

DRIVING FORCES IN MODELLING DYNAMIC URBAN SPATIAL GROWTH FOR THE GEORGE TOWN CONURBATION (GTC)

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ABSTRACT: Urban growth and transformation of spatial land use and land cover have affected various important physical environments, social, and economic activities. Researchers throughout the world have implemented diverse approaches in understanding the dynamic process of urban spatial growth where models have been developed to predict and simulate future urban growth and development. Model were developed based on the driving forces or factors that stimulate urban development. Therefore, the driving forces must be identified and analysed, especially for those that can be applied to forecast future changes and their potential environmental effects. The objective of this paper is to identify and analyse possible driving forces that promote urban spatial growth using the George Town Conurbation as a case study. The driving force were identity by reviewing recent research journals and articles regarding modelling urban growth. In addition, on-line survey was also generated and distributed to planners, academicians, researchers, and urban modellers to assess their perception on urban land use transformations and also measure the weight of potential drivers or factors that stimulate urban spatial growth. The findings indicated that distance to public amenities, cheap housing price, distance to workplace, and proximity to area that support new and growing businesses are among factors that are important determinants of urban development. The results provide valuable insights in modelling the dynamic urban spatial growth in future research.

Keywords: urban growth, land use and cover, driving force, George Town Conurbation

INTRODUCTION

Urbanisation is among the most significant process that has shaped land use and land cover drawing a great deal of attention throughout the world. It is estimated that urban's population will rise from 3.57 billion in 2010 to 6.34 billion in 2050 where almost 70 percent of the world's population are expected to live in the cities (United Nations, 2014). This immense figure is mainly due to migration from rural areas to city in search of better quality of life generated by rapid urbanisation (Tan et al., 2015; Deng et al., 2009). Lu et al. (2013) and Liu et al. (2008) stress that urban population growth is beneficial to urban development and economic development, especially in promoting business and industry. Consequently, urban regions are more developed, for instance, more infrastructure and pleasant environment as a result of rapid urbanisation (Su et al., 2011).

However, overpopulation in urban areas contributes to a number of social, economic and environmental problems such as pollution, traffic congestion, rise of housing prices, and loss of natural areas (Tan and Li, 2013). Increased urban population has forced cities to expand vertically or horizontally, encroaching into agricultural land and natural boundaries, and changing land use and land cover without us realizing it (Kumar et al., 2011; Su et al., 2011). The George Town Conurbation is no exception as exemplified by the two revision made by Town and Country Planning Department (Town and Regional Planning Department, 2015a) on George Town Conurbation's boundaries due to rapid urbanisation caused by George Town city. Deeper understanding of the concepts or mechanisms underlying the urban growth can diminish the negative impacts of urbanisation while maximising the positive impacts (Aguayo et al., 2007).

Urban spatial growth models have been extensively applied to project the future growth of a city where one can clearly understand the process of urbanisation (Verburg et al., 2004). These models have the ability to simulate the spatial changes of land use and land cover of a city and forecast the possible urban development according to data received (Wahyudi and Liu, 2014). The basic concepts underlying urban spatial growth models were initiated in the North America five decades ago (Batty, 1971) and have been adopted in Europe, East Asia and West Asia countries. Models are crucial in forecasting urban growth when various factors or driving forces that stimulate urban change in a

highly complex manner are involved (Entwisle et al., 2007). Therefore, modelling and simulation techniques are believed to be essential approaches to understand the mechanisms underlying urban systems and contribute toward planning and managing urban growth (Tayyebi et al., 2011; Entwisle et al., 2007, Al-Shalabi et al., 2013; Wahyudi and Liu, 2014).

Determining and studying the factors or driving forces that stimulates urban growth is the fundamental step in modelling the dynamic urban spatial growth. Aguayo et al. (2007) emphasises that the factors that stimulate urban development, especially those factors that can be used to predict future changes and their potential environmental effects must be identified and analysed in order to understand the spatial and temporal dynamics of these processes. Therefore, the objective of this paper is to identify and analyse possible driving forces that promote urban spatial growth in the context of urban growth in Malaysia, which will then be included in modelling the George Town Conurbation.

