Delineating urban growth limit for managing urbanisation in Iskandar Malaysia

Muhammad Azizol Ismail*, Ahmad Nazri Muhamad Ludin and Nafisa Hosni

Department of Urban and Regional Planning, Faculty of Built Environment, Universiti Teknologi Malaysia, 81310 UTM Skudai, Johor, Malaysia

azizolismail@gmail.com

Abstract. Statistics have revealed that the rapid pace of urbanisation has become a massive concern of many regions. Thus, policies of urban containment (green belt, urban growth limit, and urban service) are adopted in land-use management strategies to curb urban sprawl and preserve green areas. This paper aims to delineate Urban Growth Limit (UGL), the spatial urban containment tool deployed by authorities and planners to separate urban areas from non-urban areas while promoting compact development in Iskandar Malaysia. In order to achieve the aim, the GIS Binary Urban Suitability Model is developed. The developed model becomes the basis in delineating the proposed UGL. Nevertheless, these preliminary results give a unique perspective and idea how UGL could be implemented to coordinate urban expansion while preserving environment in the future.

1. Introduction

Urban growth is a complex spatio-temporal process that occurs globally due to the increasing rate of urban population, unorganised urban expansion, and economic and infrastructure development initiatives [1, 2]. A report by [3] reveals that in 2014, 54 percent of the world’s population were living in urban areas, and this number will increase to 66 percent by 2050. The dynamics of population and urban growth are among the most relevant information required for future economic development planning, natural resources allocation, and environmental management [4]. Rapid urbanisation activities not only have elevated the urban dwellers’ standard of living, but also have been associated to environmental pollution, uncontrolled solid waste management, lack of services and amenities, as well as densification and unplanned residential areas.

One way to stimulate sustainable urban growth is through appropriate policies, and among the various policy managements of urban growth, the urban containment policies have been widely used to efficiently control land use and protect open spaces from being developed. An urban containment policy consists of three components: urban service, greenbelt, and urban growth limit (UGL). This paper focuses on UGL, the most widely discussed urban containment tool in academia [5].

2. Urban growth limit

Many similar terms have been adopted to describe urban growth limit, for instances urban growth boundary in the United States [6], urban construction boundary in China [7], yellow line in Albania [8], Randstad/Green Heart in Netherlands [9], urban promotion zone in Japan [10], urban fence in France [11], and urban edges in Africa [12].
In the United States, the concept of UGL has been initiated in 1977 when the Columbia Region Association of Government has proposed UGL for the Portland region to deal with the uncoordinated use of lands [13]. Then, in 1980, the policy was approved by the Land Conservation and Development Commission in line with the state-wide planning goals. The state land-use goals demanded the establishment of UGL, natural resources protection, and wise use of urban land.

As pointed by Rohse, 1987 cited in [14], UGL is “a line drawn around a metropolitan area that delineates where urban development may take place (inside the UGL) and where it may not (outside the UGL).” The aims of UGL are to encourage higher urban density, promote housing diversity, preserve agriculture area situated outside the line, and decrease infrastructure cost such as sewer and transportation [15]. In summary, UGL is a spatial planning tool for regulating the direction of urbanization while protecting rural areas based on an explicit policy.

Between 1980 and 1999, studies on the impact of UGL implementation focused on specific trends such as farmland protection and green area preservation issues (e.g. forest, wetland). A number of studies [16, 17, 18] investigated how UGL protects prime farmland from urbanisation effects. Other studies [14, 19] focused on green area issues. However, between 2000 and 2017, the trend inclined toward economic perspective and the themes seemed to be diverse. Figure 1 shows the timeline of UGL implication from 2000 to 2017. UGL has given significant impacts on various sectors including real estate, agriculture, urban form, natural hazards, open space, social welfare, commuting, and physical activity.

![Figure 1. Timeline of UGL issues from 2000 to 2017](image-url)
Figure 2 illustrates the hotspot and geographical distribution of the case studies on UGL which at most pertain to the policies in Portland, Oregon, United States, and Portland (Oregon is the pioneer in adopting UGL into the planning system.)

