia. As a result, the study highlights compact city 2D and 3D indicators and the importance of these indicators is ranked under each development scenario based on expert's opinions. The study develops a composite sustainability index map in three scenarios environmental protection, economic efficiency, and social equity. Then, the GeoDesign approach applied for evaluating the compact city development. Finally, the computed sustainability index map of Spatial Multi Criteria Analysis (SMCA) model was analyzed and combined with 3D GeoDesign visualization to examine the sustainability levels of future development of the study area. GeoDesign dealt with centrality, high density and proximity, intensification, mixed land uses and public transit systems. The study found that the future development of the study area is a polycentric urban structure, and the proposed light rail transit (LRT) stations of transit oriented development (TOD) concept are not located in the core of the proposed high density mixed land uses urban centers. Furthermore, the assessment of development sustainability by considering planning and design criteria through GeoDesign enhanced the results of simulated analysis and reduced the possibilities for disregarding any of the related measures of the involved sustainable development concept.

ABSTRAK

Meningkatkan dan penilaian rancangan pembangunan adalah penting bagi memastikan perancangan yang lebih baik dan amalan reka bentuk. Pembangunan bandar padat reka bentuk dan perancangan konsep bandar yang terkenal sangat berguna bagi memastikan kelestarian dan mengatasi masalah alam sekitar, ekonomi dan sosial yang disebabkan oleh terkapar bandar. Walau bagaimanapun, hasil dan impak pembangunan bandar padat tidak jelas jika menggunakan kaedah analisis spatial konvensional untuk penilaian. Kajian ini bertujuan untuk memperbaiki dan memajukan proses dan metodologi menilai bandar padat manfaat pengambilan pembangunan daripada konsep baru muncul baru GeoDesign. Kajian ini dijalankan di pusat bandar Johor Bahru, ibu kota Negeri Johor, Malaysia. Kajian mengetengahkan bandar padat petunjuk 2D dan 3D dan kepentingan indikator ini berada di kedudukan di bawah setiap senario pembangunan berdasarkan pendapat pakar itu. Kajian ini membangunkan kelestarian komposit indeks peta dalam tiga senario perlindungan alam sekitar, kecekapan ekonomi dan kesaksamaan sosial. Yang dikira indeks kemampuan peta Spatial Multi Kriteria Analisis (SMCA) model telah dianalisis dan digabungkan dengan 3D GeoDesign visualisasi untuk mengkaji tahap kemampuan pembangunan masa depan kawasan kajian. GeoDesign diuruskan keutamaan, ketumpatan yang tinggi dan jarak, intensifikasi, guna tanah bercampur dan sistem transit awam. Kajian mendapati bahawa pembangunan masa depan kawasan kajian adalah struktur bandar polycentric, dan yang dicadangkan (LRT) stesen konsep TOD tidak berada di dalam teras tanah bercampur berkepadatan tinggi yang dicadangkan menggunakan pusat-pusat bandar. Penilaian kemampuan pembangunan dengan mempertimbangkan perancangan dan reka bentuk melalui kriteria GeoDesign dipertingkatkan hasil analisis simulasi dan mengurangkan kemungkinan untuk mengabaikan mana-mana langkah-langkah yang berkaitan terlibat konsep pembangunan lestari.

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LIST OF ABBREVIATIONS

2D	-	Two Dimensions
3D	-	Three Dimensions
CAD	-	Computer Aided Design
CBD	-	Central Business District
CE	-	CityEngine
CGA	-	Computer Generated Architecture
DEM	-	Digital Elevation Model
GIS	-	Geographic information system
KMZ	-	Keyhole Markup Zipped
LRT		Light Rail Transit
MCA	-	Multi Criteria Analysis
OSM	-	OpenStreetMaps
SMCA	-	Spatial Multi Criteria Analysis
SQL	-	Structured Query Language
TOD	-	Transit Oriented Development
XML	-	Extensible Markup Language

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Development Plan evaluation and assessment is an essential and it can contribute to a better planning practice, the plans should be evaluated to achieve desired goals and objectives. Increasing number of researches has explained on the process of sustainable development principles, particularly at the city level and a high number of scholars have explained urban sustainability implementing and measuring from various aspects.

