



THE INTEGRATION OF GIS AND REMOTE SENSING
TECHNIQUES FOR URBAN MORPHOLOGY:
A CASE STUDY OF GEORGETOWN, PULAU PINANG

BY

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the degree of Master of Urban and Regional Planning

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ABSTRACT

This study analyses the potential applications of geospatial technology for urban planning research in urban morphology. Urban morphology is the study of the form of human settlements and the process of their formation and transformation. It is an approach in designing urban form that considers both physical and spatial components of the urban structure. The study was conducted in Georgetown, Penang purposely main to identify the evolution of urban morphology and the land use expansion using remote sensing imagery and geographical information system (GIS) techniques. Three components of urban morphology, namely building plots, street layout and open spaces with four series of temporal satellite Spot J in years 2004, 2007, 2009 and 2014, and Georgetown land use map 2011 were used in determining the transformation of the study area and detecting an expansion of land use development using change detection technique. Three types of land uses were classified, namely build-up areas, un-built and water bodies showed a good accuracy with achievement above 85%. The result shows that built-up area significantly increased due to the rapid development in an urban area and the evolution of urban morphology components also transformed. Finally, this study clearly demonstrates the relationship between urban planning and geospatial applications in creating sustainable and resilient city, and future urban governance as well.

م. ملخص البحث

هذه الدراسة تحليل التطبيقات المحتملة للتكنولوجيا الجغرافية المكانية للبحوث التخطيط العمراني في التشكل الحضري. مورفولوجيا الحضري هو دراسة للمستوطنات البشرية وعمليات تشكيل والتحول. وهو نهج لتصميم المناطق الحضرية التي يعتبر كل من المكونات المادية والهيكلي المكاني للمدينة. الدراسات التي أجريت في جورج تاون، بينانغ للتعرف على التطور الصرفي والتوسع في استخدام الأراضي في المناطق الحضرية باستخدام الصور الإحساس عن بعد وتقنيات نظام المعلومات الجغرافية (GIS). ثلاثة مكونات التشكل الحضري المؤامرات بناء، تخطيط الشوارع والمساحات المفتوحة مع أربعة سلسلة الأقمار الصناعية الأرضية سبوت J في 2004، 2007، 2009 و 2014 والترية جورج تاون استخدام خريطة في عام 2011 في تحديد التحول من منطقة الدراسة واكتشاف توسع تطوير استخدام الأراضي باستخدام تقنيات الكشف عن التغيير. ثلاثة أنواع استخدام الأراضي التي صنفت بناء، وليس شيدت وأظهرت دقة جيدة مع هدف من 85٪ وما فوق. والنتيجة تظهر زادت المساحة المبنية بسبب التطور السريع في المناطق الحضرية وتطوير المناطق الحضرية التشكل يحدث المكون. وأخيرا، تقدم هذه الدراسة فهما وتعزيز العلاقة بين التخطيط العمراني والتطبيقات الجغرافية المكانية في متابعة والدفاع عن المدينة والإدارة الحضرية في المستقبل كذلك.

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion, it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Master of Urban and Regional Planning.

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DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

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A CASE STUDY OF GEORGETOWN, PULAU PINANG**

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*This thesis is dedicated to my cherished **husband** and **parents**;*

Who taught me,

“Don't ever give up.

Don't ever give in.

Don't ever stop trying.

Don't ever sell out.

*And if you find yourself succumbing to one of the above for a brief moment,
pick yourself up, brush yourself off, whisper a prayer, and start where you left off.*

But never, ever, ever give up.”

-Richelle E. Goodrich-

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LIST OF ABBREVIATIONS

GIS	Geographical Information System
JPBD	Jabatan Perancang Bandar dan Desa
KOMTAR	Kompleks Tunku Abdul Rahman
MRSA	Malaysian Remote Sensing Agency
SAP	Special Area Plan
UNESCO	United Nations Educational, Scientific and Cultural Organization

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Urban morphology is the study of the form of human settlements and the process of their formation and transformation. The study seeks to understand the spatial structure and character of a metropolitan area, city, town or village by examining the patterns of its component parts and the process of its development. Moreover, the urban morphology occurred based on certain characteristic such as the configuration of urban fabrics, natural and man-made structures, street layout, architectural complexity, open space and other physical element (Li and Yeh, 2004; Sharifah et al., 2013). Those characteristics will influence the changes of environment, economic, and social activities of the urban settlement.

Besides that, urban morphology analysis can help to identify the transformation of the urban form development and the evolutionary of urban form and structure (Cheng, 2011). Urban morphology plays fundamental role in the resilience of the urban system and enhances the urban growth of the specific settlement. It can represent as a tool to control the development activity and provide opportunities and constraints for city-building processes, such as land subdivision, infrastructure development, or building construction.

