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ASSESSMENT OF AHP FOR OPTICAL OBSERVATORY AND NEW MOON SIGHTING SITES IN PENINSULAR OF MALAYSIA

R. Umar[1], M. K. A. Kamarudin[1,*], N. A. F. Nik Wan[1], A. F. Ireana Yusra[1], H. Juahir[1], M. R. Razali[2] and A. I. Anuar[2]

[1]East Coast Environmental Research Institute, Universiti Sultan Zainal Abidin, Gong Badak Campus, 21300 Kuala Nerus, Terengganu, Malaysia

[2]Department of Surveying Science and Geomatic, Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA, 02600 Arau, Perlis, Malaysia

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ABSTRACT

The aim of this study is to select the best location for astronomical observations sites using Multi Criteria Decision Analysis integrated with Geographical Information System (GIS). To solve these problems, four factors were determined which are elevation or slope, road network, population density and land used. These factors were divided into two categories namely geographical and anthropogenic criteria. The factors were evaluated using Analytical Hierarchy Process technique and the weights of variables were determined. The study matched the layer on the optical observatory and moon sighting sites. As the result, this study showed the most suitable areas were located extensively in eastern and southern part of Peninsular Malaysia. However, the final decision of this study, site testing measurement will be required in these preliminarily selected areas.

Keywords: astronomy; geographical information system; analytical hierarchy process; observatory and moon sighting sites.

Author Correspondence, e-mail: mkhairulamri@unisza.edu.my

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1. INTRODUCTION

To decide the suitable area for build an optical observatory is a complex problem that involves some factors from various sources. This paper intends to analyze the current status for observatory and moon sighting sites in peninsular of Malaysia by using Multi Criteria Decision Analysis (MCDA) integrated with Geographical Information System (GIS). To solve these problems, four factors were determined which are Elevation or slope, road network, population density and land used. These factors were divided into two categories: geographical and anthropogenic criteria. These factors were evaluated using Analytical Hierarchy Process technique and the weights of variables were determined. The result of this study was shown the most of the suitable areas were located extensively in eastern and southern part of Peninsular Malaysia. This study also offers an accurate, cost and time effective procedure for preliminarily of site selection for an astronomical observatory. However, the final decision of this study, site testing measurement will be required in this preliminary selected area.

1.1. Study Area and Source of Data

The study area of this research is in peninsular of Malaysia which located near the equator. This country was divided into 2 regions which are Peninsular of Malaysia, Sabah and Sarawak. Sabah and Sarawak are called Borneo. Peninsular Malaysia had covered the southern half part of the Malaysia, which extends 740 km (460 mi) from north to south with the maximum width around 322 km (200 mi). However, the structure / area of the land were occupied by mountainous with more than half of it over 150 meters (492 ft) above sea level. Malaysia’s climate is denoted as equatorial, being hot and humid throughout the year and the average rainfall of this country is 250 centimeters (98 in) a year with the average temperature of 27 °C (80.6 °F) [1].

The climates of the peninsular and east Malaysia differ as it directly affected by wind from the mainland, and opposed to the more maritime weather of the east. Malaysia also has two monsoon seasons, which are the Southwest monsoon from late May to September and the Northeast monsoon from October to March. The Northeast monsoon brings in more rainfall affected than the Southeast monsoon, originating from China and the North Pacific for the Northeast monsoon whereas the Southeast monsoon originates from the deserts of Australia.

The transitions of these two monsoons will start from May and October.

In this study, we focused on the area of Peninsular Malaysia (Fig. 1) and had chosen four variables for selecting the suitable sites for astronomical observatory. The data can be used to categorize/separate into two groups, which are geographical and anthropogenic datasets. These groups of data will be explained in the following section. However, the source of data was also obtained from different agencies in Malaysia such as Malaysia Centre for Geospatial Data Infrastructure (MaCGDI), Department of Statistic Malaysia, and Department of Survey and Mapping Malaysia (JUPEM). The data included spatial and attribute data. The other sources of spatial data including topology maps for high places in Malaysia and the GIS maps were obtained from a previous study done by the researcher in Faculty of Arts and Social Sciences, University of Malaya [2].

