An Integrated Approach of Analytical Hierarchy Process and GIS for Site Selection of Urban Parks in Iskandar Malaysia

Rasli, F. N.,[1] Kanniah, K. D.,[1,2*] Muthuveerappan, C.[3] and Ho, C.S.[4]
[1]Department of Geoinformation, Faculty of Geoinformation and Real Estate, Universiti Teknologi Malaysia 81310 Skudai, Johor Darul Takzim, Malaysia, E-mail: kasturi@utm.my
[2]Centre for Environmental Sustainability and Water Security, Research Institute for Sustainable Environment Universiti Teknologi Malaysia, 81310 Skudai, Johor Darul Takzim, Malaysia
[3]Centre of Real Estate Studies, Faculty of Geoinformation and Real Estate, Universiti Teknologi Malaysia 81310 Skudai, Johor Darul Takzim, Malaysia
[4]Low Carbon Society Centre, Faculty of Built Environment, Universiti Teknologi Malaysia, 81310 Skudai Johor Darul Takzim, Malaysia
**Corresponding Author*

Abstract
Rapid urbanisation with increasing population, transportation and industrial activities are responsible for many environmental problems including global warming and climate change. Increasing green spaces in cities was among various formulated strategies to curb the issue, which can help to reduce the urban temperature by absorbing atmospheric carbon dioxide (CO_2) and providing thermal comforts. The objective of this study is to find suitable locations for developing urban parks in Iskandar Malaysia (IM), as since its establishment in 2006, IM has been undergoing rapid urbanisation and high demand in varieties of sectors which lead to high emission of greenhouse gases (GHG) and high temperature in the area. In this study, the guidelines set by the Department of Town and Regional Planning (JPBD) Peninsular Malaysia are used to integrate parameters such as park size, distance from main roads and topography for selecting suitable areas for parks development in IM. An integrated approach combining Analytical Hierarchy Process (AHP) and Geographic Information Systems (GIS) is adopted to provide weightages for each of the parameter layer by providing scoring and ranking to each parameter and conducting weighted overlay analysis to identify suitable locations for six different types of parks. In the final site suitability map, it reveals that although 623 areas show high suitability for park development, only 27 of them lie near the water bodies where all the water bodies in this study consist of rivers. Based on the obtained results, these locations can be proposed to the Municipal Councils in IM for development of new parks. The parks within the cities can act as a very good medium of cooling with the presence of trees to store and sequester excess CO_2 and the presence of water bodies to reduce the ambient air temperature. However, the final decision to consider these suitable locations for future developments of parks still depends on the local authorities.

