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# GIS BASE TOURISM DECISION SUPPORT SYSTEM FOR LANGKAWI ISLAND, KEDAH, MALAYSIA

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**Abstract**
Tourism is an activity that implies the geographical dimension for users (the tourists) providers and planners. Besides its spatial dimension, tourism involves aspects of social, economic and environmental implications. Geographic Information Systems (GIS) is particularly developed for the management purpose as well as to study the spatial phenomena. More specifically, the GIS is employed for developing, storing, managing, analyzing, and visualizing the extensive amount of spatial and non-spatial data related to activities and resources. This paper is part of the "Development of Tourism Decision Support System (TDSS)" project of Sustainable Tourism Research Cluster (STRC) of Universiti Sains Malaysia. This paper focuses on a GIS-based spatial decision support system (SDSS) application that integrates GIS functions and SDSS designs with user friendly graphic user interfaces (GUI) in helping visitors of the Langkawi Island to choose and plan their activities more effectively, according to their personal preferences and constraints.
**Keywords**: GIS, Tourism Decision Suport System, Langkawi Island.

## 1. INTRODUCTION

Tourism can be defined as a set of activities (for leisure, business, religious, health and personal purposes) engaged in by persons temporarily away (maximum of one year) from their usual environment, excluding the pursuit of remuneration from within the place visited or long-term change of residence (Smith, 2004). As a field, tourism is currently among the world's largest industries and fastest growing economic sectors. Tourism activities employ 3% of the global labor force and if indirect jobs are considered, this share increases to 8% (UNEP, 2013). By 2000, the international tourist arrivals worldwide was approximately 697 million (WTO, 2002) and has increased to 1.035 billion in 2012

(UNWTO, 2013). Tourism is a multi-faceted sector (Figure 1) and within the tourism sector, coastal tourism is by far the most significant in terms of tourist flows and generation of income (Salehudin et al., 2013).

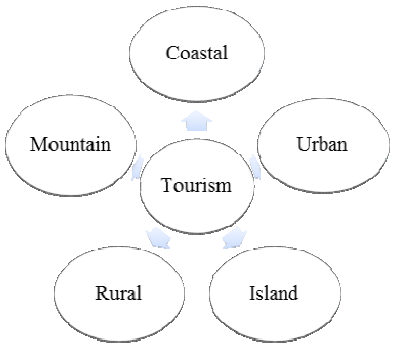


FIGURE 1 - DIFFERENT TYPES OF TOURISM (SOURCE: EU-COMMITTEE OF THE REGIONS, 2006)

Interchangeably known as geospatial information system, GIS is any system being used to store and process data referenced to the Earth's surface (Molenaar, 1998; Nair & Katiyar, 2011), which growth and expansion are further influenced by the Internet development starting in 1990s. GIS facilitates the tourism development by providing insights on location, areas' conditions, trends and changes, routing to through the site and resources usage patterns; in addition to balancing an area sustainability and tourism (Butler 1993). Therefore, GIS has been widely used in tourism settings; from information kiosks and hiking maps to web-based maps (Duran, et al., 2004). As it enables the information transaction to a wide network at the expense of low budget, the Internet is gaining in popularity and in importance. The internet based GIS is more mobile, powerful, flexible and better able in sharing and communicating using geographical knowledge (Colas, 2002). The Internet based GIS allows the users to access GIS services without having to install the GIS software on their computer and more importantly, GIS implementation in tourism settings is still limited. This suggests that there is so much that can be achieved. Against this background, this paper aims to discuss the importance of TDSS and the development of the Internet based GIS for Langkawi tourism.

## 2. TOURISM INDUSTRY IN MALAYSIA

The tourism industry enjoys a long tradition. Tourism is a complex host-tourist interaction (Ismail & Turner 2008) that can be broadly encapsulated into mass and alternative tourism, which can be further categorized into international and national based. Regardless the categories, the high dependency level on the environment as well as the rapid development rate imply that the tourism industry operation shall be executed within the sustainable development context (Chan 2009). The tourism industry



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successfulness is a three-fold process that involve developing, managing and marketing the products, facilities and activities; sufficiently and effectively (Fridgen 1991).