3. Methodology
The study area is in Iskandar Malaysia, Johor (Figure 3). It is one of the economic regions and corridors in Malaysia which brings in more focused economic and infrastructure investment to an already established urban conurbation located at the southernmost tip of Peninsular Malaysia. Iskandar Malaysia covers a total area of 2,300 sq. km or 230,000 hectares. It is established in 2006. As in 2005, 1.4 million people live in that region. It is projected that Iskandar Malaysia’s population would climb to 3.0 million by 2025.
Figure 4 shows the flowchart of developing Iskandar Malaysia Urban Suitability Model. The aim of the model is to determine which areas are suitable for urban growth and which areas are not encouraged. All spatial data are projected in the Rectified Skewed Orthomorphic (RSO). The ArcGIS 10.3.1 software is used to execute all the tasks.

As spatial data preparation, all the vectors data such as transportation, built-up, agriculture, vacant land, water bodies, and forest are converted into raster. Meanwhile, Digital Elevation Model (DEM) data is downloaded from United States Geological Survey (USGS) website. The data is then reclassified into binary-based representation. The zero “0” value is assign to the area where the urban growth is discouraged while one “1” value is assign to the area where urban growth is encouraged. Figure 5 represents the Model Builder to facilitate the whole process.

The Map Algebra expression by using the Raster Calculator is deployed to combine the calculated grids in order to create an Iskandar Malaysia Binary Suitability Model. The Equation (1) below shows the expression that is used to accomplish the raster combination task.

**Iskandar Malaysia Urban Land Use Suitability Model** = [Agriculture binary map] x [Built-up binary map] x [Forest binary map] x [Transportation binary map] x [Water binary map] x [Vacant binary map] x [Elevation binary map]

(1)
4. Results and discussion

Figure 6 illustrates the developed suitability of binary maps. The binary maps depict which areas are recommended for urban growth to occur, and which area may not be recommended for such activities. It comprises layers such as bio-physical parameters (e.g. forest, water body, and elevation), socio-economic parameters (e.g. transportation, and built-up area) and others including agriculture as well as vacant land.

Landscape topography plays a significant role in shaping the geometry of UGL. The bio-physical factors could limit the urban growth from taking place. Another consideration when delineating UGL is the existence of reserve areas. The development in this area usually prohibited by law. Areas above 300 metres above mean sea level are considered as hilly area and must be preserved for environmental reasons. Area within certain distance to the river are discouraged for urban development.

There are several buffers created along the bio-diversity zone in Iskandar Malaysia for instance 500 metres buffer zone for Ramsar sites, Gunung Pulai, and Sultan Iskandar Reservoir. Then, 50 metres buffer zones are also created for forest reserve and mangrove forest vegetation. Meanwhile, the possibility of urban growth promotion is higher in socio-economic parameters. All built-up, infrastructure and utilities, and open space are classified into urban land use.
Figure 6. Binary maps of (a) agriculture (b) forest (c) transportation (d) water body (e) built-up (f) elevation

Figure 7 shows the generated Iskandar Malaysia Land Use Suitability Model. The yellow bold line represents the delineation of Iskandar Malaysia Urban Growth Limit. Currently, the urban development in Iskandar Malaysia is concentrated towards several strategic and potential areas. First, in Johor Bahru (Southern part) because of the central business district, financial district, and Malaysia/Singapore Causeway. Second, in Iskandar Puteri (Western part) which turns to become a new administrative centre for Johor. The urban growth is also spreading towards Senai-Skudai (Northern part) the place where Senai International Airport is located. The development is encouraged
inside the line and discouraged beyond this line. So then, it would promote more compact development or local municipalities could focus on high-density urban development. There are many approaches towards smart growth or planned growth including multi-purpose land use with compact building design, walkable communities, preservation of agricultural lands, open space, and nature protected areas. Agriculture production zone will remain as agriculture land until 2025, where urban developments will not be accommodated in this zone. These areas are significant in generating agri-business employment and production as well as function as food security zone for the region. These areas also include the Felda agriculture lands which are within Iskandar Malaysia. Indeed, if the urban growth keeps growing without any control or limit, it would encroach environmentally sensitive area such as the Ramsar Sites, Gunung Pulai, and Iskandar Reservoir. Thus, implementing urban growth limit could preserve these areas as well as rural area from negative effects of urbanization.

