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## **GIS-BASED MULTICRITERIA EVALUATION APPROACH IN PLANNING TOURISM DEVELOPMENT SITES IN ENVIRONMENTALLY SENSITIVE AREAS**

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### **Abstract**

Multicriteria evaluation approach has become useful mechanism in selecting choice possibilities based on number of alternatives. This approach has become useful for planners and engineers especially when dealing with allocating suitable sites for tourism development, which has often being undertaken within environmentally sensitive areas. Taking Langkawi Island, which has pristine natural resources, as example, this study demonstrates the usage of GIS-based multicriteria evaluation approach in identifying environmentally sensitive areas to be protected and conserved in planning for tourism development. Criteria used for determining ESA included coastline, topography, natural resources and forest, and tourism sites. Soft-information gathered through interviews with 3 different stakeholders/experts namely engineer, environmental officer and planner, to calculate weights for each criteria mentioned above. The study found that new built-up area shall only be confined within existing urban area namely Kuah area in order to ensure ESA and tourism sites to be protected and conserved. GIS-based MCE approach provides systematic mechanism where soft information can also contribute towards planning for tourism development as well as safeguarding the environment.

*Keywords: Multicriteria Evaluation Approach, GIS, Environmentally Sensitive Areas, Malaysia*

### **1.0 INTRODUCTION**

In Malaysia, tourism sector has contributed significant to the Gross Domestic Product (GDP), such that in 1988 this sector contributed approximately 9.8 billion and it increased to RM31.1 billion in the year 2000 (Malaysia, 2001). Tourist arrival in Malaysia also increased dramatically. For example, in 1998 tourists' arrival was about 5.5 million people and it increased to 16.4 million in the year 2005 and reached 20.9 million in 2007. It is further increased to 25.3 million in 2012 (Tourism Malaysia, 2012). Although the growth of tourism sector brings economic benefits to the country, it has created major challenges in planning and managing the environment and landscapes of tourism sites. This is due to the needs to plan and develop various supporting products such as accommodations and transportation networks to satisfy the demand from the growing number of tourists (Norhidayah, 2013).

Tourism products and its supporting products usually are developed in areas with scenic beauty such as near the coastlines or elevated terrain such as hillside land (Thullen, 1996). For example, hillside land is developed to make high profit, insufficient flat land or its scenic beauty, fresh air and exclusiveness (Gue and Tan, 2003). However, the development of this area brought greatest challenge to engineers and planners since this area is prone to landslide, soil erosion and damage of biodiversity. Institute of Engineers, Malaysia (IEM, 2000) had published guidelines on mitigating the risk of landslide on hillside development due to the concerned by the public. The development of hillside is safe with proper planning, design and construction, and maintenance. However, in the development of hillside, factors of safety considered primarily focused on risk-to-life or consequences to life (casualties) and economic risk or consequences (damage to properties or services) (Gue and Tan, 2003; IEM, 2000). This guideline, however, ignores the impact of such development on the environment. In order to undertake development within and near environmentally sensitive areas, proper planning and various considerations need to be undertaken. The use of Geographic Information Systems (GIS) and multicriteria evaluation (MCE) approach provide a framework that allow various stakeholders to be involved in decision making (Voogd, 1983; Samat, 2002; Malcweski, 1999). Thus, in the contact of developing tourism development sites, in addition to spatial information, planners and engineers may use perception, views and preferences from various stakeholders in assisting the decision making process. This study, therefore, demonstrates the usage of soft information involving human values or perception in conducting GIS-based MCE approach in identifying environmentally sensitive areas, which will be incorporated into the process of selecting suitable sites for tourism development in Langkawi Island, Kedah, Malaysia.

## **2.0 BACKGROUND OF THE STUDY**

Management of area designated as ESA such as forest and wetlands needs to consider the protection and conservation of ecosystems. ESA can be defined as “*special area that is very sensitive to any form of changes to the ecosystem due to natural processes or activities in or around it, either directly or indirectly, at any level is determined based on the integration sensitive characteristic elements of disaster risk function, the value of life support and the heritage and legacy of the area*” (JPBD, 2011). Town and Country Planning Department (JPBD) have established an action plan to guide and conserve ESA. The successful implementation of ESA management depends on the basic information on topography, river basins, sub-elements and elements ESA. Subsequently, the Malaysian government, therefore,

has imposed proper environmental impact assessment (EIA) to be undertaken for any development project involving environmentally sensitive areas including hillside. EIA is a study to identify, predict, evaluate and communicate information about the impacts on the environment of the proposed project and to detail out the mitigating measures prior to project approval and implementation (EIA, 2003). The assessment undertaken would allow ESA to be identified and thus the decision regarding whether development to be allowed could be made (Daliza, 2008). In addition to EIA, Town and Country Planning, 1976 Act 172 Section 22 (2A) also addresses a balance between physical development and environmental conservation (JPBD, 2005). This act was amended to incorporate environmental conservation in tourism development (JPBD, 2011). Subsequently, EIA report needs to be submitted for every physical development to be undertaken within and near ESA (Daliza, 2008).