1. Introduction

Rapid urbanization in association with deforestation, fossil fuels burning, industrial and transportation activities especially in the developing countries (including Malaysia), has significantly increased the greenhouse gases (particularly the atmospheric CO_2 contents) and air temperature (United Nation, 2015). The global concentration of CO_2 has recently risen up to 400.47 parts per million (ppm) as of June 2015 from 379.87 ppm in June 2005 (NASA, 2015), thus, showing an increment of 20.6 ppm in a decade. The urbanization processes in these countries are inevitable, and hence will continue as it is anticipated that by 2050, developing and developed areas will cover 64.1% and 85.9% of the world respectively (United Nation, 2015). Increasing population along with growing transportation and industrial activities are the major sources of greenhouse gas (GHG) emissions. In Malaysia, urban area transportation activities alone have resulted in approximately 49% of the total GHG emissions (Lim and Lee, 2012). Increased GHG emissions in the urban environment has resulted in elevated surface and air temperature and decreased thermal comforts for people with the increasing population of 7.349 billion (United Nation, 2015, Kanniah et al., 2013a and Sheikhi et al., 2015), Malaysia is currently a developing country where rapid urbanisation and transformations are taking place. Malaysia aims to become a high income nation that is both developed and sustainable by 2020 (UTM- Low Carbon Asia Research Centre, 2014). One of the rapid development economic regions is Iskandar Malaysia (IM) which is located in Johor, southern part of Peninsular Malaysia (Figure 1). IM was established in November 2006 and currently adopting low carbon concept as its direction of development to achieve the goal of building a sustainable society. The rapid economic development and urbanisation in IM is expected to increase CO_2 to 31.3 $MtCO_2eq$ in 2025 from 11.4 $MtCO_2eq$ in 2005 under the business as usual scenario (UTM- Low Carbon Asia Research Centre, 2014). Nevertheless, the emission can be reduced by 31% with appropriate counter measures (Ho et al., 2013). Integrating green and blue infrastructures in the planning of new cities can help to reduce the effect of high urban surface temperature and excessive CO_2 concentration in the atmosphere (Kanniah et al., 2013b). Planning green areas or parks with trees, shrubs and water bodies in the city can serve many purposes such as providing shade that brings cooling effect which saves energy, and reduces pollution, thus improving air quality, etc. (Konijnendijk et al., 2013). IM covers an area of approximately 221,634 hectares (2,216.3 km^2). The existing open space in IM is 6,199 hectares covering only 3% of the total area. If all the open spaces were developed as green space in accordance with the existing population of 1.35 million people, the ratio of people to the open space will be 46 m^2 per person. Although this ratio has surpassed Hong Kong, Singapore and Kuala Lumpur with 2, 8 and 11 m^2 respectively, it is very low compared to Melbourne which has 80 m^2 per person. Hence, there is a need to increase the green area in IM as looking at the current trajectory of population growth; the amount of green space per person will be further reduced by 2020. Therefore, in this study, we attempt to identify suitable locations that can potentially be developed into urban parks in IM. In order to develop these parks, the location of the park must be given a high priority as strategically located park (close to main roads, easy access to public transportation, near to densely populated areas, flat terrain etc.) will be well utilized by the communities to maximize its usage. For these purposes, various spatial analysis tools are available for site selection studies. In site selection studies, various existing tools mostly use integration techniques rather than a single technique for producing better results. Examples of integrated techniques used in site selections are Weighted Linear Combination (WLC) and Spatial Cluster Analysis (SCA) (Moeinaddini et al., 2010), integration of multi-criteria decision making (MCDM) with GIS (Sharifi et al., 2009 and Eskandari et al., 2015), GIS and remote sensing (Oikonomidis et al., 2015, Breeze et al., 2015 and Razak et al., 2015), GIS and WLC (Jafari et al., 2015), new Spatial Multi Criteria Decision Making (SMCDM) and WLC (Mousavi et al., 2014), system based GIS and Multi Criteria Decision Analysis (MCDA) (Qaddah and Abdelwahed, 2015 and Hazra and Acharya, 2015), web- based GIS and MCDA (Niaraki and Malczewski, 2015a), MCDA and GIS in Multicriteria Spatial Decision Support System (MC-DSS) (Niaraki and Malczewski, 2015b), GIS and Fuzzy MCDM (FMCDM) (Chang et al., 2008 and Latinopoulos and Kechagia, 2015), FMCDM and Fuzzy AHP (Hamdani and Wardoyo, 2015), AHP, GIS and Maximal Covering Location Problem (MCLP) (Allahi et al., 2015), Analytical Hierarchy process (AHP), GIS and remote sensing (Pinto et al., 2015), GIS and AHP (Wang et al., 2009, Jalaliyoon et al., 2015, Aliniai et al., 2015, Hadipour et al., 2014, Mishra et al., 2015, Kamali et al., 2015, Foroughian and Eslami, 2015, Ebrahimi et al., 2015, Siddayao et al., 2015, Mustafa et al., 2015, Khaki et al., 2015 and Ahmadi et al., 2015) etc. The combination of multi criteria evaluation with GIS has recently become a popular tool for different site selection studies (Uyan, 2013). Being attractive to urban planners (Ullah and Mansourian, 2015), the technique has been used for supporting spatial decision making (Erden and Coskun, 2010) especially in regional planning (Qaddah and Abdelwahed, 2015), and it is the most commonly used expert- based method (Svoray et al., 2015). AHP is one of the multi criteria evaluation techniques that have been widely accepted by industries (Jalao et al., 2014) for solving support decision systems (Uyan, 2013). AHP enables the calculation of relative weight or importance of each of the parameters considered in the analysis by comparing the parameters to each other (Saaty, 2008 and Nefeslioglu et al., 2013). Both qualitative and quantitative measures can be considered in the process of selecting the best alternative from a number of choices of multiple criteria (Erden and Coskun, 2010). The criteria of land- use planning can be set in an organized way based on existing data with simple mathematical operations. AHP allows individual judgments in a reliable way and can finally overlay all the standardized criteria that help to make rankings based on locations (Ullah and Mansourian, 2015). As GIS is widely known as a powerful tool for its spatial analysis capabilities (Wang et al., 2009) and increase the efficiency of siting (Zamorano et al., 2008), the integration of GIS and AHP methods provides a mechanism to thoroughly explore complicated problems and provide immediate and efficient feedback for users especially the decision makers. Based on these considerations, this paper focuses on combining AHP with GIS for the most suitable and appropriate site selection of urban parks in IM. Such studies have not been attempted in Malaysia thus; this paper focuses on six types of parks using parameters based on guidelines of Department of Town and Regional Planning, Malaysia. The results of this study will produce the outputs of more types of specific parks that can be developed in urbanized IM.