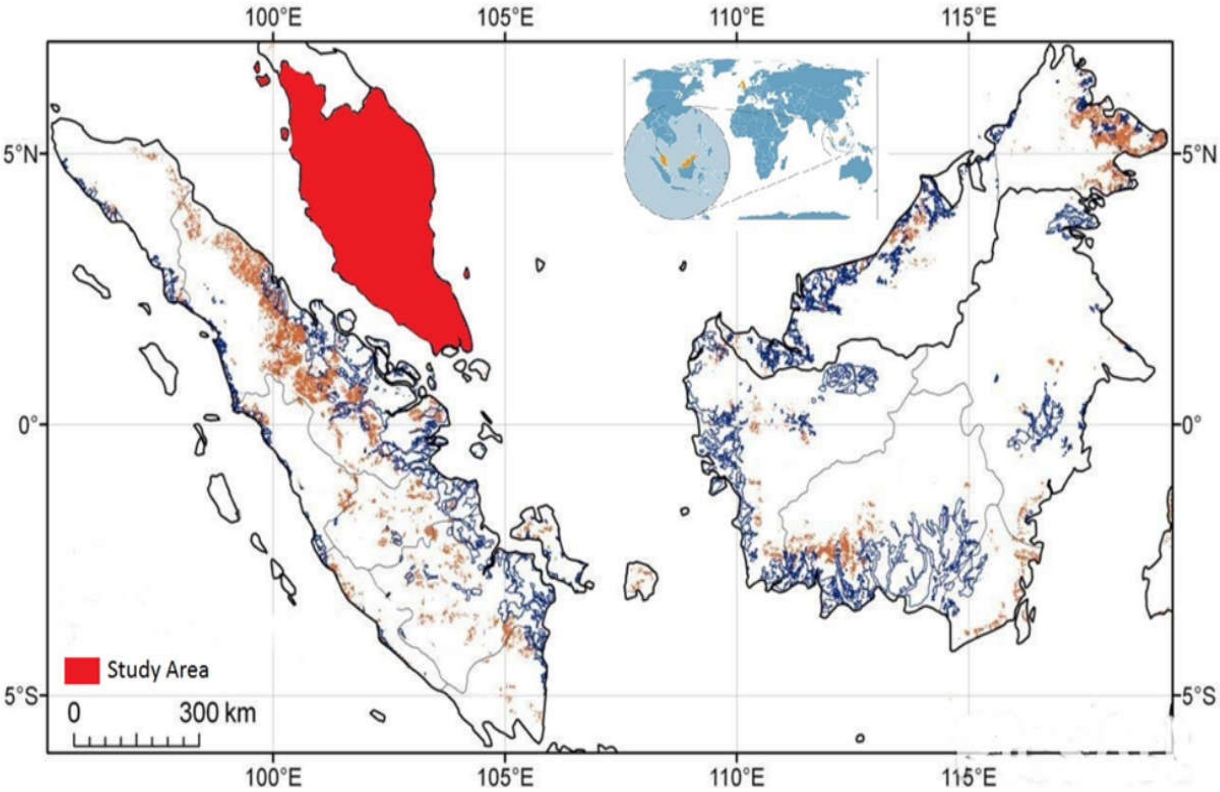


Fig.1. Location of study area

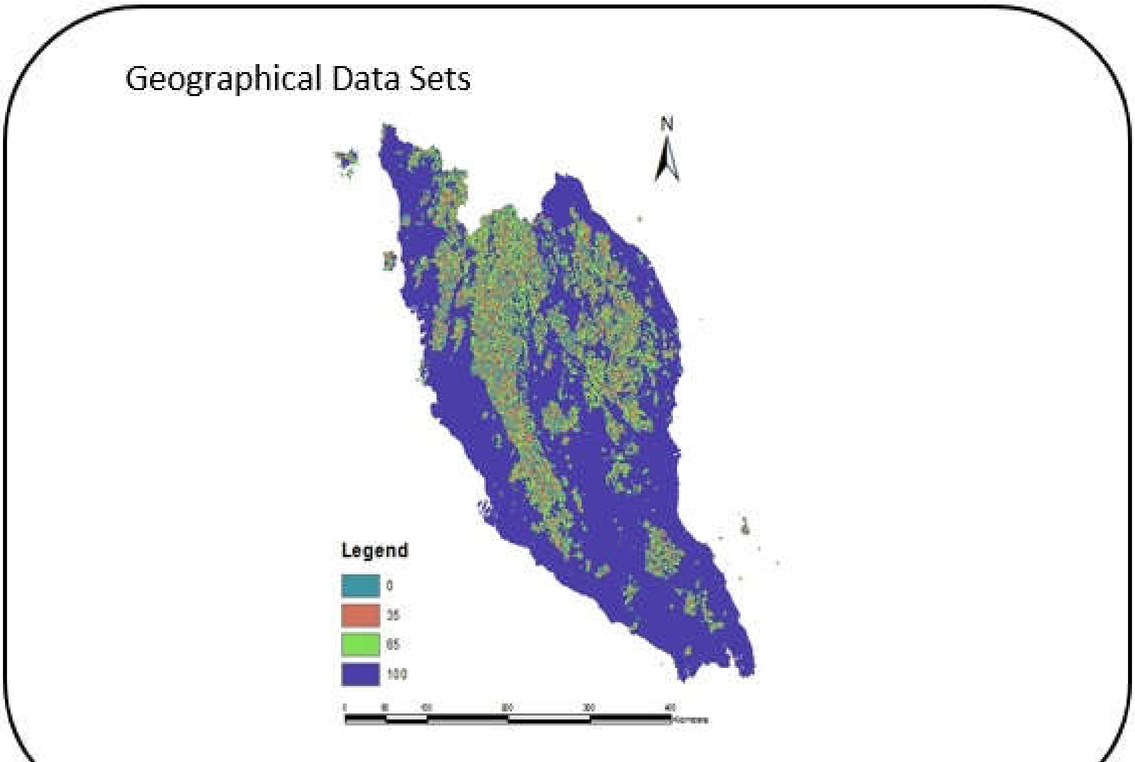
2. RESULTS AND DISCUSSION

Table 1 showed the variable of elevation or slope have the highest value 0.38 (38%) and followed by the variable of road network 0.27 (27%), land used 0.23 (23%) and population density 0.12 (12%). In conclusion, the decision makers decided the best factor that influence to build the astronomical observatory was elevation or slope in peninsular Malaysia. Therefore, the value of the variable elevation was higher than that of other variables.

Table 1. The weightage of each variable

Criteria	Weightage	Interest criteria	Interest Criteria (%)
Population density	0.49	0.12	12
Road network	1.06	0.27	27
Land used	0.94	0.23	23
Elevation/slope	1.52	0.38	38
∑=	4	1	100

After the analytic hierarchy process (AHP) is done. The next step is combined all layer using raster calculator in ArcGIS with the weightage value (Fig. 2). In this research, all variables will be combined to get the result for select the suitable sites to build an astronomical observatory. By using a location for observatory and *hilal* determine the location in Malaysia, we also pinpoint of latitude and longitude (Table 2 and 3) to see suitability of location.



(i)