Although the EIA report was produced to ensure the safety of the proposed development project, environmental disaster still occurred (EIA, 2003; JPBD, 1997). This is probably due to incompetence personnel, lack of slope maintenance or other human negligence. In the landslide disaster that occurred in Bukit Antarabangsa, Kuala Lumpur, Malaysia on Dec 6, 2008 which took five lives and destroyed 14 single-unit bungalows, for example, the task force report cited ingress into slope, especially where the drainage is not well maintained, lack of maintenance of slope, overdevelopment with insufficient infrastructure, lack of competence expertise in hillside constructions, lack of competence authority personnel when giving approvals, lack of monitoring and so on among the causes of the disaster (Bhattacharjee, 2012). Most of the reasons cited were mainly related to human carelessness.

The advance of engineering and construction might not hinder development at steeper slope or rough terrain; however, it might jeopardize the environment (Uran and Janssen, 2003; Lambin, 2005). For example, hillside or coastal developments might cause landslide or damage the aquatic organism respectively (Norhidayah, 2013; Gue and Tan, 2003; JPBD, 1997). In order to control such damage, proper planning and control need to be undertaken in the development of hillsides, coastal areas or other ESA. Such actions will require huge amount of information. Information can be defined as data that has been interpreted for specific purpose (Samat, 2002; Malcweski, 1999). In planning and conserving ESA, accurate and up-to-date spatial and aspatial data representing physical characteristics such as land use, topography, soil conditions, and socio-economic conditions such as population dynamics, provision of services and land value, and environmental conditions are required (Longley et al., 2010). This information can be classified as hard and soft information (le Clerq, 1990;

Melcweski, 1999). Hard-information or factual is the information derived from facts, figures, quantitative estimates or systematic survey such as remote sensing and census collection (Eastman, 1999). On the contrary, speculative or soft information represents the opinion, preferences, priority or judgments of decision makers (Samat, 2002). This information can be based on intuition, ad-hoc survey, questionnaires, in-depth interview, comments, projection and forecast. Both hard and soft information are particularly significant in planning and development of ESA such as hillside or beaches in order to avoid environmental degradation (Thullen, 1996; Gue and Tan, 2003; Samat, 2007).

Proper control and plan, therefore, need to be devised to ensure that the negative consequences to the society, economy and the environment are reduced (Samat, 2002; Uran and Janssen, 2003). Zoning regulation, for example, has been used in many part of the world to protect the natural environment, environmentally sensitive areas, areas with valuable landscape, natural heritage or historical sites or the spot with scenic beauty and agricultural area (EIA, 2013; Daliza, 2008; Longley et al., 2010). Protected natural areas are playing essential role in land management. Therefore, larger areas of land can be legally designated under the category of protected area (Couclelis, 1991; Carsjen and van Lier, 2002; Atauri et al., 2000). In order to evaluate the impact of land use development on the environment, GIS has been effectively used to map, plan and monitor land use activities in various places (Longley et al., 2010; Bahaire and Elliot-White, 1999). The study conducted by le Clerq, (1990), for example, evaluate the application of GIS in planning and allocating various tourists activities ranging from camping, biking and parachuting in Turkey. It showed that GIS is invaluable tool in combining spatial and non-spatial data in choosing suitable sites for various tourist activities. Furthermore, the study undertaken by Fritz et al., (2000), integrated GIS and multi-criteria evaluation approach (MCE) in evaluating wildness continuum in Britain. Various spatial variables such as distance from transport network and distance from population centers were used to define wilderness area. In Malaysia, the study undertaken by Yaakup and Abu Baker (2004) and Abdullah et al (2004) demonstrated the usage of GIS-MCE in identifying potential sites for urban development. The integration of GIS and MCE provide a framework for both spatial and aspatial data to be combined and used in decision making process. Such an approach allows the recognition, assimilation and corrects use of large amounts of information (hard and soft information) about existing condition in the decision making (Malcweski, 1999; Yaakup et al., 2006). Therefore, this approach can potentially be use in planning and conserving ESA especially for tourism development.