The available approaches of urban and regional planning implemented a continuous, cyclical system approach based on the identification of demands and goals, the preparation and evaluation of alternative sequences of actions and monitoring of implemented program. This effort normally includes the identification of developing land use which typically connected with other planning data such as housing, employment, and population which makes this task difficult where rapid urbanization is taking place (Yaakup, 2004). However, to achieve the desired goals and objectives of development planning, control development programs as well as evaluate alternatives that are in line with current and future scenarios, an effective planning approach is required. For long time, Geographic information system (GIS) technology has been practiced in planning activities, which basically include plans preparation as well as development control (Johar et al., 2003).

GIS has been noted to be very useful as a spatial analytical tool in monitoring and evaluating urban sustainability. It has the ability to join spatial data with attributes to carry out spatial analysis from these data. Moreover, sustainability assessment of urban development includes evaluation and measurement of spatial data that can be controlled to specific degree by GIS. Separately from data integration, manipulation, and analysis, GIS could be employed in visualizing various scenarios of alternatives from sustainability indicators (Kamal and Hazem 2013).

GeoDesign is a planning and design approach which tightly combines the formation of a design proposal with impact analysis informed by geographic context (Flaxman, 2010). Furthermore, Abukhater and Walker (2010) noted that GeoDesign is a growing concept for a practice that combines GIS techniques with design and to develop advanced tools for urban design, planning, architecture and community development. In other words, GeoDesign brings geographic analysis into the design process, where initial design sketches are promptly examined for suitability against a many of database layers representing a diversity of physical and social factors for the spatial extent of the project.

Compact City concept is generally a high density, mixed uses city, providing an effective public transit systems and measures that encourage cycling and walking and intensification of development within boundaries of the city (Burton, 2000). Compact city has recently become a widely accepted concept as well as a nationwide movement that intentions to correct arising problems caused by urban sprawl. Compact City initiatives are generally designed to encourage concentrated development, infill development, and redevelopment and to promote environment sustainability, economic equity, and a better sense of community for a specific city or area.

GeoDesign has the ability to evaluate development plans through GIS analysis models and its product of urban design through 3D GeoDesign visualization, and Compact City concept as sustainable development has 2D and 3D criteria related

to urban planning and design that can be implemented to evaluate future development through GeoDesign. So far, GeoDesign has not been applied for evaluating the compact city development so this study is going to adopt this concept.

As result, the evaluation of Compact City development can be carried out more effectively through GeoDesign by improving both Compact City plans and the planning process, also it can better clarify the relations and the differences of the indicators for sustainable urban development. Therefore, it supports the decision makers to test the sustainability levels of urban development more comprehensively. However, the proposed concept of this research will be adopted to examine the future development sustainability level of Johor Bahru, the capital city of Johor state, according to its comprehensive development plan.

1.2 Research Background and Motivation

In past years, fast changes were perceived in most cities of the universe. The cities converted to be centers of inclusive consumption and resulted in various environmental and ecological issues. Subsequently, it is unacceptable to neglect vacant areas in the city and direct their development towards the neighboring regions without taking benefits of the existing situation. There are many wastelands within the cities while boundaries of these cities are extending and destroying the rural areas (Zagorskis et al., 2007).

The city centers became challenging to realize because the level of spatial group is now very insignificant and based generally on access by vehicle (Urban Task Force, 1999; Rogers, 2000). However, Frey (1999) argues that measures should be engaged to analyze the negative impact of urban sprawl. Firstly, a frugal way of economic sustainable development and land use must be implemented more

effectively through underlying the use of wastelands as development alternative. And mixed land uses adaptive environment, providing the higher population density, equal planning and extreme dependency on public transit systems.

The establishment of “sustainable development” as a common concept has revived debate about the form of urban development (Jabareen, 2006). Also, Jabareen (2006) stated that sustainable development concept has inspired and motivated researchers and experts in diverse disciplines to pursue development forms for society settlements that meet the requirements of sustainability and facilitate built environments to perform in a more positive manner than at present. Consequently, the form of a contemporary city has been observed as a cause of environmental problems (Alberti et al., 2003; U.S. Environmental Protection Agency, 2001; Frey, 1999).

