

RECONSTRUCTING 3D GIS MODEL AND URBAN  
FORM DATABASE FOR TRADITIONAL MALAY  
CITY KOTA BHARU

BY

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## ABSTRACT

In recent decades, the role of 3D GIS as a modelling and platform for urban analysis has been used extensively in many fields of research. The ability of the GIS platform to handle spatial database and even to model and manage 3D databases creates more research and development on the field. The study aim is to reconstructing 3D GIS model and its database in order to determine urban form elements for Traditional Malay City in Malaysia. This study has demonstrated the use of the geospatial technique and databases formation to the most prominent known Malay town in Kota Bharu. The extraction of 3D geospatial databases that obtained from multicopter drone and laser scanning system have been used for this study. This dataset used for further construction of 3D GIS model and databases formation. There are few processes consist of pre-processing, main processing and data analysis involved in constructing 3D GIS model. Three elements of urban form consist of street network, land use and building have been analyzed in order to determine its role in formation the Traditional Malay City. The analysis showed, the overall existing development does not have a rigorous change, particularly on the urban layout and distribution of land uses, compared to the development in early period of establishment of Kota Bharu in 1845 till 1910. Therefore, there are a lot of cultural heritage building such as places, mosque and communal settlement houses which reflected the Traditional Malay identity still existed in study area. From the finding of and analysis from the historical context and also from the 3D GIS models, shows that, there are 3 main urban form elements which are associated with the formation of Traditional Malay City of Kota Bharu which are, land use element, street network element and building elements. These three elements were the main contributors in the formation of Traditional Malay City of Kota Bharu where the current form and arrangement of these three elements still related with the early establishment of Kota Bharu in 1845. the most land use concept which strengthening on the social interaction between the Sultan, aristocratic, communal and religion. Besides, on the street network, the connectivity between the places by the street structure created the sense of security and privacy and social engagement between the places. For the third urban form element, building element, the analysis found that, there are still structure or building including settlement structure which still applied the Kelantan Traditional Malay design on their façade, roof and form. In the meantime, the reconstructing of the 3D GIS model from the geospatial techniques was able to make use of the 3D GIS model and its databases as the final output model which can help to develop sustainability in cultural heritage, providing access to the heritage database in 3D format, and assist in analyzing and redefining rules of traditional Malay heritage to modern cities nowadays.

## خلاصة البحث

في العقود الأخيرة، كان دور توظيف نظام المعلومات الجغرافية ثلاثية الأبعاد (3D GIS) يستخدم على نطاق واسع نموذجاً ومنصةً للتحليل الحضاري في العديد من مجالات البحث. إن قدرة منصة نظام المعلومات الجغرافية على التعامل مع قاعدة البيانات المكانية وحتى على تصميم قواعد البيانات ثلاثية الأبعاد وإدارتها تخلق المزيد من البحث والتطوير في المجال. تهدف الدراسة إلى إعادة بناء نموذج نظام المعلومات الجغرافية ثلاثي الأبعاد (3D GIS) وقاعدة بياناته من أجل تحديد عناصر الشكل الحضري لمدينة الملايو التقليدية في ماليزيا. وقد أظهرت هذه الدراسة استخدام تقنية الجغرافيا الفضائية وتشكيل قواعد البيانات إلى أبرز المدن الملايوية المعروفة في كوتا بھارو. وقد استخدم في هذه الدراسة استخراج قواعد بيانات جغرافية فضائية ثلاثية الأبعاد (3D) التي تم الحصول عليها بالطائرات بدون طيار/الدرون ونظام المسح الضوئي بالليزر. وتستخدم مجموعة البيانات هذه في بناء المزيد من نموذج نظام المعلومات الجغرافية ثلاثية الأبعاد (3D GIS) وتشكيل قواعد البيانات. وهناك عدد قليل من العمليات التي تتكون من المعالجة المسبقة والمعالجة الرئيسية وتحليل البيانات التي ينطوي عليها بناء نموذج نظام المعلومات الجغرافية ثلاثي الأبعاد (3D GIS). وقد تم تحليل ثلاثة عناصر من نمط الحضري تتكون من شبكة الشوارع واستخدام الأراضي والمباني من أجل تحديد دورها في تشكيل المدينة الملايوية التقليدية. وأظهر التحليل أن التطور الحالي عموماً لا يحدث تغييرات صارمة، ولا سيما في التخطيط الحضري وتوزيع استخدامات الأراضي، مقارنة مع التطورات في الفترة المبكرة من إنشاء مدينة كوتا بھارو من عام 1845 حتى عام 1910. لذلك، هناك الكثير من مباني التراث الثقافي مثل الأماكن والمساجد ومنازل المستوطنات المجتمعية التي تعكس الهوية الماليزية التقليدية لا تزال موجودة في منطقة الدراسة. ويتضح من البحث والتحليل من السياق التاريخي ونمذجة نظام المعلومات الجغرافية ثلاثية الأبعاد (3D GIS) أن هناك ثلاثة عناصر رئيسية من أشكال المدن المرتبطة ببنية مدينة كوتا بھارو الماليزية التقليدية ألا وهي من عنصر الأراضي المستخدمة وعنصر شبكة الشوارع وعنصر المباني. وكانت هذه العناصر الثلاثة الرئيسية المساهمة في تشكيل المدينة الملايو التقليدية من كوتا بھارو من حيث الشكل الحالي وترتيب هذه العناصر الثلاثة لا تزال تتصل مع إنشاء مبكر لمدينة كوتا بھارو من عام 1845، وهو أكثر مفهوم استخدام الأراضي التي تعزز على التفاعل الاجتماعي بين السلطان، والأرستقراطية، والمجتمع والدين. بالإضافة إلى ذلك، تكون صلة في شبكة الشوارع بين المساكن من بنية الشارع الإحساس بالأمن والخصوصية والمشاركة الاجتماعية بين الأماكن. أما بالنسبة إلى العنصر الحضري الثالث وهو عنصر البناء، فقد وجد التحليل بأنه لا يزال في المبنى هيكل بنائي يستخدم في تصميم مباني كلنتان الملاوية التقليدية على واجهته وسقفه وشكله. وفي خلال ذلك، تمكنت إعادة بناء في نمذجة نظام المعلومات الجغرافية ثلاثية الأبعاد (3D GIS) من التقنيات الفضائية الجغرافية (3D GIS) وقواعد البيانات المصممة للإنتاج النهائي الذي يمكن أن يطور الاستدامة في التراث الثقافي ويتيح الوصول إلى قاعدة البيانات التراثية في التخطيط ثلاثية الأبعاد (3D) ويساعد في التحليل ويعيد تعريف أنظمة التراث الملايوي التقليدي للمدن الحديثة في الوقت الحاضر.

