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Assessing the Effect of Land Use on the Higher Education Institution Development by Using/Integrating Geographical Information System (GIS) and Remote Sensing (RS) Data/Approach for Land Suitability Analysis

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Abstract
Developed area is an indicator to depict the growth of an area in terms of economical aspect and social interaction among the locals due to the establishment of higher education institution. However, before developing a new area, local authority need to find or locate a suitable location where it can be done. This study is carried out by focusing on two (2) objectives: (i) to identify the growth development pattern for the past 20 years within the area of Seri Iskandar, Perak and (ii) to determine suitable area for urban development by using GIS based technique and remote sensing. With the help of Geographical Information System (GIS) and Remote Sensing (RS), land use or land change around Seri Iskandar, Perak will be determined by using the data from year of 1999 to 2019. Satellite images will be processed to investigate the land use or land changes in Seri Iskandar, Perak. The land use or land change will be ascertained by categorising them into developed area, mixed agriculture, water bodies, bare soil, vegetation, cloud and forest. Therefore, this study can assist the local authority in making a proper planning for urban development in Seri Iskandar, Perak. The influence of establishing a university may be estimated by looking at the land use patterns and population growth in the Seri Iskandar town area. Besides that, it can help agencies such as Department of Town Planning and private companies in determining which site or land can be used for development purpose.

Keywords: Land use pattern, Geographical Information System, Remote Sensing data, Land Suitability Analysis

1.0 Introduction

Cities are expanding in space as a result of the continued global urban population rise (Marshall, 2007; Shlomo et al., 2011). On the one hand, the change from rural to urban can be beneficial to the global environment since it allows for more efficient use of space and resources. A study that has been conducted by several researches: Chen et al., (2008); Thomas and Cousins (1996), believed that compact cities are a viable urban form. However, in many cases, city growth is less tightly planned or poorly managed, resulting in vast physical footprints, low building densities, and generally monofunctional land-use types. This phenomenon, known as 'urban sprawl,' is most common in the United States, but it may also be found in several European regions (EEA, 2006).

Ungoverned urbanisation raises demand for ecosystem services while putting their availability at jeopardy. Cities, for example, consume so much land that natural ecosystems are destroyed and biodiversity is lost (McKinney, 2002). Chormanski et al., (2008) and Meija and Moglen (2010) mentioned that due to increased surface inability to respond and reduced soil roughness, it also increases flood risk low-density development has a negative impact on ecosystem services supply, as well as higher public expenses for infrastructure investments and upkeep, as well as a diminished sense of community (Putnam, 2000).

More than half of the world's population now lives in cities, owing to socioeconomic factors that cause people to migrate from rural to urban areas (Desa, 2014). As a result, the tendency toward urbanisation is accelerating, resulting in an increase in the urban population and the size of urban regions (Desa, 2014). Sustainability, particularly sustainable urban planning, has garnered considerable attention in recent decades as a result of worries about clean air and water, climate change, and land usage (Wheeler and Beatley, 2014). Land-use change is a result of changes in urban population, hence competent land-use planning is required to determine the optimal land regions for urban growth. The phrase "land-use" is defined by the FAO as "human activity on land, such as agriculture, construction, roads, and so on." While the phrase "land cover" refers to both natural and man-made features found on the earth's surface. The Food and Agriculture Organization of the United Nations (FAO) defines land-use planning as "the systematic evaluation of land and water potential, land-use possibilities, and economic and social conditions in order to select and adopt the optimal land-use options" (FAO, 1993). Environmental and cultural heritage preservation are major considerations in urban development. Preservation of cultural heritage assets entails preserving a nation's past (Doan and Yakar, 2018). The ecological, environmental, and socio-economic components of land-use planning, as well as land-use sustainability, must all be considered during the planning process (FAO 1993, 2007). As a result, land suitability assessment and good land-use planning are critical for long-term urban development (Nguyen et al. 2015; Scholten and Stillwell, 2013).

Sarapirome and Charungthanakij (2019) said that these land use transformations into built-up and industrial regions are regularly conducted without regard of the site's suitability and sustainability, depending on demography, economics, and industrial growth. Growth in the industrial sector implies advancement in economics and the standard of living, while growth in agricultural sector suggests food sufficiency to sustain the fundamental quality of life (Sarapirome and Charungthanakij, 2019). Forest conservation contributes to critical human needs, wildlife protection and preservation, and risk management. However, due to the limited nature of land, not all types or characteristics of expansion can be accommodated on the road to development. Sarapirome and Charungthanakij (2019) stated that growth in the industrial sector is more likely to pollute the environment, putting human health at risk, than growth in the agricultural sector. Hence, in order to retain balance and sustainability, a thorough and responsible planning should be done based on the sort of development that is being implemented, without sacrificing or completely disregarding other vital land uses (de Vries and Chigbu, 2017).