According to Medlik et al., (1991), the tourism industry stimulates the developing countries' economic growth by means of revenue distribution. Malaysia particularly, has recognized tourism as one of the economic development pillars since 1990 (Mohamed et al., 2006). Figure 2 showed the total tourist arrivals and receipts from 2004 to 2012 for tourism industry in Malaysia.

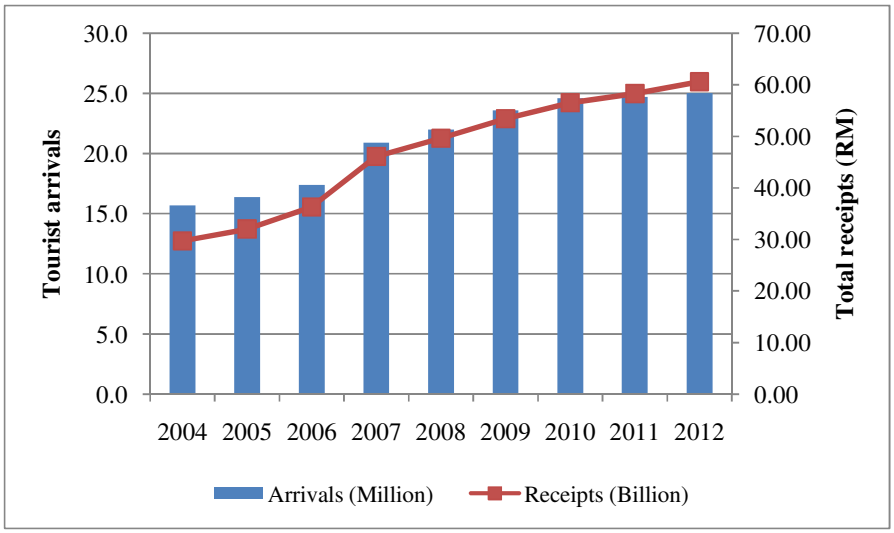


FIGURE 2 - TOTAL TOURIST ARRIVALS AND RECEIPTS FROM 2004 UNTIL 2012

In the context of Malaysia's island tourism, it is learned that the tourists' visitation propensity is more toward Langkawi (in Kedah), Perhentian (in Terengganu), Pangkor (in Perak) and Tioman (in Pahang) (Mohamed et al., 2006). Langkawi in particular, the tourist visitation is stimulated by its picturesque 99 small islands and the complete archipelago that is 450 million years worth in value.

Additionally, the establishment of the Langkawi Geopark as one of the World Heritage Sites (gazetted by UNESCO in 2007) has contributed to increases in tourists' arrival (Othman & Mohd Rosli 2011). On top of this, Langkawi's multi-society background and unique historical sites have further generated the tourism receipts (Ismail & Turner 2008).

The World Heritage status directly translated into the importance of balancing between the archipelago's geological value and the tourism industry development. Simply stated, the working parameters (social, economic and environmental) are to be managed based on its carrying capacity (Nair & Azmi 2008).

## 3. SPATIAL DECISION SUPPORT SYSTEM AND TOURISM

An extensive amount of tourism data in addition to considerable variables that need to be scrutinized at once has encouraged the GIS usage for data collection and interpretation. More specifically, GIS enables the users to explore a number of data resources (each resource provides a unique feature) on a subject (for example location) which in return, allows for effective data visualization and integration. As a result, GIS offers insights on a particular location's current spatial trend where this information will then employ by tourism personnels for management and planning purposes. Thus, GIS helps in frameworking approaches to achieving sustainable tourism development. According to Crain and Macdonald (1984), GIS applications in tourism settings can be viewed from the following: [1] the first phase (inventory) gathers the interest information (Rhind 1990), [2] the second phase (analysis) scrutinizes the information gathered and [3] the third phase (management) involves transferring data to a decision support system. Table 1 show the capabilities of the GIS on tourism application. It can be noticed that the evolution of GIS applications in tourism is very close to the three phases of GIS applications as described by Crain & MacDonald (1984). First there were the inventory applications for assembling and organizing features of interest and which performed mainly simple data queries such as the location and condition questions identified by Rhind (1990). At a second stage there were analysis applications in which more complex analytical operations were undertaken. The third stage is related to management applications. It actually reflects the evolution of an information system from a transaction processing system to a decision support system (Crain & MacDonald, 1984).