LITERATURE REVIEW

To date, various studies that identify and implement driving forces urban growth model have been done by many researchers and academicians throughout the world (Lo and Yang, 2002; Aguayo et al., 2007; Goetzke et al., 2007; Lu et al., 2013). For example, Aguayo et al. (2007) revealed that urban growth areas are stimulated by distance and density of specific elements which implies proximity and neighbourhood are two important driving forces to urban development. It is difficult to develop an area if the road network is not well constructed because it is the key to open many opportunities, especially for business by attracting higher population migration. The demand for high quality house has promoted urban growth such as construction of shopping malls, nodes and highway (Lo and Yang, 2002). Residents' desire to live at location with easy access to other destinations helps to explain the construction of nodes and highway in many urban areas. Supporting that factor, Li et al. (2013) also indicate that the road network plays the most important role in developing the new urban landscape. Road network not only facilitate residents' daily lives but also reduce the cost of construction of amenities like shopping malls and hospitals and so forth (Li et al., 2013). However, it is undeniable that the physical landscape and neighbourhood influence also contribute to stimulate urban development which influences decisions regarding road network development (Li et al., 2013). Proximity and accessibility to markets or social services which are considered cost-weighted distances were used as socio-economic variables that stimulate urban growth (Goetzke et al., 2007).

Industrialisation or commercialisation which implies economic factor is also one of the important determinants in promoting urban development (Lu et al., 2013; Liu et al., 2008; Lo and Yang, 2002). It offers many job opportunities which attract employees to stay at the vicinity and also influence road network development to stimulate economic factor in regional trade (Lu et al., 2013). Lo and Yang (2002) found that industrial and commercial activities are located at high-density urban area which proved that these two activities are also important forces in developing an area. Increase of investment to secondary and tertiary industries has boosted land for residency and become the direct factors of land conversion for development (Liu et al., 2008). Liu et al. (2008) also suggest that urban growth is more likely to be expanded if the location is closer to urban centres. This may be due to the many economic resources in urban areas offered by industrial and commercial activities.

Briassoulis (2008) proposed that urban model should consider bio-physical driving forces which consist of characteristics and processes of the natural environment. Suitability of a location to develop can be impacted by bio-physical factors, for instance, slope layer need to be taken into consideration in urban expansion model (Verburg et al., 2004). Hu and Lo (2007) proposed that steep and elevated areas are less likely to be developed due to the cost of construction and higher risk of land instability. Bio-physical factors may partially constrain urban development. Factors like economic gains and insufficiency of land availability might lead developer to consider developing despite the high cost and risk of slope and elevation. Apart from that, zoning status or legally protected areas has produced best result in sensitivity analysis of developed urban model which signify it as an important factor of urban expansion (Poelmans and van Rompaey, 2010).

Kuang, et al. (2014) realised that urban planning, management strategies and policies have become major driving forces that need to be considered in modelling urban growth as they can affect other drivers. China experiences unprecedented speed of urbanisation rate since the Chinese government set up the Special Economic Zone which has emerged as China's commercial and industrial hub while USA remained and maintained relatively stable urbanisation rate due to introduction to a variation of distinct zone to manage rural and urban areas (Kuang et al., 2014). Their research has proven that political factor is capable of either changing or expanding dramatically or managing an urban development which can be crucial in modelling. Instead of exercising land use policy to direct physical development, it can also serve as a platform to promote economic, social, environment and other goals which indirectly stimulate urban development (Briassoulis, 2008). Lu et al. (2013) identify that implementing policy for boosting economy, developing a potential location and enhancing living environment have maximised the effect of urban growth at high rate of land use transformation. Private property developers will take opportunity to develop nearby location as proposed by urban planning and management policies from the government as they foresee potential of development driven by political factors.

Due to the fact that Malaysia is facing rapid urbanisation similar to other countries, four major conurbations: Kuala Lumpur, George Town, Johor Bharu and Kuantan have been identified in National Physical Plan 2 in order to facilitate urban planning process (Hashim, 2011). All of the above-mentioned conurbations were named after the major cities that trigger rapid urbanisation to its surroundings. George Town city has developed rapidly and caused the George Town Conurbation to expand its boundary to Southern Kedah and Northern Perak (Town and Regional Planning Department, 2015b). The existence of North-South Expressway and good road network are factors that drive urban development in George Town Conurbation. The industrial and commercial areas located in Penang, especially in Bayan Lepas and Juru are also key factors that stimulate urban development. However, researchers found that negative impacts from urban development will worsen in Seberang Perai region in Penang State and encroach into agricultural and natural areas if proper urban planning is not in place to contain its expansion (Samat et al., 2014).