5. Conclusion
This paper provides preliminary results of the GIS Binary Suitability Model for the sake of delineating UGL in Iskandar Malaysia. The policy to coordinate urban growth such as the UGL should receive more attention from developing countries compared to developed countries. In a certain policy such as in Malaysia, the term UGL is not to be specifically mentioned, but rather, is stated in other terms such as carrying capacity, new urbanism, urban renewal, smart city, protecting urban sensitive area, and protecting primer agriculture land. UGL can still be implemented but policy makers need to focus on particular issues, for instance, socio-spatial theme. To be more comprehensive and practical, UGL needs to be incorporated with other spatial and non-spatial policies, and in the twenty-first century, the challenges faced by policy makers and planners in managing urban growth while preserving the environment are enormous. A UGL policy requires urban and urbanisable land to be separated from rural area. Thus, the UGL has been documented as an effective regional planning tool in coordinating urban growth. However, with the advancement of software, technology, hardware, the method of delineating UGL should be designed in the more sophisticated ways. Future research might explore the methods of delineating UGL.
Acknowledgment

This work is financed by Zamalah/Institutional Scholarship provided by Universiti Teknologi Malaysia and the Ministry of Higher Education of Malaysia.

References

[1] Sudhira HS, Ramachandra TV and Jagadish KS 2004 Urban sprawl: metrics, dynamics and modelling using GIS Int. J. of Applied Earth Observation and Geoinformation 5 29-39
[2] Hegazy IR and Kaloop MR 2015 Monitoring urban growth and land use change detection with GIS and remote sensing techniques in Daqahlia governorate Egypt Int. J. of Sustainable Built Environ. 4 117-124
[3] United Nations 2014 Department of economic and social affairs, population division World Urbanization Prospects: The 2014 Revision, Highlights (ST/ESA/SER.A/352)
[4] Fusilli L, Marzialetti P, Laneve G and Santilli G 2014 Urban growth assessment around Winam Gulf of Kenya based on satellite imagery Acta Astronautica 93 279-290
[5] Long Y, Han H, Lai S K and Mao Q 2013 Urban growth boundaries of the Beijing metropolitan area: comparison of simulation and artwork Cities 31 337-348
[6] Adler S 2017 A historical perspective on the metropolitan Portland urban growth boundary in Planning the Pacific Northwest (New York: Routledge) pp 52-63
[7] Huang X, Li Y, Yu R and Zhao X 2014 Reconsidering the controversial land use policy of linking the decrease in rural construction land with the increase in urban construction land: a local government perspective China Review 14 175-98
[8] Prato GB 2017 Changing Urban Landscape in Albania in Diversity and Local Contexts (Switzerland: Palgrave Macmillan, Cham) pp 17-37
[9] Korthals Altes WK 2018 Rules versus ideas in landscape protection: is a Green Heart attack imminent? Int. Planning Studies 23 1-5
[10] Yoshitake T, Teramachi K and Deguchi C 2015 Progressing suburbanization and the controversial land use management in a Japanese local city-a case study of Miyakonojo City, Japan J. of the Eastern Asia Society for Transportation Studies 11 979-996
[11] Hoggart K 2018 City hinterlands in European Space In The City's Hinterland (London:Routledge) pp 11-28
[12] Horn A and Van Eeden A 2018 Measuring sprawl in the Western Cape Province South Africa: an urban sprawl index for comparative purposes Regional Science Policy & Practice 10 15-23
[13] Sterrett J, Ozawa C, Ryan D, Seltzer E and Whittington J 2017 Planning the Pacific Northwest (New York:Routledge)
[14] Nelson AC and Moore T 1993 Assessing urban growth management: the case of Portland, Oregon, the USA's largest urban growth boundary Land Use Policy 10 293-302
[15] American Planning Association 2002 Growing Smart Legislative Guidebook: Model Status for Planning and the Management of Change APA Planners Press
[16] Furuseth OJ 1980 The Oregon agriculture protection program: a review and assessment Nat. Resources J. 20 603
[17] Gustafson GC, Daniels TL and Shirack RP 1982 The Oregon land use act implications for farmland and open space protection J. of the American Planning Association 48 365-373
[18] Kline JD and Alig RJ 1999 Does land use planning slow the conversion of forest and farmlands? Growth and Change 30 3-22
[19] Holland CC, Honea J, Gwin SE and Kentula ME 1995 Wetland degradation and loss in the rapidly urbanizing area of Portland Oregon Wetlands 15 336-345