TABLE 1 - CAPABILITY OF A GIS

| Examples of functional capabilities | Examples of basic questions that can be investigated using a GIS (after Rhind, 1990) | | Examples of Tourism applications |
|---|---|---|---|
| Data entry, storage and manipulation | Location | What is at? | Inventories of tourism resources |
| Map production | Condition | Where is it? | Identifying most suitable sites for development |
| Database integration and management | Trend | What has changed? | Measuring tourism impacts |
| Data queries and searches | Routing | Which is the shortest route? | Visitor flows |
| Spatial analysis | Pattern | What is the pattern? | Analyzing relationships associated with resource use |
| Spatial modeling | Modeling | What if…? | Assessing potential impacts of tourism development |
| Decision support | Alternatives | How to decide? | Decision making |

(Source: Baharie & Elliot-White, 1999)



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GIS applications can provide at least three different types of information which are Tourism Resource Maps, Tourism Use Maps and Tourism Capability Maps. Tourism resource maps enable planners and stakeholders to analyze the resource set to identify how much is available and where it is. This tourism resource maps also can helps planners and managers determine the capability of an area for the creation of new tourism products or services, identifying locations suitable to tourists or tourism. Tourism use maps allow planners and stakeholders to analyze the resource set to evaluate land use options and identify zones of conflict or complementarity's, such as access points, water, wildlife habitats etc. Tourism capability maps allow planners and stakeholders to analyze the resource set to monitor tourist resources at risk due to management, planning decisions and other sectors (Bahaire & Elliott-White, 1999). Beedasy & Whyatt (1999) developed a decision support system (SpaME) to assist tourism planning in Mauritious, which further enhanced by adding a visibility analysis component. This application is designed to handle all criteria simultaneously and to facilitate users understanding the interactions that may take place between these criteria in a dynamic environment.

McAdam (1999) document the GIS usage on visual impact assessment (landscape view analysis), with specific attention given to the number of visitors. Beedasy & Whyatt (1999), on the other hand, developed a decision support system (SpaME) to assist tourism planning, which further enhanced by adding a visibility analysis component.

This application is designed to handle all criteria simultaneously and to facilitate users understanding the interactions that may take place between these criteria in a dynamic environment. In the context of mapping the trail impacts (for example soil erosion), Giles (2003) and Tomczyk (2010) concentrate on landscape management and environmental sensitivity. According to Tomczyk (2010), this method able to study spatial diversion, distribution of environmental sensitivity and factors that are important for environmental sensitivity in selected areas. The GIS data exist in layers (also known as data integration) which could be presented in the form of tables, maps, graph or a combination of these three.

Malczewski (1999) identifies GIS contribution in these three phases. For intelligent phase GIS can ideally perform the data acquisition, storage, processing and management for identifying opportunities or problems. For design phase, it related to the development and the analysis of possible alternatives to the problem identified in the intelligent phase.

This phase also involve formal modeling/GIS interaction in order to develop a solution set of spatial decision alternatives. Integration of decision analytical techniques and GIS functions is critical for supporting the design phase. GIS, spatial decision alternatives are derived by manipulation and analysis of the data stored in a GIS, using its overlay function in a spatial context. The choice phase, it involves

evaluation and selecting a particular alternative from those alternatives available where it may use specific decision rules to evaluate and rank alternatives. GIS contribution here is not as strong as in the previous two. All this three phases necessitate the identification and use of sustainable tourism indicators for assessing present situation, identifying weakness, monitoring, and evaluating alternatives.