## APPROVAL PAGE

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## DECLARATION

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*In the name of Allah, the Most Gracious, the Most Merciful. All praise be to Allah, we praise Him and seek His help and forgiveness.*

*This thesis is dedicated to my dearest family, for all the sacrifices, patience, endless support and encouragement, especially:*

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## **ABBREVIATION**

|     |                               |
|-----|-------------------------------|
| GIS | Geographic Information System |
| 3D  | Three Dimensional             |
| 2D  | Two Dimensional               |
| UA  | V Unmanned Aerial Vehicle     |
| TLS | Terrestrial Laser Scanning    |
| MLS | Mobile Laser Scanning         |

# CHAPTER ONE

## INTRODUCTION

### 1.1 INTRODUCTION

The formation of a town or a city most likely are process or expansion and changing of the same system in settlement area or village area from the small settlement and expand into more complex settlement system (Hudson,1970). Even though many town or city are originally from the village settlement system but according to Hudson (1970) in the book “A Geography of Settlements” the town can be described as “village which succeeded”. There are also a town; which purposely planned and establish as it was rather than a town; which resulted from the expansion of the settlement area. Basically, the village settlement area are defined based on the population which the major daily activities related with the agriculture activities (Hudson 1970). Meanwhile, town and city have a bit of different in term of function where, the city are represent for a leading town and have a most complex types of associative with social life and culture for a civilization (Hudson, 1970; Mumford,1938; &Dickson 1964). Relates with the study topic’s which the use of the term Traditional Malay City, which refers to the leading city which associated with the Traditional Malay culture, social life, architecture design, locational factors, the ruling system and more aspect and criteria which will be further discuss in the literature review part in chapter two.

This study focused on the integration of two main aspect which are the Traditional Malay City and 3D GIS city modelling. These two components play vital role in new dimension for the urban design, cultural heritage preservation of document and supporting

towards built environment industry. The study on the Traditional Malay City are significant with the current push and demand towards the new development, and expansion of a city especially in Malaysia. The study was closely related with the cultural heritage study where, the formation of the city was associated with the culture, social environmental factor expressing the Malay community.