Ochola et al., (2019) said, despite the good effects of universities, such as employment creation and socioeconomic development, their establishment results in changes in land use and land cover, which have detrimental environmental consequences. The removal of vegetation and consequent exposure exposes the soil to erosion elements and disrupts the water cycle. Furthermore, the authors stated, forest cover has a vital ecological role in replenishing atmospheric moisture, which is readily harmed by human development initiatives such as the formation of universities. Constructed pavements in urban areas prevent water from infiltrating into the soil, interfering with ground water recharge. Major consequences, such as excessive subsurface water removal, are also proven to be the result of the university's establishment as a result of increasing water demand. In the immediate university neighbourhoods, haphazard construction has frequently resulted in slum development with poor waste management.

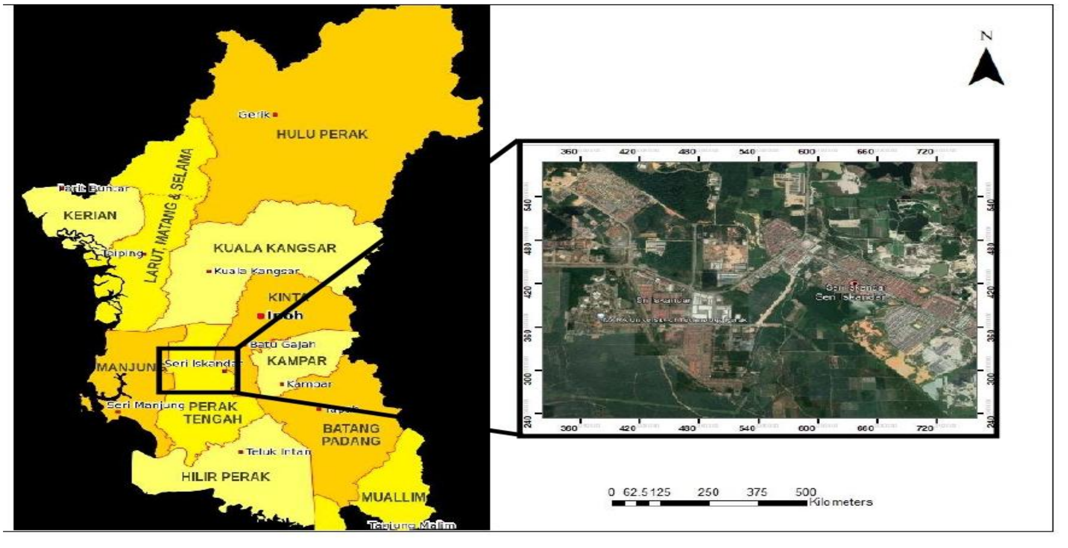
As various universities' importance is being recorded, a number of impacts accrue. The population drawn by these institutions, call for increased housing services, demand for food and supply of other goods and services. The general expansion of the university in terms of schools, programs, departments and services translates to the general increase of its populace. As a consequence, small and medium enterprises become prominent to help cater for the rising demand of the area's increased population. According to Bondinuba et al., (2013), the current surge in student enrollment in higher education institutions has become a major concern. They said that scholars and practitioners had become increasingly worried about student housing difficulties. As a result, it is clear that other educational stakeholders who have joined the team are providing additional accommodation options for students on or off campus. In developing countries, private participation in housing provision at institutes of higher learning has substantially aided the urbanisation process in the university's immediate area.

This study is carried out to to identify the growth development pattern for the past 20 years within the area of Seri Iskandar, Perak and at the same time, determining a suitable area for urban development by using GIS based technique and remote sensing.

2.0 Methodology

2.1 Study Area

Seri Iskandar is a town in Perak Tengah and the district capital of Perak Tengah. It is around 40 kilometres southwest of Ipoh, along the main Ipoh-Lumut route. Tronoh, a once-famous mining town, and Bota are two nearby towns. Seri Iskandar is home to Universiti Teknologi Petronas, a branch campus of Universiti Teknologi MARA, and Kolej Profesional MARA. The coordinate of Seri Iskandar, Perak is 4.3590°N, 100.9849°E.