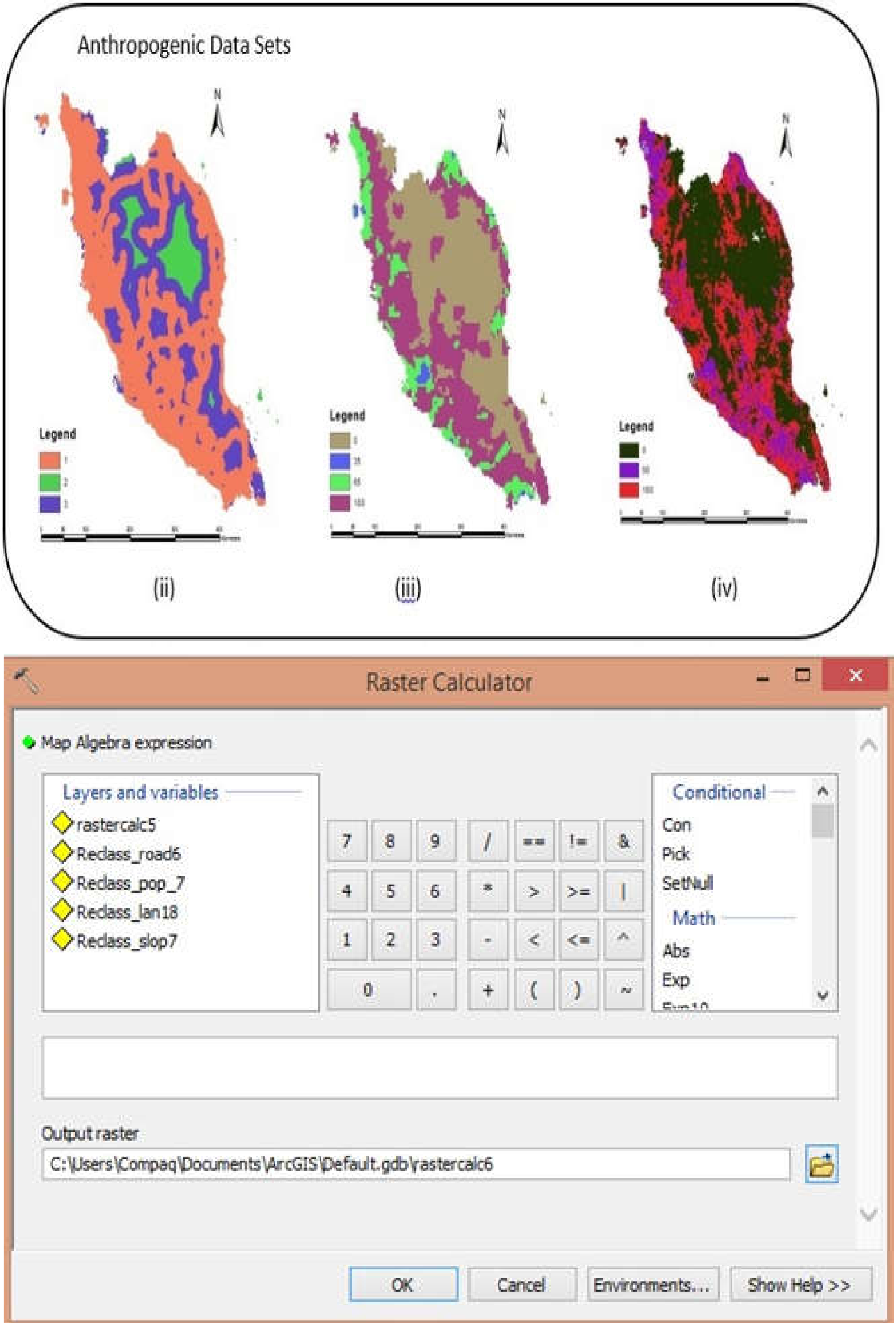


Fig.2. Raster calculation process

Raster calculation combined all variables to get the suitable sites to build an astronomical observatory in peninsular Malaysia. In this research, peninsular of Malaysia has more potential to build an astronomical observatory. The region represented a bright color with a value scale of 0, an area which is not suitable for build astronomical observatory, while the dark color are referred to suitable sites for build astronomical observatory with a scale of 100. We classified it into 3 groups which are A (0-35), B (36-65) and C (66-100) that represented not good, middle and good. We found that both locations (observatory and viewing location of the new moon) in Malaysia were still acceptable (Fig. 3). Based on the resultant map, most of the location located in group B and C. However, the government needs to take actions toward preventing the increasing of light pollution in the future especially from the residential area and city development.