### 3.0 METHODOLOGY AND DATA

This study involves the integration of soft and hard information identifying ESA for tourism development using GIS and MCE. Figure 1 illustrates the conceptual framework used to identify sites for tourism development. As shown in this figure, GIS-MCE is used to identify ESA, which then will become constraint to be used in selecting potential sites for tourism development.

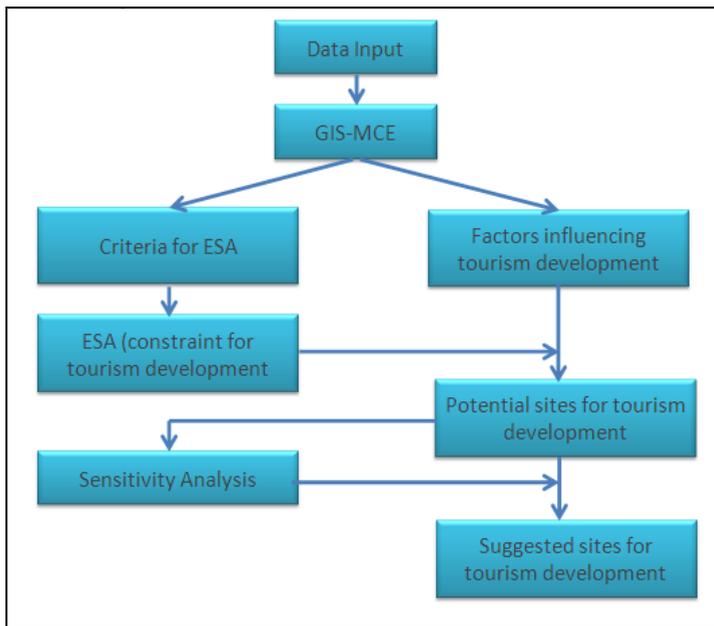


Figure 1: Conceptual framework of the study

There are five steps involved in conducting GIS based MCE analysis namely i) determining the objective of the analysis, ii) defining criteria influencing land use for tourism development, iii) standardizing criteria chosen in step two, iv) assigning weights for each of the criterion used; and v) combining all criteria by using decision rule. In this study, the objective is to identify suitable sites for tourism development. Then, criteria influencing tourism development are selected. Criteria chosen could be those influencing or constraining tourism developments. The numbers of criteria used are unlimited but those criteria should be able to identify the objectives to be solved (Malczewski, 1999; Eastman, 1999). In the context of selecting sites for tourism development, criteria used included proximity to existing transportation network, proximity to existing developed areas, proximity to industrial sites, and proximity to existing infrastructure. Constraints, on the other hand, are criteria that hinder the development of specific sites. In this study, ESA is used as a constraint for tourism

development sites. The study, therefore, needs to determine ESA for the study area prior to identifying suitable sites for the developments. After identifying criteria influencing and constraining tourism development, the score for each criterion needs to be standardized such that the scale used is comparable. Standardizing the scores for each criterion could be done by using range approach or fuzzy approach. The fourth step involves determining weights or relative importance of each factor. Various approaches could be used to determine weight such as ranking, rating, analytical hierarchy process (AHP) or fuzzy approach (Carsjen and van Lier, 2002). In this study, AHP method is used since it allows the weight for each criterion to be compared with another criterion as a pair (Malcweski, 1999). In determining the weights, soft information in the form of opinion, preference and knowledge was compiled based interview using structured questionnaire with three experts namely planner, academician and officer at Department of Environment. This approach allows stakeholders to influence the decision making regarding the development to be undertaken. Finally, decision rule or approach to combine the all criteria is applied. The study used weight linear summation approach (WLC) to combine all factors and identify potential sites for tourism development. This can be presented using Equation 1 below.

$$S_{i,j} = \sum_{m=1}^M x_{i,j} \cdot W_m \cdot C_m \quad (1)$$

where,

$S_{i,j}$  = the suitability score for a cell at row  $i$  and column  $j$  for urban development;

$x_{i,j}$  = the value of factor  $m$  for the cell at row  $i$  and column  $j$ ;

$W_m$  = the weight of the relative important of factor  $m$ ;

$C_m$  = the Boolean value of the presence of any constraint that hinders new development to occur at the cell at row  $i$ , column  $j$ ; and,

$m$  = the factors used in the model.