2. Methodology

2.1 Study Area

Iskandar Malaysia (IM) was established on 8th November 2006 and geographically, it covers the districts of Kulai, Johor Bahru, Johor Bahru Tengah, Pasir Gudang and several sub- districts of Pontian with five local authorities (Figure 1). IM has a tropical climate with warm weather all year round and consistent rainfall, more towards the year-end. It has temperature ranging from 21°C to 32°C while annual rainfall varies from 2,000 mm to 2,500 mm (Source: Malaysia Meteorological Department). The main landcover/landuse in IM includes forest, mangrove, oil palm, rubber and urban areas (Kanniah et al., 2015). IM had 1.35 million people in 2005 and it is projected to have 3 million people in 2025. About 66% of the population is of working age. The urban developments within IM are carried out at five flagship zones, A, B, C, D and E (Figure 1). These flagship zones cover Johor Bahru City Centre, Nusajaya area, the Western Gate Development covering Port of Tanjung Pelepas, the Eastern Gate Development covers Pasir Gudang area especially Tanjung Langsat Port and Johor Port and Senai-Skudai area, respectively. Apart from five local authority's administration, the IM developments are also managed by Iskandar Regional Development Authority (IRDA). For site suitability analysis, the entire IM region is covered and analysed. However, the seashore region of Pontian was not covered as the seashore is mainly covered by mangrove forests.

2.2 Data

The data and methodology adopted in this study are shown in Figure 2. The landuse was acquired from Iskandar Regional Development Authority (IRDA), and Department of Town and Regional Planning (JBPD). Besides landuse data, we also obtained main road and contour lines data from IRDA, Johor. To represent the accessibility to green spaces, distances to main roads were created using 'buffer' tool. We created buffer zones at 100 m interval up to 10,000 m or 10 km around the main roads. 100 m interval was used in this study because it is an appropriate walking distance. The contour lines were obtained from the GPS survey conducted by IRDA in 2010. The contour ranges between 20 m and 640 m with 20 m interval. Using the Spatial Analyst tool in ArcGIS, contour lines were transformed to Digital Elevation Model (DEM) and then the slope map. The slope values were auto-generated and values produced are from 0 degree to 20.95 degrees as the highest slope.

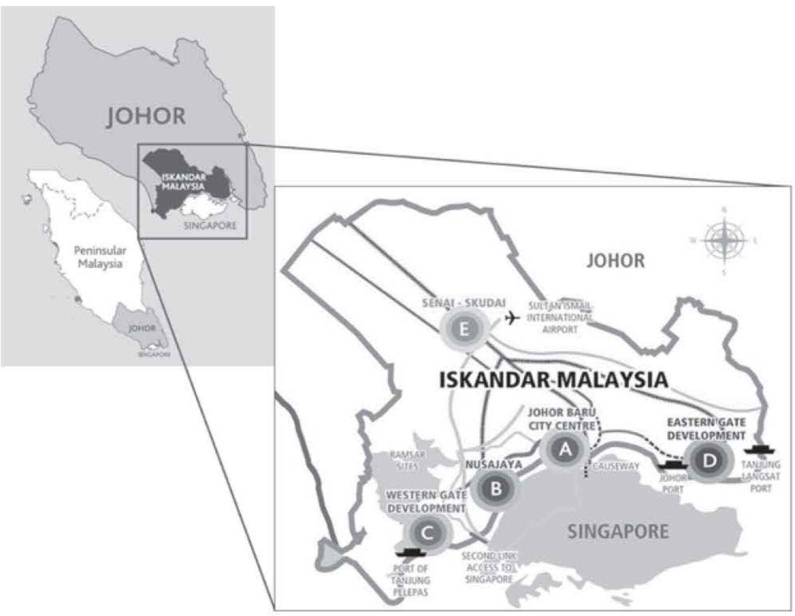

Figure 1: Iskandar Malaysia region in Johor, Peninsular Malaysia with the five flagship zones (UTM Low Carbon Asia Research Center, 2013)