The urban morphology analysis aided by using geographic information system (GIS) and remote sensing technique. These techniques can reveal the relationships of pattern, trend, form and structure of urban settlements. It will help to investigate the past and present patterns and trends of urban growth.

1.2 BACKGROUND OF THE STUDY

Rapid development in urban settlement contributes to the changes of environmental, economic and social activities. This transition of the metropolitan area, city, town or village from the past to the present condition describe the process of urban growth which gives impacts to the form and structure of settlements. Therefore, urban morphology become as an essential key for the urban development to identify and determine the resilience of the whole urban system that will create urban dynamic. The understanding of urban growth and interpretation of urban morphology can be a key challenge to the rapid urbanization of the settlements.

Urban morphology is an approach in designing urban form that considers both physical and spatial components of the urban structure (Paul, 2008). The criteria for the evolutionary process of development at the particular city such as plots, blocks, street layout, buildings, urban material and open spaces are considered as part of the history. Therefore, this transformation affecting urban morphology includes economic, technological globalization, environmental and climatic impact, demographic change and household preferences (Gillen, 2006).

The significance of urban morphological study has yet to realize amongst urbanists, it however, occupies an interesting position at the confluence of current reflections on the nature of cities, providing a basis of the cross-disciplinary search for relevant urban design methods. In this case, urban morphology is the missing constituent in the process of urban design. Therefore, its value is in the provision of detailed physical characteristics in the evolution of urban form, bridging the divide that exists between this geographical knowledge, urban planning and architectural design (Paul, 2008).

In addition, urban morphology is the study of the city as a human habitat. It analyse a city's evolution from its formative years to current transformations which identifying and dissecting its various components. Therefore, buildings, gardens, parks, streets and monuments consider as main elements of morphology analysis. However, these elements consider as organisms that constantly used and transformed through time. The urban morphology analysis could be a yardstick to understand and to design the sustainable urban form and spatial structure in order to produce dynamic urban settlements. As can be seen, the symbiotic and interrelation of the urban form towards economic, environment and social activities, will provide systematic interactions and resilience to the urban settlements.

Using GIS and remote sensing technique are the methods in analyzing the evolution of urban morphology. GIS is a computer-based information system used to digitally represent and analyze the geospatial data or geographic data. GIS technique enables to have a better understanding and evaluate data in many major areas such as environmental and natural resource management, facilities management, street network planning and engineering and information system.

Therefore, GIS is most widely used technologies application that is used in the whole world. Besides that, remote sensing also consider as an important source of information for urban analysis at the territorial scale. This technique enables to analyze urban feature such as physical planning, economic planning, social planning and forecasting future model of the selected area (Donnay et al., 2001).

Both techniques can provide a useful and direct measure of the physical form and morphology of urban land cover that is very useful in delineating the extent of individual urban settlements and in generating magnitude of size estimates for settlement systems (Batty and Longley, 1994). Moreover, the developments of these

techniques have led to significant improvements in its capability for decision-making process in selected major areas.

Remote sensing can detect the transformation of urban morphology when the transitions of land cover from one type to another or when the intensity of the land use or even the material composition changes. Moreover, urban morphology can change over time as the new urban fabric is added and as the existing fabric is internally modified. For example, new buildings replace old ones, plots are amalgamated or subdivided, street layout is modified and more. The changes of internal components are major concerns that represent the interrelation of physical evolution, such as economic, cultural and political dimensions that associated with the urban dynamics (Rashed et al., 2005).

Urban morphology analysis requires multi-temporal data sets that covering the whole urban areas across a long period. This analysis can summarize the changes and trends of urban form and urban spatial structure. Therefore, morphology analysis can investigate the relationship between the land covers changes and population density from past and present year in order to identify the urban growth rate either decrease or increased, the population growth rate or the built up density.

Thus, this research is to identify the evolution and changes of urban morphology in urban settlements within particular years. Remote sensing and GIS are now providing new tools for advanced ecosystem management. The collection of remotely sensed data facilitates the analysis of earth's system function patterning and change at local, regional and even global scales. By using this method, the transition of urban settlements in terms of urban form and spatial structure can be analyzed and it will help to forecast future development that suitable and create sustainable and resilience for urban growth.

1.3 CASE STUDY

The study area has been chosen is Georgetown city located on the north-east corner of Penang Island. The history of Georgetown started when Captain Francis Light found the island on 11 August 1786 and obtained the Island of Penang from Sultan Kedah. He is a trader for the British East Indian Company and he developed the Island of Penang as one of the important port for trading in Southeastern of Asia.