### 3.1 The Study Areas

Langkawi Island was chosen as a study area. It is a tropical island located of the north-west coast of Peninsular Malaysia between 6° 10'N and 6° 30'N latitude and 99° 35'E and 100° 0'E longitude. The biggest and most developed island is Langkawi measuring about 47,848 hectares. Figure 2 shows Langkawi Island and tourists' attraction sites which are divided into nature based attraction, manmade attraction, historical and natural heritage, and sport and recreational. Other islands are uninhabited or sparsely populated. Topography of this island is mountainous covered by forest reserved area of 26,266 ha that is 54.6% of total land area.

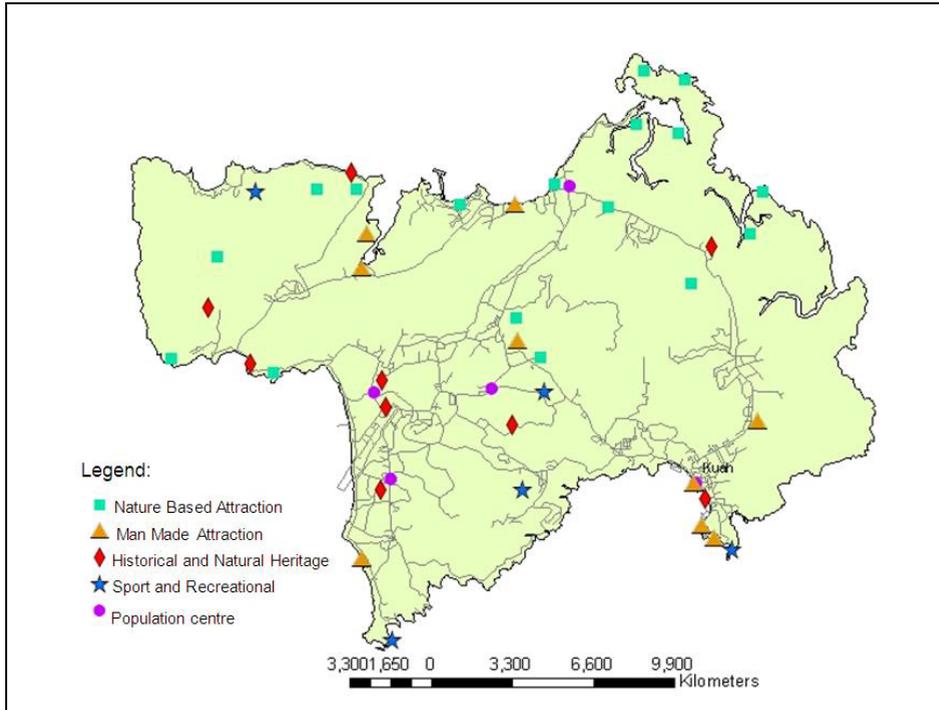


Figure 2: The study area

This island was selected as a study area since it has been one of the attractive tourism sites in Malaysia. In addition to its scenic beauty, various tourism products and its supporting products have been developed to cater the demand for ever growing tourists. For example, hotels and transport infrastructures have been built in this island to support tourist arrivals. Although built environment was directed to Kuah area, the development of tourism products were scattered throughout the study areas. This is to cater for growing number of tourists' arrival in the Island. In addition, Langkawi population was 84,054 in 2005 and it increase to 94,777 in 2010. Langkawi's population is forecasted to increase to 119,009 in 2015 (Langkawi Municipal Council, 2005; Department of Statistics, Malaysia, 2010).

### 3.2 Determining Environmentally Sensitive Areas for Tourism Development Sites

ESA is used to constrain tourism development within specific sites. In determining ESA, five factors are used. Table 1 below describes selected criteria used in determining ESA. The selection is made based on existing literature, planning documents and expert opinion (Daliza, 2008; Yaakup and Abu Baker, 2004; Abdullah et al., 2004).

