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RESEARCH ARTICLE

LAND USE CLASSIFICATION AND MAPPING USING LANDSAT IMAGERY FOR GIS DATABASE IN LANGKAWI ISLAND

Zuhairi, A.*, Nur Syahira Azlyn, A., Nur Suhaila, M. R., Mohd Zaini, M.

Remote Sensing, GIS, and Physical Oceanography Modelling Laboratory Department of Marine Science, Kulliyah of Science, International Islamic University Malaysia, Jalan Sultan Ahmad Shah, Bandar Indera Mahkota, 25200, Kuantan, Pahang, Malaysia.
****Corresponding Author Email: zuhairiahmad@iium.edu.my***

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ABSTRACT

This study examined the land use changes in Langkawi Island for over 12 years. Land use maps were derived by analysing temporally available satellite imageries of that area. Subsequent Landsat imageries of the years 2006, 2014 and 2018 were processed in Environment for Visualising Images (ENVI) software using Normalize Differences Built-Up Index (NDBI) and supervised classification. The land use classes obtained were categorised according to the Soil and Water Assessment Tool (SWAT) land use classification namely URLD, URMD, URHD, FRSE, UINS, UIDU, URTN, RICE, AGRR, and WATR. The analysis of the land use maps provides a comparison for the area of land use class around Langkawi Island based on the *Rancangan Kawasan Khas 2020* (RKK). This study will give an overview of the stakeholder on the current land use of Langkawi Island for future land use planning. Moreover, the land use map generated in this study can be used as a functional land use input for the SWAT model and provide a temporal Geographic Information System (GIS) database on the land use of the Langkawi Island**.**

KEYWORDS

Land use classification, Langkawi Island, Landsat, ENVI, NDBI, supervised classification.

1. INTRODUCTION

Land use refers to information regarding the function of land resources (ACLUMP, 2016). In other words, alteration of land cover to cater to the socio-economic aspect of the people living in the area (Leman et al., 2016). Over the years, the changes in land use and land cover can be occurred naturally and as the impacts of human activities (Samat, 2010). However, the land development practices pose a significant threat towards the environment and the biodiversity of the area (Halimaton et al., 2011). Nonetheless, the risk of such practices to the environment can be reduced by proper land management and planning.

The studies on the land use changes have been done by using remote sensing technology because it enables a reliable and direct observation from the satellite imagery. For example, Landsat 8 has a better radiometric resolution that is improved from 8 bits in Landsat 7 to 12 bits in Landsat 8 (Xie et al., 2014). Therefore, it allows the analysis of land use/cover to be done with less difficulty. The result of the land use classification from the remote sensing image can be integrated into the Geographical Information System (GIS) which enable the production of a map representing the land use of the particular area.

A land use map can serve as a database therein a set of data that can be exploited by various stakeholders (Carrion et al., 2009). In Malaysia, an initiative for the GIS database was done by the Federal Department of Town and Country Planning in the year 2013 through the development of I-PLAN which consist land use information particularly throughout the Peninsular Malaysia (Federal Department of Town and Country Planning, 2016). This information is invaluable, especially to stakeholders such as the land managers and planners. Furthermore, the information on land use is also one of the required data needed to run the Soil and Water Assessment Tool (SWAT) (Villamizar et al., 2019). A well functional land use data that is derived by using the SWAT land use classification will be useful for the impact assessment of the land use based on the water yield.

Despite the great importance of monitoring land use, lack of research was done to assess the land use, particularly in Langkawi Island. The development that is done in the area to promote tourism might cause more harm than good to the environment. Land use study revealed that the island had experienced a significant increment in the built-up area category within a period of 30 years from 1974 to 2005 (Samat, 2010). The development plan revised in aspiration for the Langkawi to become the top 10 Island and Eco-Adventure Destination has led to more development within the area (LADA, 2019). Therefore, the land use changes in the subsequent years must be assessed to depict the current situation of the land use in Langkawi Island.