Due to remarkable achievement as trading port during the first century after its founding, the migrant communities found Georgetown as the best place to start and begin a new life. George Town is jointly inscribed as the Historic Cities of the Straits of Malacca, and together, the city stand as testimony to the centuries of maritime trade that shaped this country and a had a significant influence on the region.

1.4 PROBLEM STATEMENT

With the rapid increase of urban growth, it creates socioeconomic, environmental and political problems. This phenomenon will necessitate advanced methodologies such as technologies, which help city planners, economists, environmentalists, ecologists and resource managers solve the problems which accompany such growth. Urban planners need information about the rate of growth, pattern and extent of sprawl to provide the basic amenities such as water, sanitation and electricity. As a result, the information will be able to respond to the expectations and needs of the urban growth and at this point, it can help to forecast future model of urban settlements (Kalyani and Govindarajulu, 2013).

Urban morphology thus plays a fundamental role in the resilience of urban system. Morphology analysis is possible to summarize the changes and trends of urban form and urban spatial structure (Cheng, 2011). In the recent years, the challenge

facing most of urban areas is how to accommodate future population and development growth in a sustainable manner. Any of transformation of urban patterns and forms need to take as consideration so that it will minimize the negative impact towards environment. Some of the cities such as City of Granada, the environment of the city becomes physically degraded, damaged or even destroyed by the impact of the urban development that follows modernization. Therefore, the development of the city should be managed in a way that not contribute to deterioration of the urban environment. Thus, track back the history of the urban form and structure spatial in the city helps to re-plan the development in the City of Granada.

The relationship between urban morphology and planning is poorly developed (Whitehand and Morton, 2004). Thus, the significance of urban morphological study has yet to be realized amongst urban planner. However, urban morphology study provides important knowledge to the planner in order to develop any area in city or even for fringe belt. Lack of interest and awareness in history among the planner and others prevents to develop the settlements into a systematic urban dynamic (Green and King, 2003). Hence, the responsibility for the built environment is not been taken seriously towards realization of sustainable urban development.

The morphological analysis can be done by using Geographic Information System (GIS) and remote sensing that provides the advance techniques and methods for studying urban land development and assist urban planning. According to Narimah (2006), over the past forty years, many planning applications ranging from daily administrative operations to strategic planning functions used GIS. This technology has various analytical functions that can use in dealing with spatial problems such as urban planning and management issues. It is useful in assisting planners, decision

makers and the community to efficiently respond to challenges, plan successful future and improve service delivery.

Although GIS has become a common planning tool in many western developed nations, its application in many developing nations is still limited. This is because, the data has to be updated, come from reliable sources and available at a suitable scale. Thus, the data and its availability in digital format are very important in evaluating urban land use problem. Hence, both techniques consider having potential in developing a new perspective on solving problems (Green and King, 2003). Thus, in this research there are some problems and issue, which are:

1. The transformation of urban form and spatial structure affecting urban morphology includes environment and climatic impact, land use activities, urban patterns, street layout and open space.
2. Lack of awareness of using GIS and remote sensing technique as tools to analyze urban morphology that can provide comprehensive information on the transition of patterns and trends and the expansion of urban growth.
3. Rapid urbanization of urban morphology components can affect the future of urban forms and trends.
4. Uncontrolled transformation of land use provides unsustainable development for the city.

1.4 RESEARCH QUESTION

Based on the problem statement, the relevant research questions can be developed as below:

1. What are the components influence the urban morphology in study area?
2. How to identify the land use change activity in the study area?

3. How the urban morphology study can affect the city development in order to achieve a sustainable and resilient city in the future?
4. How the GIS and remote sensing technique benefited in the urban planning area?

1.5 AIMS AND OBJECTIVES

The aim of this research is to identify the evolution and changes of urban morphology within specific periods by using GIS and remote sensing technique. The urban morphology analysis will help to determine the transition that the urban settlements facing thus will give an understanding of the patterns and trends of the urban settlements. There are four objectives have been formulated in order to achieve the goal.

1. To determine encroachment of main land use using GIS and remote sensing techniques.
2. To analyze urban morphology of Georgetown based on component, namely building plots, street layout and open space.
3. To examine the impacts of urban morphology components on the actual development occurs in the Georgetown.
4. To recommend the physical guidelines in managing urban morphology issues to the local authority and related stakeholders.

1.7 SCOPE OF STUDY

This research will analyze the evolution of the urban morphology of the selected study area. Understanding urban morphology is important in creating an urban settlement in a sustainable manner. Moreover, urban morphology also can help to identify how the