Table 1: Criteria used to determine ESA and their description

<b>Criteria used to determine ESA</b>	<b>Description of development restriction</b>
Forest	No development shall be allowed within forest reserve areas
Agriculture	No development shall be allowed within areas reserved for agriculture
Topography	No development shall be allowed in areas above 300m height
Rivers	No development shall be allowed near or within areas reserved for rivers
Coastlines	No development shall be allowed within less than 200m from coastline

Source: JPBD (2004), Yaakup et al. (2004)

Based on the description above, input maps were prepared in ArcView 3.2 GIS software and transferred into Idrisi 3.2 GIS software. ArcView 3.2 software is used for data preparation since it is easy to use and provide platform for various format. In addition, data obtained from various departments (Geography Section, Universiti Sains Malaysia, Town and Country Planning Department, Kedah) are in ArcView 3.2 format. While Idrisi 3.2 software is used for conducting GIS-based MCE analysis since this software has integrated GIS-MCE module which allows non-technical users (potentially, planners or other decision makers) to use it easily (Samat, 2002). After preparing and converting data into Idrisi 3.2, weights for each criterion above are assigned. In this study, weights are derived based on soft information from experts in various fields including engineer, planner, environmental officer, academician, decision maker and land administrator. Table 2 below shows criteria used to determining ESA and the average weight obtained from 3 experts.

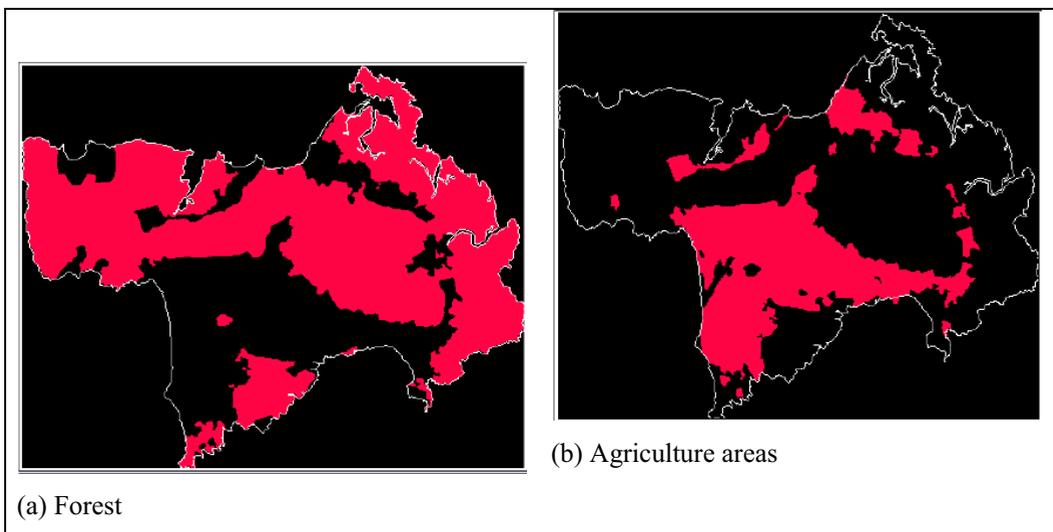
Table 2: Criteria and weights defining ESA to constrain tourism development from three different stakeholders

<b>Factors Influencing ESA</b>	<b>Average Weight from 3 Experts Interviewed</b>
Agriculture Area	0.4222
Forested Areas	0.1496

Topography	0.2244
River	0.0664
Coastlines	0.1226
Consistency Ratio	0.070

Table 2 shows weight used for five criteria that have been used to define ESA which will be used to derive constraint map for tourism development. These criteria are presented in the maps as shown in Figure 3 below.

Based on MCE approach undertaken, Figure 3 illustrates ESA. This map is used as constraint for development of tourism sites. This map shows most parts of Langkawi is environmentally sensitive, which should be protected and conserved. Therefore, these areas shall not be allowed to be transformed to built-environment. However, tourism development in the form of eco-tourism could be considered. Based on criteria shown in Figure 3, environmental constraints areas (Figure 4) was produced. The environmentally sensitive areas should act as control mechanism against development.