GIS could be the technology to use for identifying and monitoring indicators and these three stages of decision making do not necessarily follow a linear path from intelligence, to design, and to choice. The GIS data exist in layers (also known as data integration) which could be presented in the form of tables, maps, graph or a combination of these three. GIS offers the following information, namely: [1] Tourism Resource Maps, which allow for identifying the tourism resources sufficiency in producing new tourism products, [2] Tourism Use Maps is used for land-use zones evaluation in order to detect conflicts between land usage and [3] Tourism Capability Maps serve the purpose of tourism resources management in terms of the development plan (Bahaire & Elliott-White, 1999).

These GIS data are then used in the three-stage decision making process (Simon 1960). The first stage (intelligence) focuses on identifying potentials and/or problems, the second phase (design) involves structuring alternatives to problems identified in the first stage while the third stage (choice) concentrates on evaluating and ranking the identified alternatives (Malczewski 1999).

The other powerful aspect of GIS is its flexibility in modeling spatial objects to suit the particular needs of the user or application. Nevertheless, given that most of the spatial decision making involves semi-structured problems (Simon 1960), the analytical process uses both GIS and SDSS (Ascough, et al., 2002). The simplest perspective on the definition of SDSS is that a GIS is implicitly a DSS, as a GIS can be used to support the three-stage decision-making process (intelligence, design and choice) (Simon 1960). Muller (1993), on the other hand, identifies SDSS as a growth area in the application of GIS technology.

Spatial decision support systems (SDSS) is an interactive computer-based system (Malczewski 1977), designed for the purpose of solving problems/generating solutions in relation to spatial decision making process (Jankowski, 1995). SDSS includes the integration of a geographic database management system with analytical modeling capabilities, a visualization component, and a user-friendly decision making interface (Densham and Goodchild, 1989). The technology consists of a data management core, usually a GIS, supplemented by analytical modules and accessed by a custom interface (Walsh, 1993; Fedra & Feoli, 1998). Individuals are likely to place different values on variables and relationships, and use the information in different ways. Standard GIS software is not designed to handle these situations.



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Spatial decision problems often involve a large number of decision alternatives, each evaluated on the basis of multiple criteria. Spatial decision support systems normally consider situations where complex spatial problems are poorly defined, semi-structured and/or fully articulate objectives (Ascough, et al., 2002; Zhang & Day, 2002). SDSS facilitates such decisions by allowing users to specify their decision criteria and preferences interactively.

SDSS then uses these data to create and recommend routes that meet the users' stated criteria. SDSS based on GIS becomes the logical choice to develop an application that can help the visitors plan their recreational activities. First of all, each visitor is likely to have specific preferences in terms of what he/she would like to experience and also some of constraints.

Matching an individual's interests and preferences with the opportunities is a semi-structured spatial decision problem that will benefit from a SDSS based on GIS application. Based on the preferences and constraints selected by the user, the SDSS based on GIS then retrieves all relevant data from various GIS layers and performs the necessary analyses to identify the routes that meet the user-specified criteria and constraints. Information on the recommended routes is presented in both map and text formats for users to make their decision.

Feick and Hall (1999; 2000) develop TourPlan application, a GIS-based SDSS for tourism designed to assist site selection and impact evaluation for tourism planning as well as land development strategies in Small Island States (SIS). Two key modules were developed for the TourPlan SDSS where first module (Site Selection Assistant) allows users to specify scenarios of alternate tourism land use patterns to be developed. The second module (Multiple Criteria Analysis Assistant) determines the criteria weightings from the user input and computes the rank of each alternative scenario.

Evaluation results are then displayed in both map and tabular forms for users to make their final decision. Feick & Hall (2000) describe the development of TourPlan, a GIS-based decision support system designed to assist individuals and groups to explore alternative land-related development strategies in Small Island States while building consensus and identifying conflict in land use planning for tourism. The system has a tourism-based land management orientation meaning that it assists the designation of appropriate land for tourism-related development or for a competing land use.