Furthermore, the effect of land use on the environment is equally important to be evaluated. Being an island, Langkawi's surrounding coastal environment will be affected by the land use whereby any kind of runoff

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will flow into the ocean. A SWAT modelling will be able to execute the assessment of water yield provided that the land use map input is functional. Hence, the objectives of this study are to determine the changes in the area of land use types for the past 12 years and provide a functional land use classification based on SWAT land use classification table.

2. Materials and Methods

2.1 Study area

Langkawi island is located at the northwest coast of Peninsular Malaysia between the latitude of 6° 9' 00" N and 6° 29' 00" N and the longitude of 99° 35' 00" and 99° 57' 00" E (Figure 1). It has tropical weather and temperature that ranges from 24 °C to 33 °C. Langkawi archipelago is made up of 104 islands with a total land area of 477 km² (LADA, 2014). Of all the islands, there are three inhabited islands which are Langkawi Island, Dayang Bunting Island, and Tuba Island (Othman, 2011). Langkawi Island is easily accessible through airplane and ferry. Hence, it has been one of the preferred islands for international and local tourists.

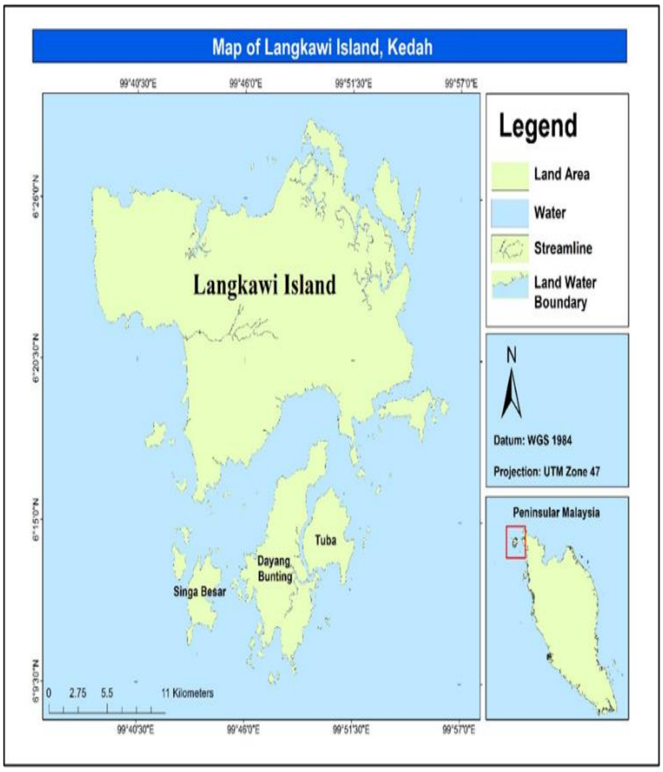

Figure 1: Map of Langkawi Island

3. Methodology

3.1 Data acquiring and preprocessing

The Landsat images of Langkawi Island for the years 2006, 2014 and 2018 were obtained from the United States Geological Survey (USGS) Earth Explorer. Table 1 shows the details on the satellite images retrieved from the USGS website. Afterwards, to improve the quality of the image, few preprocessing procedures were done of which include mosaicking and subset. Mosaicking is done to create a single raster dataset as the satellite image for the whole Langkawi Island as the island is not covered in a single dataset. The process can be done in ENVI platform using the mosaicking function.

The projection of raster dataset must be in WGS 1984 UTM 47 N. Later, a subset was done in the ArcMap 10.2.2 software by clipping the Langkawi Island shapefile to the raster dataset of Langkawi to reduce the size of the area needed to be analysed. Then the result of the process was exported back into the ENVI in the format of *.tiff* for further analysis. A geometric correction procedure was also performed to reduce the distortion in the coordinate of the raster dataset as referred to the Ground Control Point (GCP).

Table 1: Details of the satellite images for the year 2006, 2014 and 2018.