The United States Environmental Protection Agency in 2001 determines that urban form directly influences ecosystems, endangered species, water quality and habitat through habitat fragmentation, land consumption, and converting of permeable natural surfaces with impervious surfaces. In addition, urban form influences travel activities which impacts air and water quality, premature loss of countryside land, open space and wetlands, soil contamination and pollution, noise and global climate.

In addition, Newman and Kenworthy (1999) suggest that the promotion of sustainable development has associated with the popularization of the urban compactness concept by improving the environmental and ecological justifications behind it. In the meantime of 1990s, studies have been usually directed to the advocacy of cities that are spatially compact, with a mixed uses of land. However, many researchers agree that compact city form compromise chances to reduce energy consumption for travelling, since working and leisure amenities are closer together (Newman and Kenworthy, 1999).

Compact cities are preferred because urban land can be redeveloped, while countryside lands outside the urban boundary are protected. Eventually, it is claimed that even with high population concentration a good quality of life can be sustained. The compact form can be applied on a numerous of scales, from urban infill to the formation of completely new settlements, such as the concepts of Urban Villages in the United Kingdom and New Urbanism in the United States (Jabareen, 2006).

Compactness offers density of population and built form and intensification of its functions, mixed and diverse land uses, effective land planning, and efficient transit systems. The European Commission's Green Paper in 2005 supports strongly the "compact city," assuming that it produces urban spaces more sustainable environmentally and improves living quality. The compact city has been endorsed in the United Kingdom and throughout Europe as a component of the strategy designed to challenge the impacts of unsustainability (Livingstone and Rogers, 2003).

Additionally, there are different aspects of the characteristics of Concept Compact City for urban planning and design, in term of urban form these characteristics include high, dense settlements; less reliance on automobiles and clear boundary from surrounding areas (OECD, 2012). As a result, combining urban form features through 3D visualization techniques with spatial plans is an essential for achieving better sustainable development.

1.3 Problem Statement

From the extensive acceptance of the sustainable urban development concept, finding effective methods to evaluate and assess comparative sustainability levels of future and existing developments become significant concern (Brandon, 2007). Numerous studies have been proposed different methods for sustainability

assessment (Norman, 2004). Although, compact city is proposed as a solution of urban sprawl, there is a lack of studies on its impacts assessment and evaluation. However, the applications of geographic information systems (GIS) and related techniques are suitable tools in measuring the impact of development activities and evaluating its environmental, economic and social sustainability.

Traditional GIS does not provide a realistic physical representation of the city or development being studied. However, 3D views of the city are key tools for increasing understanding and improving communication. 3D visualization and analysis of environmental properties is an efficient way of assessing the impacts of urban projects. So, the tri-dimensional geographical information system (3D GIS) is well adapted to help in sustainable urban planning (Trung et al., 2007).

Additionally, the representation of built forms within GIS remains overlay simplistic, usually consisting of 2D footprints. This makes it difficult to conduct neighbourhood, city or regional scale assessments that take into account important characteristics of design proposals (Flaxman, 2009). Accordingly, Compact City development is an urban design and planning concept, design aspects of this concept are represented by proposing 3D indicators while 2D indicators represent planning aspect indicators.

Current GIS systems still depend heavily on professionals both in the training of the tools and in understanding the forms in which the data is being presented (Shiffer, 1998). However, CAD systems provide no ability to overlay additional data and provide little context out with the building or area being studied (Isaacs et al., 2010). As a result, the proposed methodology is to combine GIS 2D analysis results with 3D GeoDesign urban models and insert the 3D models in the surrounding landscape that is characterized by GIS simulation to contextualize the Compact City development that is undergoing sustainability assessment to incorporate design and planning criteria.

Most planners are already using GIS at some levels. At the least, their future land use maps are made with GIS tools, and their parcel data are stored in GIS databases. This type of use does not take advantage of full GIS capabilities. GeoDesign combines the information capacity of GIS with the decision making process of design, yielding tools that are informative, interactive and ideal for Smart Growth plans and planning processes (Abukhater and Walker, 2010). Accordingly, this research aims to investigate 2D and 3D criteria of Compact Development to inclusively utilize the indicators related to design and planning. Finally, there has been the lack of research studies in the application of GeoDesign with Compact City Concept for the assessment of sustainability of urban future development and this study is going to explore this possibility of such integration.