(Source: ArcGIS)

Figure 1. Map of Seri Iskandar, Perak

2.1 Multi Criteria Decision Making/Analysis (MCDM/MCDA)

Multi Criteria Decision Making/Abalysis (MCDM/MCDA) is a technique that integrates the performance of alternatives across a number of contradictory qualitative and/or quantitative criteria, resulting in a solution that requires agreement (Seydel, 2016 and Kolios et al., 2016). Morales and de Vries (2021) used the term Multicriteria Evaluation (MCE) in the study conducted by these authors. Knowledge from a variety of domains is incorporated, including behavioural decision theory, computer technology, economics, information systems, and mathematics. Dadda (2014) and Mardani et al., (2015) said that many MCDM techniques are required, suggested, and effectively applied in a variety of application areas since the 1960s.

The goal of MCDM is to assist decision makers in picking selected options or a single alternative that meets their needs and is consistent with their preferences, rather than to advise the best solution. Brito et al., (2010), Belton (2002) and Dooley et al., (2009), said that knowledge of MCDM approaches and an appropriate grasp of the viewpoints of decision makers themselves (players involved in the decision process) are crucial for efficient and effective decision making at the early stages, according to the authors. The analytical hierarchal process (AHP), the analytical network process (ANP), TOPSIS, data envelopment analysis (DEA), and fuzzy decision-making are some of the MCDM methodologies accessible. In several fields, MCDM has become one of the fastest expanding problem areas (Triantaphyllou, 2013).

Different evaluations employing numerous criteria have garnered attention in the area of GIS-based decision-making, which are thought to be effective in solving challenges involving a high number of variables and covering wide, often inaccessible territory (Vasquez et al., 2020; Pereira and Duckstein, 1993; Malczewski, 2004; Eastman, 1999). As a result, numerous land use suitability studies have used GIS-based MCE to incorporate people's preferences, with experts acting as decision-makers. Considering land use suitability as a multidisciplinary approach that encompasses various disciplines of science, a rising number of criteria have been utilised in the analysis that are weighted based on their relative importance in determining the ideal growth conditions for a certain land use. Overall, the goal of MCE approaches is to evaluate a wide range of options while taking into account several criteria and competing objectives (Nijkamp et al., 1990).

One of the most significant parts in MCE is the set of assessment criteria, which must be appropriately developed in order to provide a valid result. The criteria are classified as "Factors" or "Constraints" in general. Factors are spatially referenced factors that impact (improve or remove) the effectiveness of the aim under consideration in the context of land use suitability and site selection (Lopez-Marerro et al., 2011; Lai et al., 2013), whereas "Constraints" are criteria that exclude the region from the study. Careful consideration must be given to the criteria to be employed in MCE. In order to achieve the intended results, the number of criteria must not be too small or too large. A large number of criteria for a single goal can be confusing to decision-makers, while a small number of criteria may not be enough to offer all of the required information (Pourebrahim et al., 2010). There is a comparison of the relative qualities of the spatially linked criteria in the MCE technique. Lai et al., (2010) said, its purpose is to combine data from numerous criteria to provide a map of appropriateness levels as an output.

2.2 Analytical Hierarchy Process (AHP)

Saaty (1980) had invented Analytical Hierarchy Process (AHP), which is now one of the most widely used methodologies for determining land suitability. AHP is a strategy that aids planners and decision makers in analysing all evidence before making a final choice on future land-use changes (Bagheri et al., 2013 and Nguyen Hieu et al., 2006). It is classified as a multi-criteria decision analysis approach. Mohammad et al., (2013) mentioned that, AHP has been combined with GIS technologies in order to determine the value of the criteria employed and compute weights using a scale of importance and expert advice.

AHP as stated by Chandio et al., (2012) is a traditional land suitability study process that provides a systematic way to making sound site selection decisions. The purpose of a second round of prioritisation among relevant criteria was to narrow in on the most important indicators based on practical experience and perceived relevance. Because sound decisions are required for land use planning, essential aspects should be examined in order to provide a wide range of possibilities from which critical decisions can be made.

On the foundation of GIS analytic functions, AHP is often used to determine the weights of influencing elements on urban expansion. AHP is a systematic strategy that can be employed in complex decision-making situations with competing criteria (Javadian et al., 2011). With driven knowledge and driven data, it is usual to determine the weights of factors in AHP. A study that has been conducted by several researches: Bagheri et al., (2013), Mohammad et al., (2013), Javadian et al., (2011) and Zebardas (2002), mentioned that the weights of components can also be derived via a questionnaire administered to experts with extensive expertise in the field of urban expansion, and then measured using the pairwise comparison approach to assess their relative relevance to one another.