YEAR	Satellite	Product Id	Path/ Row	Date	Cloud cover
2006	*Landsat 5 TM*	*LT05_L1TP_128056_20060309_20161122_01_T1*	*128/56*	*9-Mar-06*	*2*
		LT05_L1TP_128056_20061019_20161118_01_T1	*128/56*	*19-Oct-06*	*6*
2014	*Landsat 8 OLI*	*LC08_L1TP_128056_20140227_20170425_01_T1*	*128/56*	*27-Feb-14*	*0.83*
		LC08_L1TP_129056_20140306_20170425_01_T1	*129/56*	*6-Mar-14*	*5.64*
2018	*Landsat 8 OLI*	*LC08_L1TP_128056_20180206_20180221_01_T1*	*129/56*	*6-Feb-18*	*1.26*
		LC08_L1TP_129056_20180213_20180222_01_T1	*129/56*	*13-Feb-18*	*8.14*

3.2 Unsupervised classification

The land cover land use classification was performed using the ENVI platform. Normalised Difference Built-up Index (NDBI) was applied to the image to improve the quality of the classification of land use land cover in Langkawi Island. The NDBI formula utilises different bands which are different in every satellite depending on their bandwidth. Subsequently, the formula for NDBI for each of the satellite is as listed in Table 2.

Table 2: Formula for the Normalized Difference Built-Up Index

SATELLITE	Formula
Landsat 5 TM	*TM 5 - TM 4/TM 5 + TM 4 (Bouhennachi et al., 2015)*
Landsat 8 OLI	*OLI 6 - OLI 5/OLI 6 + OLI 5 (Tek, 2018; Nafiz, 2018)*

The raster image of Langkawi Island then is a subset with a mask using the land use shapefile from *Pelan Strategik Langkawi 2014-2018* (LADA, 2019). Upon subsetting, the raster images produced were the area for respective land use shapefile. Then ISODATA unsupervised classification was performed for every land use categories into five classes.

3.3 Field survey

To validate the spectral information assigned to each class, a field survey was done. This involves taking the coordinates as well as the photographs of the sites. Coordinates and some photographs were taken in the Langkawi Island. The sets of coordinate were used for the supervised classification using the Parallelepiped method.

3.4 Supervised classification and accuracy assessment

Supervised classification was done by validating the unsupervised classification using the coordinate taken from the field survey. It produced a classified image that is separated in a colour that has been assigned in colour mapping during the unsupervised classification. The accuracy assessment was performed using the confusion matrix method. The overall accuracy determines the reliability of the classification result. Therefore, the overall accuracy and Kappa coefficient must be at least 85 percent and 0.7000, respectively (Anderson et al., 2001).

3.5 Mapping and digitising the land use

The mapping of land use in Langkawi was done in the ArcMap 10.2.2 software. Each land use category was assigned according to the Soil and Water Assessment Tool (SWAT) land use classification table as in Table 3. The area of every land use category was computed, and graphs are produced.

Table 3: The expected land use categories present in Langkawi Island		
LAND USE CATEGORIES	SWAT Code	Remark
Water	*WATR*	*Waterbodies*
Urban Low Density	*URLD*	*4 unit/ acre*
Urban Medium Density	*URMD*	*Up to 20 unit/ acre*
Urban High Density	*URHD*	*Up to 50 unit/ acre*
Urban Commercial	*UCOM*	*E.g: Business*
Urban Industrial	*UIDU*	*E.g: Factories*
Urban Transportation	*URTN*	*E.g: Airport*
Urban Institutional	*UINS*	*E.g: School*
Evergreen	*FRSE*	*Evergreen forest*
Wetland-Forested	*WETF*	*Mangrove*
Rice	*RICE*	*Paddy*
Row crops	*AGRR*	*Crop*

3.6 Functionality test

The ArcSWAT is the extension of ArcGIS which can be used for SWAT modelling. The classified land use map was added into ArcSWAT as one of the required data needed to run the SWAT modelling. The percentage of overlap between the generated land use map and the watershed boundary by the SWAT model must be 100 percent in order to pass the functionality test. The simplified methods are shown as a flowchart in Figure 2.