The overall research discussion can be divided into three main parts which are the study and discussion on the Traditional Malay city, the re-constructing the 3D GIS model for the Malay city; and the third part deal with the information and database for the 3D GIS model for the Malay city. The term re-constructing was used in the study as, the 3D GIS model was need to re-construct from the database and result of the 3d point cloud,3D mesh, DSM and DTM which acquired using 3D geospatial approach. So that the term re-constructing brought meaning to reconstruct from all these databases to the final 3D GIS complete with texture and databases which defined in the research. The first part of the research focus on the study on the Traditional Malay City where will encompass about the historical study of Traditional Malay city formation, which includes the study on the Malay early settlement in Peninsular Malaysia which existed since pre historic era and also focused on the study area which is Kota Bharu . The city in the this part was represent the earliest city which comprise of ruler, citizen, building and also the administrative system. The first part of the discussion will focus on the historical research of the city, the urban form element and its characteristic which closely related with the formation of the Traditional Malay city. This study also inspired by how was the system and formation of the Malay city in the past as the Malay culture and structure especially on the formation of a Malay city in the past was closely related with the kingship system in their governance system , where the element of

palaces or “Istana” has been identified as one of the main element that exist in all early Malay cities where the palace institution and citizen plays a very unique relationship with each other’s (Harun N.S.,2014) . The selection of Kota Bharu, Kelantan as a case study for the Traditional Malay city has been choose based on preliminary studies that has been conducted and based on the historical evidence which still can be seen until todays. Based on the preliminary study such as from the historical reading, early observation at site and also from archive, the finding shows that, there are few cultural heritage buildings and settlement area from the early of establishment of Kelantan state in years 1845 century are still exist in the study area. This cultural heritage building plays main important element that really need to be preserved for the use of next generation nor towards the current civilization where the cultural heritage related closely with the relationship between a civilization and their past (Dogan, 2018). In order to documented and analysed the elements of the study area, a comprehensive method and technique has been identified to be tested in this research. The combination between 3D GIS modelling technique and the analysis of the Traditional Malay City become main bodies of the research.

Geographic Information System (GIS) nowadays become one of popular tool that vastly use in urban design, urban planning, conservation and preservation; and supporting decision making process. The evolution and competition between software and scholars in developing the GIS system has influence and pushed from the normal 2D GIS system to swiftly moving toward the 3D GIS technique as the tool for modelling, data documentation and also data analysis (Kim K.,2014). The use of the 3D GIS modelling techniques covers the second part of the research, where researcher explore on the re-constructing the 3D GIS city model which contains the spatial information based on the existing land use of the study

area in Kota Bharu, Kelantan. The re-constructing term has been used in the study as , the interactive 3D GIS model was re-constructed from the 3D mesh and others relevant data which produced from geospatial approach. The assistance on technology driven data platform consist of Unmanned Aerial Vehicle (UAV) or Drone, Terrestrial Laser Scanning (TLS) in producing point cloud and aerial orthophoto data being selected as the medium for obtaining the result for this research. The use of drone and UAV technologies in research and data collection has vastly use by many researchers based on a few consideration such as, cost-effectiveness, data accuracy, and the ability to cover for large area (Loke,2015).

The final part of the research demonstrate the ability of the 3D GIS model to build and store the information on heritage building and the Malay city information consist of information in term of georeferences data, building attribute, visualization and also the urban design form and function using the platform that can be accessed by others related parties.

## **1.2 RESEARCH BACKGROUND**

Malaysia was one of the developing countries experiencing a highly rapid urban growth. This situation has led to large migration from rural to urban areas, and resulted in the existence of slums and squatter areas (Sahabuddin &Longo, 2015). The migration will be increased in demand for new housing units and for new settlement area and the facilities. Therefore, the increasing in demand will pushed the developers to find new area for new settlements and development of the new city. Not only in Malaysia, all around the world especially in developed countries there are rapid growth in new city development. The world system structure was arranged according to the global capitalism. This structure has a core, (developed countries), where production processes are advanced requiring massive

concentration of capital and the highest level of skills; and a periphery (developing countries) that lacks capital, technologies, market power, wealth, and a bunch of the other vital valuables of production. Cities stand now as core on both internal and international levels. They are the centers of civilization, labor creation and international financial exchanges (Manirakiza, 2012). The pushing in acquiring the new land for new development or construction sometimes had neglected the cultural heritage building or site especially the one without being gazette or protected by the government and others related authorities. The cultural heritage elements were important where the heritage represent and reflect the real identity and historical value of races, religion and a civilization. The search for national identity seems to be a must for countries which have newly become either independent or a leadership that stresses certain groups of races as being "better" than others (Mohammad Tajuddin, 2005).

Malay civilization was one of the oldest civilization that ever exist and bringing a unique history, culture, architecture, and reflected into their city formation (Rusdi M., 2011; Harun N.S, 2014). The Malay city nowadays was reflected from the previous traditional Malay city which carry unique and special characteristic in term of urban design, urban form, landscape and urban setting of a city. Ironically, Malay city located in the tropical climate area and all of the traditional Malay landscape design, building material is simple, yet enhances the uniqueness of the tropical settings and the current societies prefer to use soft landscape and hard landscape elements as the attractive component of their landscape setting (Abdullah Sani, 2006; Amir Houssein et al. 2014). The uniqueness and the idea of urban form, urbans setting which idealized from the Malay Traditional local society need to be dig out and documented comprehensively.