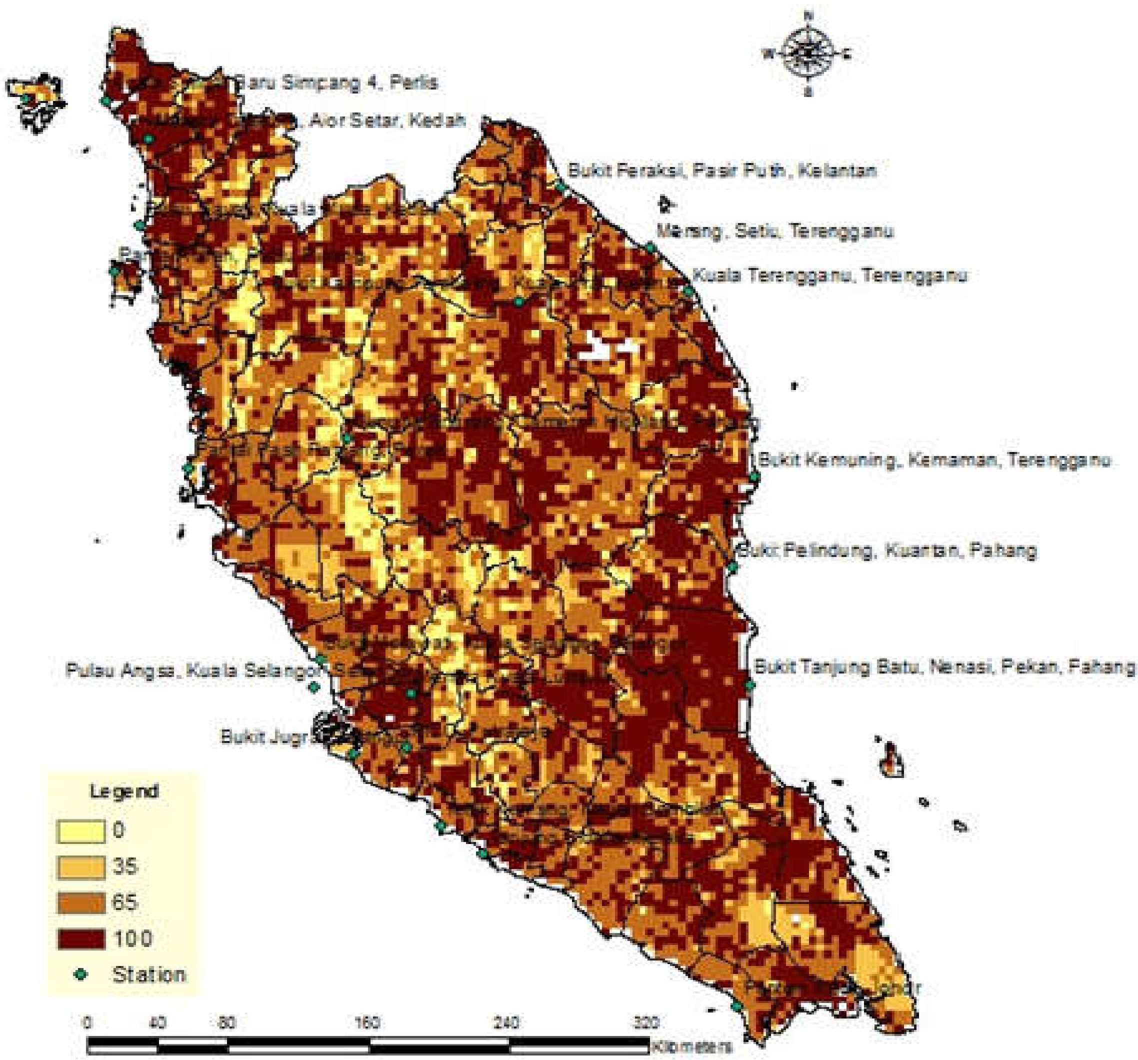


Fig.3. Final map produced

Table 2. List of *Balai Cerap* in Peninsular Malaysia

Site State	Location	Latitude	Longitude	Condition Area	Description
Terengganu	Merang, Setiu, Terengganu	5° 32' 09"	102° 56' 55"	Good	Located at the strategic area and far from residential area.
Melaka	Tanjung Bidara	2° 18' 00"	102° 05' 00"	Middle	Located near the sea
Negeri Sembilan	Teluk Kemang	2° 26' 44"	101° 51' 21"	Middle	Located near the sea
Kedah	Pemandangan Indah, Langkawi	6° 20' 11"	99° 44' 34"	Good	Located in the forestry area
Pulau Pinang	Pantai Acheh	5° 24' 44"	100° 09' 27"	Middle	Located in the forest area near the sea
Putrajaya	PICC	2° 51' 50"	101° 41' 21"	Middle	Located near the Lake
Selangor	Sungai Ayer Tawar	3° 49' 10"	101° 25' 07"	Good	Located near the vegetation area

Table 3. List of *Baitul Hilal* in Peninsular Malaysia

Site State	Location	Latitude	Longitude	Condition Area	Description
Johor	Pontian Kecil	1° 29' 15"	103° 23' 18"	Middle	Near the residential area
Pahang	Bukit Tanjung Batu	3° 12' 22"	103° 26' 48"	Good	Located near the sea and far from residential area

Pahang	Gunung Brincang	4° 31’ 04”	101° 23’ 03”	Middle	Located in the forestry area
Pahang	Bukit Pelindung	3° 49’ 53”	103° 21’ 46”	Good	Located near the sea and forestry area
Terengganu	Kuala Terengganu	5° 18’ 19”	103° 08’ 08”	Middle	Located at the top of Bukit Besar but it near from urban area
Terengganu	Bukit Kemuning	4° 19’ 03”	103° 28’ 00”	Good	Located near the Lake
Terengganu	Pulau Perhentian	5° 54’ 53”	102° 43’ 08”	Good	Located far from residential area
Kelantan	Bukit Peraksi	5° 51’ 32”	102° 29’ 03”	Good	Located near the sea
Kelantan	Bukit kampung Tembeling	5° 15’ 19”	102° 16’ 18”	Good	Located at the top of Bukit Tembeling, near the forestry area and far from residential area
Kelantan	Menara Perbandaran Kota Bharu	6° 07’ 18”	102° 14’ 12”	Middle	Located near river and urban area
Kuala Lumpur	Menara Kuala Lumpur	3° 09’ 11”	101° 42’ 19”	Good	Located in the Menara Kuala Lumpur
Selangor	Bukit Jugra	2° 50’ 10”	101° 25’ 07”	Middle	Located near the forestry area