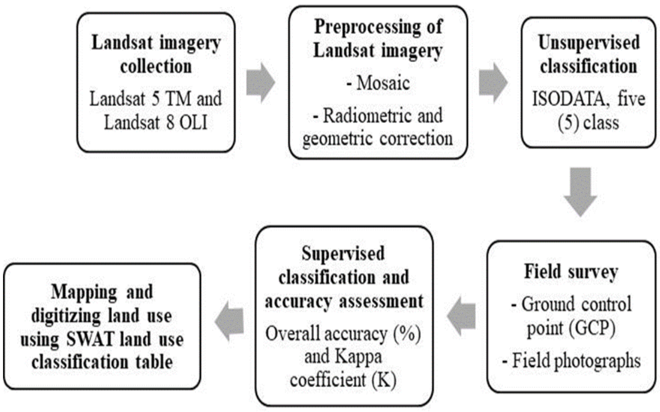

Figure 2: Flowchart of image processing and mapping

4. Results and Discussions

4.1 Analysis on the area of land use

The area of land use categories based on the unsupervised classification of Langkawi Island is listed in Table 4 and computed in Figure 3(A), Figure 3(B), Figure 3(C), Figure 3(D). The area of forest, water and paddy land use increase from 2006 to 2018. Meanwhile, the area of urban and crop land use increases from 2006 to 2014 but decreases afterwards. Subsequently, Figure 4(A), Figure 4(B), Figure 4(C) show the land use categorisation based on the SWAT land use classification in Langkawi Island in the year 2006, 2014 and 2018.

Table 4: The area of land use categories based on the unsupervised classification of Langkawi Island of the year 2006, 2014 and 2018.					
YEAR/LAND USE CATEGORIES	Area (ha)				
	Forest (FRSE)	**Urban (URLD, URMD, URHD, UINS, UIDU, URTN)**	**Water (WATR)**	**Paddy (RICE)**	**Crop (AGRR)**
2006	*24118.02*	*5438.25*	*728.82*	*794.97*	*4602.51*
2014	*24630.57*	*5463.9*	*592.83*	*1255.32*	*4790.25*
2018	*25253.71*	*5428.63*	*879.27*	*1261.17*	*4715.01*

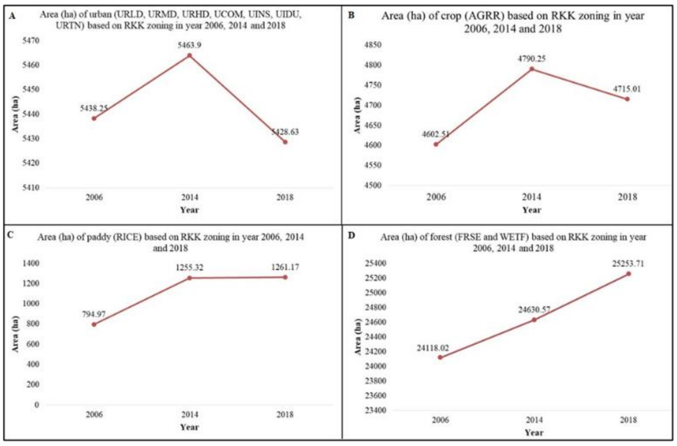

Figure 3: Area of land use categories based on the unsupervised classification of Langkawi Island: (A) Area of urban (URLD, URMD, URHD, UCOM, UINS, UIDU, URTN) based on the RKK zoning in the year 2006, 2014 and 2018; (B) Area of crop (AGRR) based on the RKK zoning in the year 2006, 2014 and 2018; (C) Area of paddy (RICE) based on the RKK zoning in the year 2006, 2014 and 2018; (D) Area of forest (FRSE and WETF) based on the RKK zoning in the year 2006, 2014 and 2018