Table 1. Saaty's Scale

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two activities contribute equally to the objective
2	Weak or Slight Importance	
3	Moderate	Experience and judgement slightly favour one activity over another
4	Moderate Plus	
5	Strong Importance	Experience and judgement strongly favour one activity over another
6	Strong Plus	
7	Very Strong or Demonstrated Importance	An activity is favoured very strongly over another; its dominance is demonstrated in practice
8	Very, Very Strong	
9	Extreme Importance	The evidence favouring one activity over another is of the highest possible order of assumption
Reciprocals of above	If activity i has one of the above non-zero numbers assigned to it while compared with activity *j*, then *j* has the reciprocal value when compared with *i*	A reasonable assumption
1.1-1.9	If the activities are very close	May be difficult to assign the best value but when compared with contrasting activities the size of the small numbers would not be too noticeable, yet they can still indicate the relative importance of the activities

Source: (Saaty, 1980)

The following is a systematic decision-making approach based on expert judgments as mentioned by Lee and Chan (2008):

1. Identify the issue
2. Create a problem hierarchy at various phases to define the problem's aims and results based on the goal, criterion, and alternatives.
3. Use a numerical pair-wise comparison scale to weight each condition.
4. For each criteria/alternative, compute the maximum eigenvalue, consistency index, consistency ratio (CR), and normalised values.
5. If any matrix has an undesirable CR value or composite weight, i.e., >0.10, the expert must make repeated judgments on that matrix until the values fall within the specified range.

The AHP is successful in ensuring that group decisions are involved. The AHP uses the notion of building hierarchies to solve issues. The hierarchy enables evaluation of the contribution made by individual criterion at lower levels to criterion at higher ones. The AHP's main goal is to help decision-makers choose the best option among a variety of options when several priorities are present.

2.3 Equations in Analytical Hierarchy Process (AHP) Model

According to Saaty (1980), AHP allows for minor discrepancies, but they should not surpass a particular threshold. AHP has the capability to measure the degree of consistency and has an effective technique for checking the consistency of decision-makers' or experts' opinions. The technique uses a suitable Consistency Index (CI) as the deviation or degree of consistency, where the consistency measures are equal to the number of comparisons considered (n), so the CI is equal to zero, and the Consistency Ratio (CR) is used to ensure that the original preference ratings are consistent.

Nyeko (2012) said that the normalised relative weights, the normalised principal Eigen vector (Cvij), and finally the principal Eigen value () are computed first in the computation of CI. This is just the average of the normalised comparison matrix's Eigen values. As a result, AHP is primarily concerned with solving an Eigen value problem requiring reciprocal matrix comparisons (Hossain et al., 2007).

As advised by Saaty (1980), the acceptable CR should be less than 0.10 (or 10%), otherwise the pairwise comparisons will be inconclusive, necessitating the need to rerun the comparisons and calculations. Table 2 displays the Random Index (RI) proposed by Saaty for simple issues, which can be utilised to compute CR.

$$\lambda = \sum_{i=1}^{n} \quad Cvij \tag{1}$$

$$CI = \frac{\lambda - n}{n-1} \tag{2}$$

$$CR = \frac{CI}{RI} \tag{3}$$

where CR stands for Consistency Ratio, CI stands for Consistency Index, RI stands for Random Index, and n stands for the number of comparisons/parameters. is produced from the accumulation of products between each element of the Eigen vector and the normalised relative weight, and it is computed by averaging the value of the consistency vector.

Table 2. Random Index (RI) values for small problem

n	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Source: (Saaty,1980)

Finally, in the situation of AHP, when a variety of preferences might be drawn from a group of specialists, an agreement must be reached. The goal is for the group to agree on the value of each entry in a pairwise comparison matrix. With the number of comparison matrices and related discussions, it is noted in the study of the AHP approach done by Ishizaka and Labib (2011) that establishing a consistent consent becomes problematic at some point. There are various strategies for obtaining agreement, but in any situation where it is difficult to gather all of the experts (remote people or a large group of people) in one place and make a decision, it is advisable to utilise the geometric mean method (Saaty and Vargas, 2005). Individual preferences are acquired first in AHP-derived priorities, followed by the accepted level of consistency. The geometric mean is used to get the collective preference of all the experts for each preference in the criteria being compared. As mentioned by Aczel and Saaty (1983), the reciprocal characteristic is preserved when the geometric mean is used instead of the arithmetic mean, as in AHP.

3.0 Conclusion

Due to an increase in the number in population, urban development is the answer to tackle this issue. However, policy makers and local authority need to take some factors into consideration before implementing it such as hazard prone area, agricultural area, local historical site, basic amenities and so forth. A proper and thorough planning can help in reducing damage to the environment and minimising the risk of natural hazard to an area. With the help of geographic information system (GIS) based techniques and remote sensing (RS), it may help the policy makers and local authority to create a proper land development plan for sustainable environment in the future. GIS – AHP model is a useful technique that can be used for the purpose of urban planning/development and environmental management.

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Sekian, terima kasih.

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Saya yang menjalankan amanah,

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