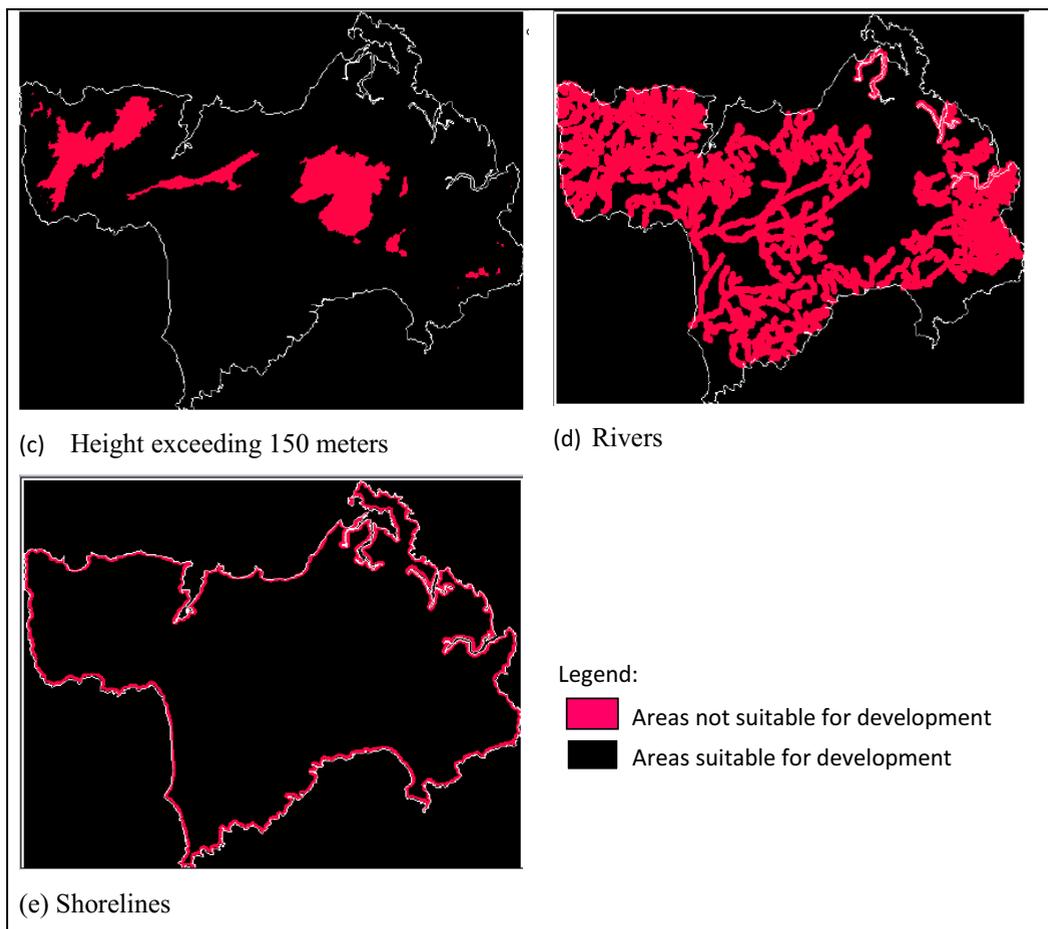


Figure 3: Criteria used to determine Environmentally Sensitive Areas

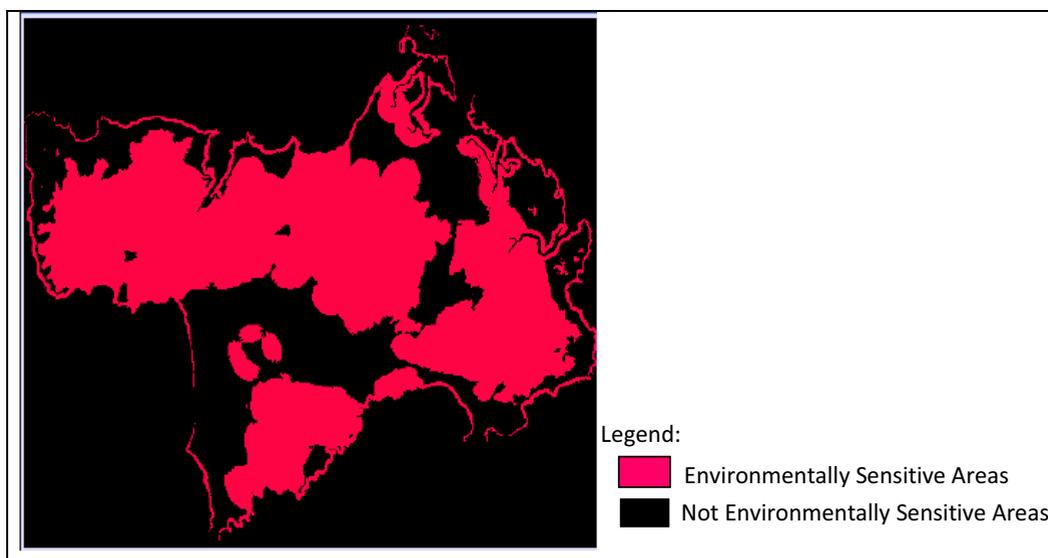


Figure 4: Constraint to be Used in Determining Potential Sites

#### 4.0 PROPOSED SITES FOR TOURISM DEVELOPMENT

This study then, attempts to identify areas suitable for tourism development in Langkawi Island. There are four criteria influencing tourism development used in this study. These criteria include proximity to existing transportation network, proximity to existing developed areas, proximity to industrial sites, and proximity to existing infrastructure. In addition, ESA map derived from the analysis above is used to constrain development. Similar to the step in determining ESA, weights were assigned based on preferences, opinion, knowledge and perception of the 3 experts. Table 2 illustrates criteria influencing tourism development sites and their respective weights based on experts' opinion. The scores for criteria influencing tourism development sites were standardized using fuzzy approach. Higher values indicate preferred areas as compared to lower values.