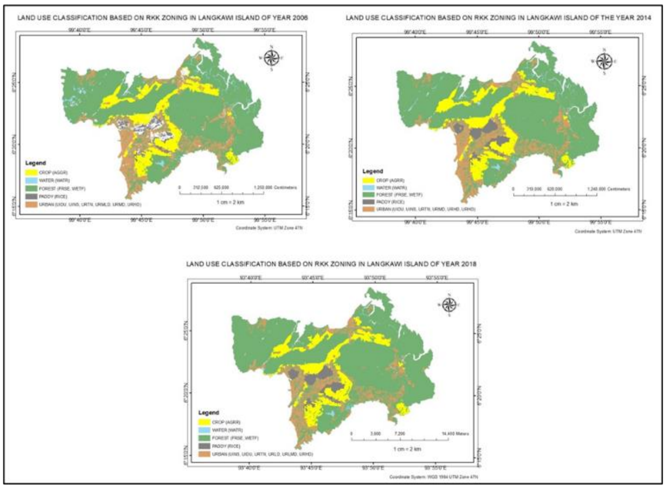

Figure 4: Land use categorisation based on the SWAT land use classification in Langkawi Island: (A) Land use classification based on RKK zoning in Langkawi Island of year 2006; (B) Land use classification based on RKK zoning in Langkawi Island of year 2014; (C) Land use classification based on RKK zoning in Langkawi Island of year 2018.

4.2 Urban

The area computed for urban land use which includes the residential area (URLD, URMD, and URHD), business (UCOM) institution (UINS), industrial (UIDU) and transportation (URTN) increase from the year 2006 to 2014. However, the area decreases from the year 2014 to the year 2018. This decrease in the area might be due to the detection of transitional areas by the satellite. The transitional area is defined as the area that is experiencing changes in its states which often occur within forests, and industrial and development areas. (Anderson et al., 2001).

4.3 Crop

The trends that are depicted for the crop is the same as urban, where the area of crop land use (AGRR) increases from the year 2006 to 2014 and decreases afterwards. The increase in the year 2014 compared to the year 2006 was due to the missing pixels resulting from the NDBI performed on the satellite image. The reflectance produced as the result of the NDBI is close to the value of the masked-out image, so it was classified within the unclassified class during the unsupervised classification. The area of land used for the crop is often mixed up with a small residential area. Therefore, it is difficult to accurately separate the land use land cover, which explains why the crop land use is taken as it is from the crop shapefile digitized from the Langkawi Development Plan. The crop category consists of plantation such as banana plant, rubber trees, and coconut trees.

4.4 Paddy

Paddy (RICE) land use increases throughout the years from 2006 to 2018. Generally, the paddy area is often flooded as the means for its cultivation. Furthermore, the paddy area in Malaysia is often accompanied with small parcel of a residential area which are scattered making the paddy land use consisting of the mixture of paddy and urban. Therefore, during the unsupervised classification, it was difficult to separate the other land use with the paddy within the paddy shapefile digitised from the Langkawi Development Plan. Hence, the same method applied for the crop was used for the classification of paddy. The paddy land use is taken as it is from the shapefile digitised. Nevertheless, in the subsequent years, the area for paddy land use is expected to increase as there are significant efforts done by Muda Agriculture Development Authority (MADA) to increase the paddy output within Langkawi as it aims to make glutinous rice as their signature product (Hifzudin and Hamzah, 2019).

4.5 Forest

Forest land use which includes the evergreen forest (FRSE), vegetation and forested wetland (WETF) shows increasing trend throughout the year. The forest in Langkawi Island is mostly contributed by the Mat Chincang and Mat Raya mountains. Langkawi Island also has a good amount of mangrove at its eastern side. Furthermore, some of the mangrove areas are made into an ecotourism site, for example, Kubang Badak Biogeotrail that comprises of mangrove ecosystem, geosites and cultural sites. This approach was done in order to protect the mangroves while making it into a new attraction in Langkawi Island. This effort was made possible through the cooperation of few organisation which are LADA, Langkawi Research Centre (PPL) and Koperasi Nelayan Sungai Kubang Badak Langkawi Bhd.