A sample application was conducted in West Bay District of Grand Cayman involving four basic types of participants: government, nongovernment, private sector and the general public. Dye & Shaw (2007) presented TrailFinder application (GIS based SDSS with easy-to-use graphic user interfaces) to help visitors choose and plan their activities in accordance to their personal preferences and constraints. Similar to TourPlan application, information on the recommended trails is presented in both map and

text formats. Petropoulos, et al. (2003) presents Statistical and Forecasting Tourism Information System (SFTIS) used for support system for tourism demand analysis and forecasting. Ramachandra et al., (2006) develop an interactive computer-based DSS to compile, analyze and present the data at disaggregated levels for regional energy planning.

## 4. GIS BASE TOURISM DECISION SUPPORT SYSTEM

Tourism Decision Support System (TDSS) consists of Tourism Database, GIS Server, Web Client and Desktop GIS Application. Figure 3 shows the architecture of a 3-tier web GIS-based system employ by this study. Figure 3 exhibits the interconnection between each TDSS component.

The database component provides data required by either Web Client or server to generate a web document or GIS Server to produce a map. This database component handles data retrieval, addition, update and deletion. In 3-tier architecture, it is also possible for the web client to allow changes in the database component, which administered by users. When the GIS Server receives a request (for example identifying a point) from the Web Server (first sent by the Web Client), it retrieves the required data from the database.

Results are then send to the Web Server in a suitable format. At this point, the Web Server prepares a web document and sends it to the Web Client.

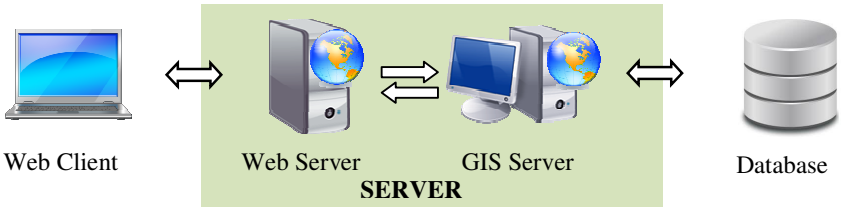


FIGURE 3 - ARCHITECTURE OF A 3-TIER WEB GIS-BASED SYSTEM

The integrated tourism information system of Langkawi Island will be implemented using ArcGIS Server and PostgreSQL with PostGIS extension as the database management software. The ArcGIS Server is chosen as it supports GIS operations including attribute- and location-based queries and network analysis. This Tourism Information System follows 3-tier Web GIS-based System architecture.

The Tourism Database stores all data related to or necessary for analysis of tourism. Interconnection between TDSS component is shown in Figure 3. Web Client (User) sends a request to the Web Server, which passes it to the GIS Server.



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When the GIS Server receives a request (for example identifying a point) from the Web Server (first sent by the Web Client), it retrieves the required data from the database. Results are then send to the Web Server in a suitable format.

At this point, the Web Server prepares a web document and sends it to the Web Client.

### *4.1. Langkawi Island Web GIS Development*

The Tourism Decision Support System (TDSS) can be accessed via Web GIS, which provides a user-friendly Graphical User Interface (GUI) and an easy access to the system via the internet. The GUI (see Figure 4) consists of a large map (displayed as either street map or satellite imagery) with a list of layers (can be either on/off accordingly), menu bar, navigation control (applied to study the map) and a zoom slider. Some layers are only available at certain scale to maintain the readability of the map. Table 3 show the list of menu available in the TDSS developed.

The TDSS can be implemented either using commercial GIS software or using free open source software (Table 4). Implementation using commercial software (ArcGIS Server) is easier, cheaper, user-friendly and more comprehensive compared to open source software. The Web GIS template is already available and only requires little works to add menu and functionality.