1.4 Research Questions

This research is proposed to find out the appropriate answer for the questions below:

1. What are the criteria in order to achieve sustainability in Compact City development?
2. How to add 3rd dimension components to GIS Analysis in the evaluation of future developments to enhance sustainability?
3. How GeoDesign concept can be adopted in Compact City development appraisal?

4. To what extent GeoDesign Concept can improve the evaluation of Compact City development?

1.5 Objectives of Study

This study aims to evaluate and assess the sustainability of urban development and the impact of the development taking the benefits of new emerging concept of GeoDesign. Objectives of the study are mentioned bellow:

- To highlight the main urban development criteria that associated with Compact City development.
- To examine the advantages and disadvantages of adopting GeoDesign in evaluation of Compact City development
- To adopt GeoDesign Concept in understanding the future urban development and its impacts.
- To formulate a framework of GeoDesign analysis in GIS composite sustainability index model in evaluating the degree of sustainability of future urban development.

1.6 Significance of Study

Rapid urban growth and its harmful environmental, economic and social impacts have become major concerns to measure for urban planners and decision makers. As result, the consideration of adopting advanced tools and approaches to evaluate alternative scenarios and assess policy for impact minimization and better development practices become crucial.

Based on concepts originate in Ian McHarg's seminal *Design with Nature*, GeoDesign incorporates geographic science with design, developing a systematic methodology for planner, designers and decision makers. Geodesign carries geographic analysis into any design process, producing designs that more closely follow natural systems (Artz, 2010).

Furthermore, the ability to visualize part of the city that is undergoing the development or regeneration within the wider city context is likely to improve engagement with the communication tool and bring a greater level of involvement from all participants in the planning process (Levy, 1995).

Using GeoDesign in sustainability assessment of the development area will improve the development plan product and planning process if used correctly by local governments and decision makers. The evaluated plans under the proposed approach of this research are better because they are based on more accurate, complete information and impacts simulation because it provides information about a plan's implications very early in the planning process. The process of sustainability assessment is better because it is more transparent and inclusive, the inclusiveness comes from GeoDesign's ability to engage planning and design criteria of compact city development in the evaluation of sustainability levels. The transparency comes from the way GeoDesign makes information and trade-offs explicit: everyone can see how this sketch leads to that result (Abukhater and Walker, 2010). Most importantly, this research is providing a conceptual framework for the application of Compact City development in GeoDesign approach to evaluate future urban

development of a specific area which can be adopted for future research in urban design and planning. In addition, the model of composite sustainability indexing of this research can be used for informing policy, strategy formation and also as supporting system for planning and decision making.

1.7 Research Organization

This dissertation is divided into five chapters; each chapter is covering a particular aspect of the study as following:

Chapter 1 discusses the overall view of this study and the motivation for conducting this research by giving a literatures background. In addition, it addresses general issues, research objectives, and research question. The significance to carry out this research is also explained in this chapter.

Chapter 2 reviews the literature related to sustainability and urban sprawl as a basis for sustainability criteria evaluation. In addition, the literatures on Compact City Development as sustainable development have been reviewed to identify sustainability assessment using 2D and 3D indicators and design the research questionnaire. GeoDesign tools, techniques and related theories are examined as a theoretical basis for the research methodology.

Chapter 3 provides solid description for the research structure and methodologies to carry out this study by explaining data, tools and methods to build the three development scenarios and GeoDesign generated maps visualization and evaluation.

In chapter 4 the results of research questionnaire, 2D GIS analysis Maps, and 3D GeoDesign maps are displayed, and result of findings are discussed and compared to other findings.

Chapter 5 concludes the research results and findings of this study. Besides in this chapter we explained how the objectives of the study are achieved. The implication of findings are elaborated and it provides recommendations regarding the research limitations and proposes potential opportunities for future research works based on this research.

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