4.6 Accuracy assessment

The accuracy assessment for the supervised image of respective land use categories listed in Table 5 shows that most of the overall accuracies and Kappa coefficient are over 85 percent and 0.7000 respectively except for Crop in the year 2006 and Transportation land use in the year 2018. The minimum accuracy should be at a minimum of 85 percent. This is crucial when dealing with the land use and land cover data needed for the planning and management purposes (Anderson et al., 2001). However, there are two land use categories with a value lower than the minimum requirements. Despite that, the data is still of satisfaction since the other overall accuracies are consistent. This was supported as one of the requirements for the classification requires several categories of the classification to be of the same percentage with each other (Anderson et al., 2001).

Table 5: The accuracy assessment for land use classification based on RKK zoning for years 2006, 2014 and 2018

YEAR	Class	Category	Overall accuracy (%)	Kappa coefficient (K)
2006	*Urban*	*Housing*	*86.36*	*0.7878*
		Business	*95.00*	*0.9216*
		Industrial	*100.00*	*1.0000*
		Institution	*100.00*	*1.0000*
		Infrastructure	*100.00*	*1.0000*
		Recreation	*100.00*	*1.0000*
		Transportation	*100.00*	*1.0000*
	Vegetation	*Forest*	*100.00*	*1.0000*
		Paddy	*100.00*	*0*
		Crop	*84.00*	*0.7835*
2014	*Urban*	*Housing*	*85.714*	*0.7717*
		Business	*100.00*	*1.0000*
		Industrial	*100.00*	*1.0000*
		Institution	*90.00*	*0.8485*
		Infrastructure	*93.33*	*0.9000*
		Recreation	*94.44*	*0.9130*
		Transportation	*100.00*	*1.0000*
	Vegetation	*Forest*	*100.00*	*1.0000*
		Paddy	*100.00*	*0*
		Crop	*91.30*	*0.8838*
2018	*Urban*	*Housing*	*95.45*	*0.9259*
		Business	*90.00*	*0.8400*
		Industrial	*90.00*	*0.8450*
		Institution	*95.00*	*0.9216*
		Infrastructure	*100.00*	*1.0000*
		Recreation	*94.44*	*0.9155*
		Transportation	*75.00*	*0.6322*
	Vegetation	*Forest*	*100.00*	*1.0000*
		Paddy	*100.00*	*0*
		Crop	*91.30*	*0.8821*

4.7 Field survey

Several photographs were taken during the field survey to validate the land use present shown in Figure 5.

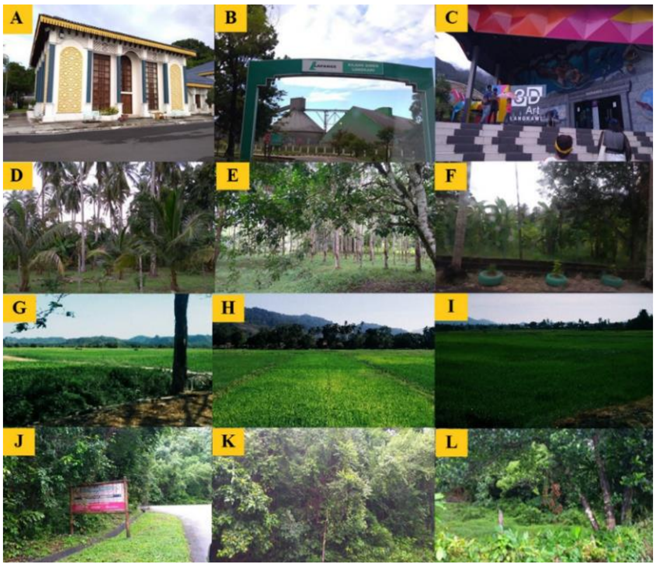

Figure 5: Field survey photographs to validate present land use categories In Langkawi Island. (A) Urban class: Business - Langkawi Craft Complex; (B) Urban class: Industrial - Lafarge Cement Sdn Bhd;(C) Urban class: Business - Art in Paradise Langkawi; (D) Vegetation class: Crop - Coconut trees; (E) Vegetation class: Crop - Rubber trees; (F) Vegetation class: Crop – Banana trees; (G, H, I) Vegetation class: Paddy; (J, K, L) Vegetation class: Forest – Gunung Raya Reserve forest.