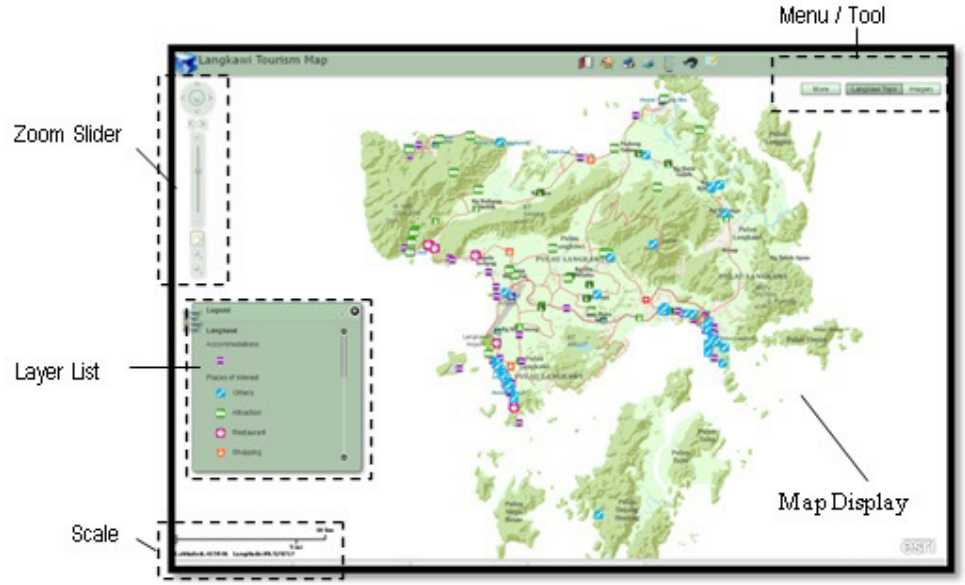


FIGURE 4 - DRAFT GUI OF THE TDSS WEB GIS FOR LANGKAWI ISLAND

TABLE 3 - LIST OF MENU IN THE WEB GIS

| Name | Description |
|---|---|
| **Map** | |
| Street Map | Display street map as the base map |
| Satellite Imagery | Display satellite imagery as the base map |
| **Tools** | |
| Find Places of Interest | Find a place of interest or facility by its name or other attributes. |
| Find Accommodations | Find an accommodation by its name or other attributes. |
| Find nearby | Find a place of interest or facility locating within a certain distance from a selected point. |
| Shortest Path | Find the shortest path in the streets from one location to another |
| Tour Planning | Arrange an efficient tour to visit several places of interest selected by user. |
| **Maintenance** | |
| Login | Login menu for registered user. |
| Add Places (Point) | Add a place of interest in form of a point. Only available for 'Contributor' and 'Manager' user level. |
| Add Places (Polygon) | Add a place of interest in form of a polygon. Only available for 'Contributor' and 'Manager' user level. |
| Edit Attribute | Edit attribute data of places. Only available for 'Contributor' and 'Manager' user level. |
| User management | This menu links to other page to manage users. This menu is available for Administrator only. On the user management page, Administrator can approve, reject, or delete users. |
| Place management | This menu links to other page to manage places of interest This menu is available for Manager only. |
| **Advanced Analysis (Manager Only)** | |
| Site Selection | Find a suitable location for tourism related development |
| Spatial Index | Calculation of several spatial index of tourism: Carrying Capacity, Development Pressure, Location, Tourist Concentration. |

TABLE 4 - IMPLEMENTATION OF TDSS USING COMMERCIAL VS OPEN SOURCE

| | Commercial | Open Source |
|---|---|---|
| Database Server | SQL Server Express 2008 | PostgresSQL/PostGIS |
| GIS Server | ArcGIS Server | GeoServer |
| Web Server | IIS | Apache |

## 5. DISCUSSIONS

Bahaire & Elliot-White (1999) conclude that GIS is a very useful tool, which can support decision making in sustainable tourism planning and management (such as activities, facilities and services) especially for areas with sensitive resources and tourism sectors that have highly depending on environmental resources. It is learned that an enhanced approach/alternative to sustainable tourism can be created by combining both GIS and SDSS applications. The integrated tourism information system of Langkawi Island offers adequate-attractive-and-user-friendly data (such as videos, maps and pictures) that are easily accessed, regardless time and place. Interestingly, this system allows changes to the data (administered by the users) where this in return, further enriched the data. Changes made to the data