METHODOLOGY

The primary objective of this paper is to identify and analyse possible driving forces that promote urban spatial growth, especially those that can be employed to predict future changes and their potential environmental effects. The identified driving forces will then be adapted in the Malaysian context to model urban growth of George Town Conurbation. In order to achieve the objective, recent research journals and articles regarding modelling urban growth were reviewed. Potential significant factors were identified by reviewing studies by previous researchers and academicians. In addition, on-line survey was conducted. The survey consists of 5 items to gather information about respondents' demographic backgrounds and another 6 items to assess their knowledges of urban development. The survey contains open-ended and closed-ended questions using Likert scale. Through purposive sampling, the surveys were distributed to planners from Town and Regional Planning Department (JPBD), academicians and researchers of public universities in Malaysia, private urban modellers and developers. This survey aims to assess their perception on urban land use transformation and also to measure the weight of potential drivers or factors that stimulate urban spatial growth in Malaysia. The study obtained 39 respondents from various professional backgrounds with 27 respondents' (69.2 per cent) aged more than 40 years old. This implies that this group of respondents have witnessed and experienced urban growth and development since year 1990. Apart from that, 84.6 per cent of the respondents (33 respondents) are directly involved or are well aware of urban development. 24 respondents (61.5 per cent) are academicians in urban studies and 9 respondents (23.1 per cent) are urban planners. The reliability of the on-line survey has been tested, especially for questions to determine the importance of a driving force in urban growth. The result, Cronbach's Alpha value of $\alpha=0.789$, indicates that the instrument is reliable. Quantitative data is analysed using Microsoft Excel 2010 and qualitative data, in the form of direct quotations, are used to supplement the findings.

Study Area

The study was carried out in the George Town Conurbation which involves Penang State and parts of neighbouring states of Kedah and Perak as proposed by Penang Town and Country Planning Department (Town and Regional Planning Department, 2015c) that is in compliant with National Physical Plan 2(NPP2) of Peninsular Malaysia. It is located in the northwest coast of Peninsular Malaysia between latitude $4^{\circ} 50' N$ and $5^{\circ} 52' N$ and longitude $100^{\circ} 10' E$ and $100^{\circ} 51' E$, with an area about 3,938 square kilometres (See Figure 1). George Town Conurbation is a metropolitan area with a total population over 2.5 million people and it is estimated to exceed more than 3 million residents by 2020 (Department of Statistics, 2010). According to the Town and Country Planning Department (Town and Regional Planning Department, 2015c), the proposal to determine the limit of George Town Conurbation boundaries was supported by economic criteria, distance travelled and mega projects on George Town's neighbouring districts.

The reason for selecting George Town Conurbation as the study area is due to the fact that rapid development in Penang especially in George Town has contributed to the rapid economic development, especially in the industrial manufacturing, trade, commerce and services sectors. In addition, its strategic location in establishing relationships and cooperation with regional countries and bordering regions are also one of the reasons for selecting this conurbation as the study area. This strategic location will intensify the northern territory's role in contributing to major economic development of the country (Majeed, 2011). Furthermore, George Town Conurbation is one of the four major conurbations that has been highlighted in NPP2 which implies that the study area is very significant in developing Malaysia (Hashim, 2011).

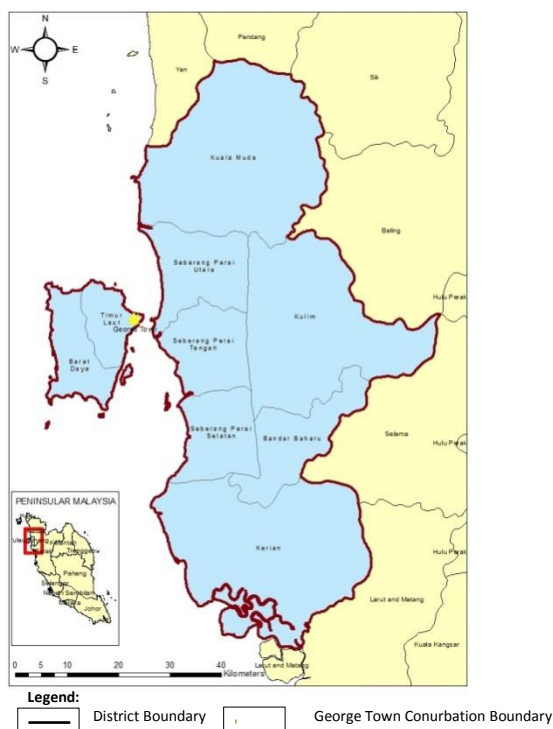


Figure 1: The Study Area (George Town Conurbation)