4.8 Functionality test

Through the designation of the SWAT land use classification codes to the respective land use, the functionality of the land use map derived was tested into the HRU analysis in the SWAT model. It was found that the designation of SWAT land-use code was functional with the percentage of overlap 95.94 %.

5. Conclusion

The area of each land use was computed, and it was found that Langkawi Island is mostly represented by the forest, vegetation and mangroves. The land use class in Langkawi Island classified as business, housing, recreation, industrial, institution, infrastructure, transportation, paddy, crop and forest. These land use categories are then assigned with the SWAT land use classification code. Thus the designation of SWAT land use classification code to the respective land use can serve as the functional land use database of the Langkawi Island. The land use map can be used to consider the planning of land use in the future. For the future work, it is recommended to use higher spatial resolution of satellite imageries for the study the land use in Langkawi Island in order to produce a large scale map of land use.

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References

Anderson, J.R., Hardy, E.E., Roach, J.T., Witmer, R.E., 2001. A Land use and Land Cover Classification System for Use with Remote Sensor Data. Geological Survey Professional Paper 964. Retrieved https://www.nrc.gov/docs/ML1409/ML14097A516.pdf

Australian Collaborative Land Use and Management Program (ACLUMP). 2016. Land Use in Australia -At a Glance, 4. Retrieved from www.abares.gov.au/landuse.%0Ahttp://www.agriculture.gov.au/abares/aclump/land-use/publications#land-use

Carrion, D., Maffeis, A., Migliaccio, F., 2009. A database-oriented approach to GIS designing. Applied Geomatics, 1(3), Pp. 75–84. doi.org/10.1007/s12518-009-0008-y

Federal Department of Town and Country Planning. 2016. Integrated Land Use Planning Information System (i-Plan). Retrieved from http://iplan.townplan.gov.my/l4/web/landuse/statistics?negeri_id=04&tahun=2014

Halimaton, S.H., Sarah, A., Rahimah, A.A., 2011. Conservation with development: Showcasing Langkawi Geopark-an introduction. Planning Malaysia, 9, vi–x.

Hifzudin, I., Hamzah, O., 2019. Langkawi jadi pengeluar beras pulut. Retrieved from https://www.bharian.com.my/berita/nasional/2019/05/567854/langkawi-jadipengeluar-beras-pulut

Langkawi Development Authority. 2014. Naturally Langkawi. Retrieved from https://naturallylangkawi.my/wp-content/uploads/pdf/MICE.pdf

Langkawi Development Authority. 2019. Tourist Arrival Statistic. Retrieved from https://www.lada.gov.my/en/information/statistics/tourist-arrival-statistics?style=blue

Leman, N., Ramli, M.F., Khirotdin, R.P.K., 2015. GIS-based integrated evaluation of environmentally sensitive areas (ESAs) for land use planning in Langkawi, Malaysia. Ecological Indicators, 61, Pp. 293–308. https://doi.org/10.1016/j.ecolind.2015.09.029

Othman, P.P., 2011. The Impact of Tourism on Small Business Performance: Empirical Evidence from Malaysian Islands. International Journal of Business and Social Science, 2(1), Pp. 11–21.

Samat, N., 2010. Assessing land use land cover changes in Langkawi island: Towards sustainable urban living. Malaysian Journal of Environmental Management. 11. Retrieved from https://core.ac.uk/download/pdf/11491416.pdf

Villamizar, S.R., Pineda, S.M., Carrillo, G.A., 2019. The effects of land use and climate change on the water yield of a watershed in Colombia. Water (Switzerland), 11(2). https://doi.org/10.3390/w11020285

Xie, X., Gu, X., Yao, Y., Li, B., Wei, X., Jia, K., 2014. Land cover classification using Landsat 8 Operational Land Imager data in Beijing, China. Geocarto International, 29(8), Pp. 941–951. doi.org/10.1080/10106049.2014.894586.

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