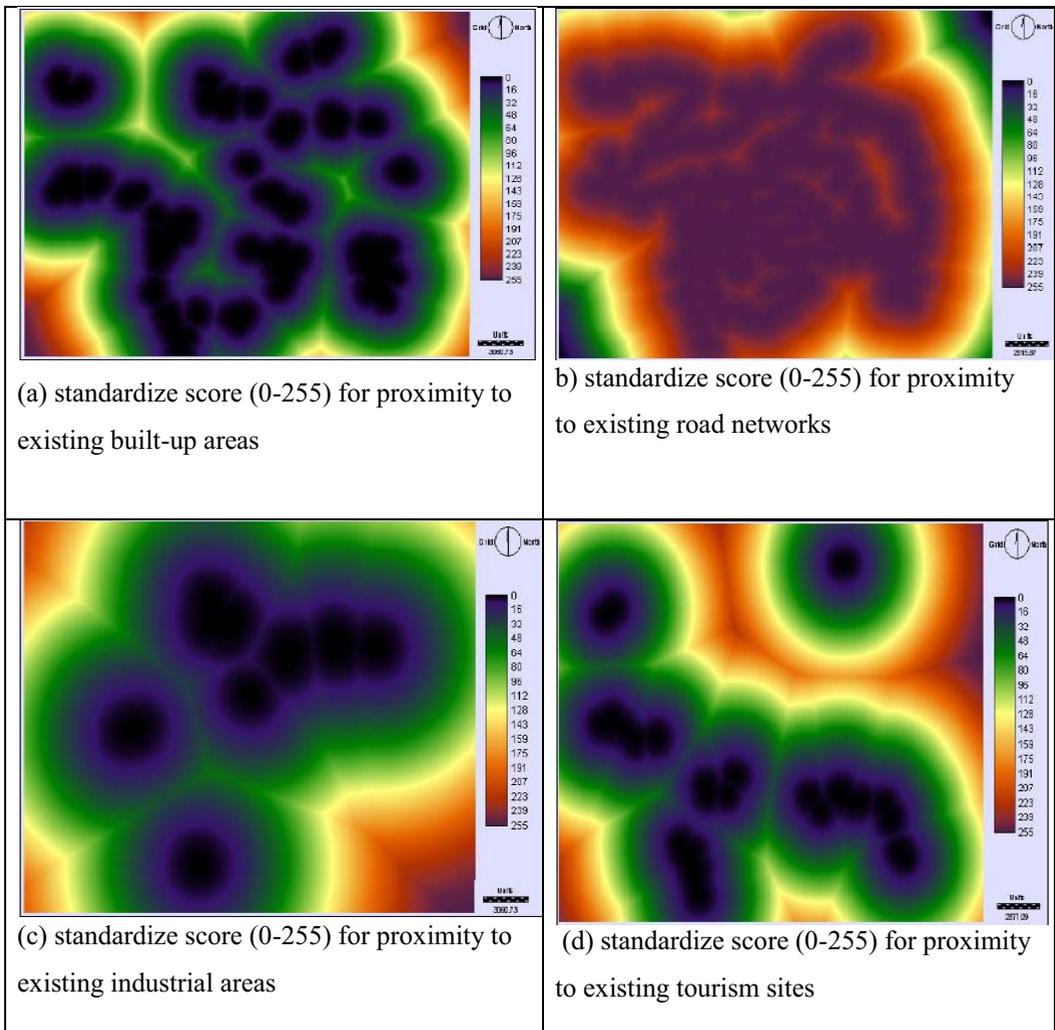


Figure 5: Criteria influencing tourism development sites

Finally decision rule based on Equation 1 is used to combine all criteria and their respective weights and constraint used in identifying potential sites for tourism development. Figure 5 illustrates suitable sites for tourism development in Langkawi Island based on 3 different experts. From the figure, the study could not identify the most suitable sites for tourism development. This means tourism development in Langkawi Island is already reaching its maximum level. Only small part at the east of Langkawi Island is suitable for tourism development. For example, from the first decision maker only 51.21 acres is suitable for tourism development. The output obtained from weights derived from the second and the third decision makers are 341.99 acres and 97.49 acres respectively. Other areas as shown in red were less suitable for tourism development, while areas represented in white in the maps are unsuitable for tourism development. These areas are either ESA which is restricted from being developed or existing developed areas.

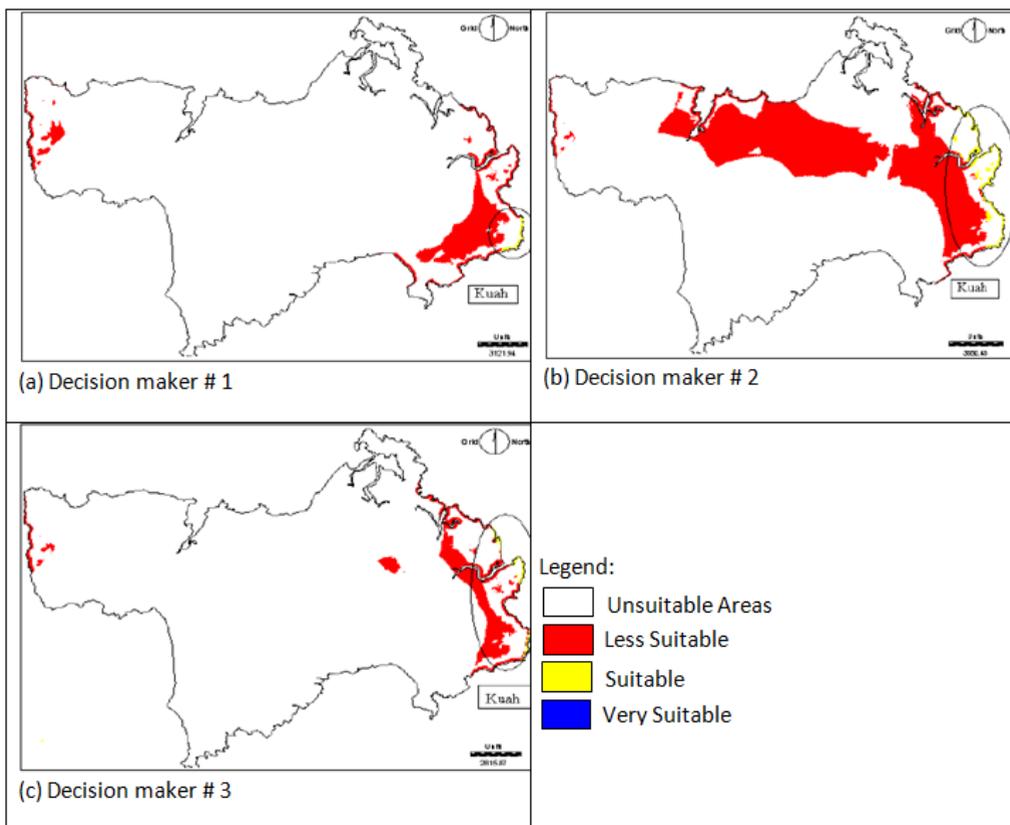


Figure 6: Potential sites for tourism development in Langkawi Island based on three different expert opinions.

## 5.0 CONCLUSION

Tourism sector has contributed significantly to the economy and social-economic development in Langkawi Island. At the same time, this activity also could bring negative consequences to the environment. Although various initiatives to At present, however the planned and strategies used to safeguard the natural areas ua regional scale land use changes analysis undertaken in Langkawi Island revealed that although the government has planned various strategies to promote tourism development, it managed to safeguard the environment. This is probably due to the effectiveness of the conservation strategy used to control urban development and urban sprawl in the island. Further analysis needs to be conducted to evaluate land use changes at local scale in order to evaluate such impact. The study demonstrates potential application of GIS-based MCE approach which provides framework to take into consideration both hard and soft information in planning and developing land for tourism activities in Langkawi Island. Experts' opinion, preference and knowledge could be integrated and used in decision making process. Furthermore, it will allow ESA to be conserved and protected.

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