RESULTS AND DISCUSSIONS

Based on the driving forces studied by previous researchers and academicians, an on-line survey was generated to determine the weight of each factor asked in the survey which will then be used in modelling the dynamic urban spatial growth of the study area. The selected driving forces was considered for their availability of data since data input and database creation is time consuming and

costly (de Bruijn, 1991). A Likert scale was used to understand the respondents' perception on intensity of importance for factors in stimulating urban development using the scale shown in Table 1.

Table 1: Scale of relative importance

Intensity of Importance	Definition
1	Equal Importance
2	Weak
3	Moderate Importance
4	Moderate Plus
5	Strong Importance
6	Strong Plus
7	Very Strong or Demonstrated Importance
8	Very, Very Strong
9	Extreme Importance

Data obtained from the questionnaire was then processed and analysed using Analytic Hierarchy Process (AHP) (Beynon, 2002; Hossain et al., 2014). Table 2 showed weightings for each factor as indicated by the data gather from the survey.

Table 2: Factors with respective weighting value

Factors	Weight	Factors	Weight
Distance to public amenities e.g. school, university, etc.	0.1122	Distance to public amenities e.g. school, university, etc.	0.1589
Distance to workplace	0.1141	Distance to workplace	0.1457
Proximity to area that support new and growing business	0.0977	Proximity to area that support new and growing business	0.1393
Distance to health centre e.g. public hospital, public clinic, etc.	0.0950	Distance to health centre e.g. public hospital, public clinic, etc.	0.1333
Distance to main road or highway	0.0906	Distance to main road or highway	0.1276
Distance to commercial or industrial area	0.0977	Distance to commercial or industrial area	-
Proximity to parks and natural features	0.0977	Proximity to parks and natural features	-
Distance to city centre	0.0879	Distance to city centre	-
Cheap housing price	0.1123	Cheap housing price	0.1589
Population density or neighbourhood	0.0948	Population density or neighbourhood	0.1362
<i>Consistency Ratio</i>	<i>0.004</i>	<i>Consistency Ratio</i>	<i>0.001</i>

(a)

(b)

Table 2(a) are weighting values for all factors rated by the respondents whilst Table 2(b) are weighting values after removing three factors with lowest mean rated by the respondents. The respondents have rated distance to commercial or industrial area, proximity to parks and natural features and distance to city centre as less important in stimulating urban development. This may be due to not wanting to spend most of their time and financial resources travelling to the workplace and buy an overpriced house, which is typically the case in city region. On top of that, it would be better to live in an environment free from commercial or industrial waste which can affect the health of nearby communities. Another reason that may have contributed to the finding is that more efficient road network will shorten travelling time, thus, distance to city centre become less important in promoting urban development.

Respondents were also required to list all possible factors that might stimulate urban growth to support their perception in rating the importance of each factor. 10 respondents (25.6 per cent) responded that population growth and migration to urban areas are factors that stimulate urban development. Efficiency of public transportation, good road network and amenities like private hospital and public school were also mentioned by 7 respondents (17.9 per cent) as factors that

promotes urban development. Some of the respondents also indicated land availability and demand for affordable housing as factors that stimulate urban growth. In addition, respondents also mentioned that business and employment opportunities together with lifestyle and entertainment offered by urban area can contribute to urban development. One of the respondents emphasised that “*Urban manager should know very well that urban development is about integration and interrelatedness of all stakeholders in urban community*”, which implies that cooperation from all stakeholders is necessary in planning and managing urban development.

CONCLUSION

The study showed that quite a number of journals and articles have revealed three major driving forces which stimulate urban development namely: physical landscape, socio-economic and environment. In fact, National Physical Plan 2 also has given a great deal of attention to these driving forces in planning the four major conurbations in Malaysia. Although the plan contributes to boosting national and public economy, rigorous policy regulations are needed to avoid unnecessary expansions especially to agricultural and natural resources. A good dynamic urban model should be able to utilise land within a boundary optimally. From responses provided, some participating researchers proposed that political factor should be considered in predicting urban growth. It has been proven that political factor does have a significant impact to urban growth but it is very difficult to quantify. Therefore, future research could investigate political factors which influence urban growth using qualitative approach.

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