3. METHODOLOGY

This study consisted of / was developed by four stages which are (i) determining the criteria and store in GIS (ArcGIS), (ii) data analyses, (iii) determining the weight of each criteria using AHP technique, (iv) aggregating the criteria and evaluating the result of final decision. The analysis process will be performed on / applied to the parameters such as elevation or slope, road network, population density and land used for deciding a suitability site in peninsular of Malaysia [3]. Then, each layer of this study will be represented in raster data format, where the vector layers were converted to raster data layers after performing the analysis and processes. The suitability value of all variables was converted into a common range (between 0 and 1) to make comparisons possible. At the end of the rescale operation for each variable, the value zero showed the slightest reasonable zones while the value one represented the most appropriate regions [4]. There are many techniques to apply GIS application such as in earthquake and river basin study [6-9].

In the next step, to select the impact of every criterion, the AHP technique was used by deciding the pair wise examinations with the learning of specialist. Finally, all variables/parameters were aggregated by multiplying of each criteria with the determined weight. The most suitable sites will be selected by applying a threshold to the resultant map. The basic scale of pair wise comparison is shown in Table 4.

Table 4. Basic scale of pair wise comparison

Intensity of Importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
2	Weak or slight	Experience and judgement
3	Moderate Importance	slightly favor one activity over another
4	Moderate Plus	Experience and judgement
5	Strong Importance	strongly favor one activity over another
6	Strong Plus	An activity is favored very

7	Very strong or demonstrated importance	strongly over another
8	Very, very strong	The evidence favoring one
9	Extreme importance	activity over another is of the highest possible order of affirmation

This study involves only an individual decision makers (Single Decision Maker) based on several criteria that have been identified. The value of scale provided by decision makers will apply in a matrix table to simplify the process of calculating the weights is shown in Table 5.

Table 5. Comparison of suitability variables in the matrix

Variables	A	B	C	D
A	1	1/3	1	1/5
B	3	1	1	1/3
C	1	1	1	1
D	5	3	1	1

Then, comparisons between variables were made by rows and columns. For instance, in line 1 compared with C1, C2, C3, C4, C5 and C6 respectively in columns A, B, C, D. If the same variables compared for instance C1 to C1 (C11), then the value is 1 so C2 to C2, C3 and C3, C4 and C4, C5 and C6 C5 and C6.

Table 6. The matrix table

Variables	A	B	C	D
A	1	0.3	1	0.2
B	3	1	1	0.3
C	1	1	1	1
D	5	3	1	1
$\sum$=	10	5.3	4	2.5

Other than that, the decision makers have to put the scale of the relative importance of each variable representing the suitability sites to build the astronomical observatory (Table 6). Then a comparison of variables in the matrix table (Table 6) eases the process of calculating the weighting variables. Next, the number of each variable must be converted to a decimal form for getting the average of each column. Then, the scale for each column variable interest will be calculated using the following formula vertically.

$$\sum AC = C1 + C2 + C3 + C4 = 1 + 3 + 1 + 5 = 10 \tag{1}$$

In the next steps, the decision makers must find the value of the ratio (R) for each variable. Then the value of ratio was provided by dividing the scale of importance of the variable with the total scale of the variables for each column as follows.

$$R = \frac{C11}{\sum C} = \frac{1}{10} = 0.1 \tag{2}$$

Then, to get the value of weightage (W) for each variable the decision makers must get the total of each variable by lines. Then, this amount will be divided by the number (N) variable suitability of 4.

$$\begin{aligned} W &= \frac{\sum C}{N} \\ &= C1 + C2 + C3 + C4 \\ &= 0.1 + 0.06 + 0.25 + 0.08 \\ &= \frac{0.49}{4} \\ &= 0.1225 \end{aligned} \tag{3}$$

4. CONCLUSION

The present study has successfully evaluated the assessment [10-12] of AHP for optical observatory and new moon sighting sites in peninsular of Malaysia. As the result, this study showed the most suitable areas were located extensively in eastern and southern part of Peninsular Malaysia. However, the final decision of this study, site testing measurement will be required in these preliminarily selected areas.

5. ACKNOWLEDGEMENTS

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