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are first validated by the administrator, where this is done to ensure the data reliability and validity. There are a lot of development of Web GIS tourism around the world for tourism promotion of the destination. Web-based tourist information system (WETIS) acts as tool to promote tourism in Eastern Slovakia region. WETIS offer detailed information on historical, cultural, geographical, geological leisure, administrative and hospitality related information complete with photographs and object descriptions (Timčák, et al., 2009). Austrian have Web GIS known that able to use for navigation through a geographical hierarchy, representing various kinds of tourism information; use different search facilities; and even book tourism products online which can be access via the www, info kiosks at the holiday destination and cellular phones (Pröll, et al., 1998; Pröll & Retschitzegger, 2000).

GeoReferenced Information System for Tourism (GeoRIST) or Web-based Tourist Decision Support System (WTDSS) was developed to offers various tools to the travelling community or tourist visiting Agra City that allows user to find route in city and query information on sights, accommodations and other place of interest nearby (Singh, et al., 2011a; Singh, et al., 2011b). There are also WebGIS system that use Open Standards (OS) and Free Open Source Software (FOSS) as its based that allow a more low cost solution without licensing cost software known as Tourist Information System for Bhopal City (Nair & Katiyar, 2011). This system provide user/tourist with data such as tourist spots, hotels, travel hubs, emergency services, national highway, railways, main road and shopping markets. Map2Day is a web-based that use 3D-GIS service and provides user interaction between 2D city maps, 3D visualization and query which is developed as a marketing tool for tourism targets from different categories entertainment, accommodation, culture, public institution and public health (Ulm, et al., 2005).

The development of Langkawi Web GIS have been built upon the same basic concept as existing Web GIS, which is to provide detailed information about the tourist destination such as accommodations, restaurants, shopping complex, public facility and tourist attraction in the destination. The system will be provide interactive map which allow users to select layer types, zooming in/out, navigation and point into the map to find the tourism information. Other than that, the system allows user to perform query in their database. For example TIScover is a Web GIS that has its own search engine while WETIS and Web GIS for Tourist of Bhopal utilize Google Map as point serch engine. In order to aid user to find or navigating the place, there is a function where user can find route that connencting between two places or points. This function can be find in TIScover, WETIS and WTDSS/ GeoRIST. Other than that, there is also search nearby function that help finding object or information in specify search radius such as in WTDSS/ GeoRIST. The most important function for the user is either the system allowing user to update or add their own data such as point data that may represent a hotel, restaurant, shopping center

or tourism facilities which can be find in TIScover and WETIS. Table 6 below shows the different between Langkawi Web GIS and other existing Web GIS namely, TIScover, WETIS and WTDSS/GeoRIST.

TABLE 6 - DIFFERENT BETWEEN WEB GIS SYSTEMS

| Function | TIScover | WETIS | WTDSS/GeoRIST | Langkawi |
|---|---|---|---|---|
| Serach Engine | Yes | Yes | No | Yes |
| Find routes | Yes | Yes | Yes | Yes |
| Search nearby | No | No | Yes | Yes |
| Allow web user add data | Yes | Yes | No | Yes |

## 6. CONCLUSIONS

Tourism is a highly complex activity and thus, requires tools that support an effective decision-making process in relation to economy, social and environmental demands. The GIS application offers functions including visualizing complex relationships of spatial components, auditing environmental conditions, examining the suitability of locations for proposed developments, identifying conflicting interests and modeling relationships. With consistent addition to and efficient management of spatial data, the GIS application can be further improvised and improved. Within this paper interest, Web-based tourism information systems are found to be built upon the same basic concept that is to provide detailed information about the tourist destinations (comes in the forms of interactive maps, texts, videos and pictures).

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