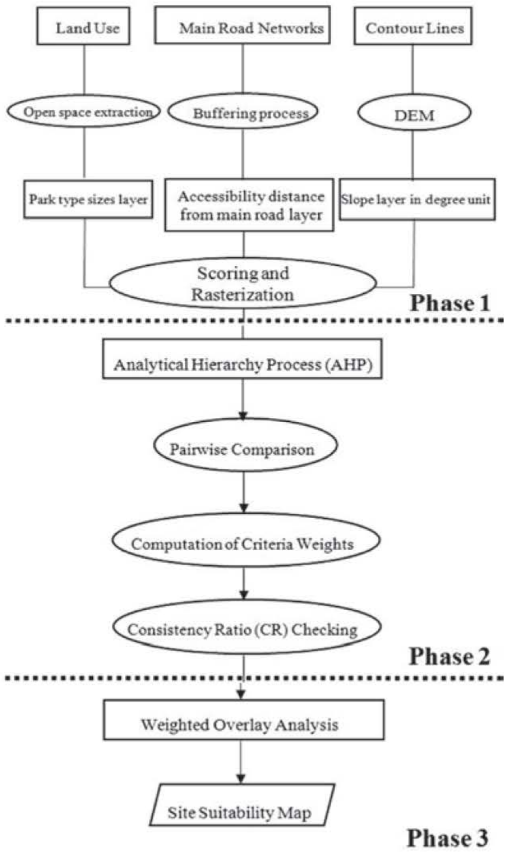

Figure 2: Methods used to identify suitable sites for urban parks development in Iskandar Malaysia

2.3 Site Selection

The park types and the selection of parameters were considered according to the JPBD guidelines (JPBD, 2013). According to this guideline, Recreation Park, Playground Lot, Playground Park, Neighbour Park, Local Park and Urban Park are recognized as park types. In addition, parameters such as population size, area size, accessibility distance from the main road and slope of the area were considered for park size selection in Malaysia (Table 1). However, we could not incorporate population size in this study as recent data were not available for this region. For the final map production, water bodies' data layer was later added to find the area near to waterways which can provide more cooling effect to the parks. This water bodies' data was extracted from the IM landuse data.

2.4 Phase 1: Data Processing and Analysis

The landuse data were geo-referenced using the ArcGIS version 10.0 catalogues, registered and projected to Cassini coordinate system. The Cassini coordinate system was used in this study to ensure that the study area was preserved and no distortion occurs which can lead to inaccurate results. The data were provided in shape file format and consists of 12 layers as follows:1) planned commercial, 2) open space and recreational, 3) institutional and public facilities, 4) infrastructure and utility, 5) industrial, 6) housing, 7) water bodies, 8) forests, 9) vacant lands, 10) commercial services, 11) transportation, and 12) agricultural and residential layers. In this study, only one layer named 'open space and recreational layer' was used for locating parks in IM. Using this layer and based on JPBD guidelines, only those areas with size from 1,000 m^2 to 1,000,000 m^2 were selected. This layer was subsequently filtered to create six new layers according to the type of parks as shown in Table 1.

Table 1: Parks with their respective sizes, accessibility distances, slope and population size

Types of Park	Accessibility Distance from Main Road (m)	Slope (°)	Population Size (people)
Recreation Park (1,000- 2,000 m^2)	200	7 (4%)	< 300
Playground Lot (2,000- 6,000 m^2)	500	7 (4%)	300-1000
Playground Park (6,000- 20,000 m^2)	1000	7 (4%)	1000-3000
Neighbour Park (20,000- 80,000 m^2)	1500	11 (6%)	3000-12000
Local Park (80,000- 400,000 m^2)	3000	11 (6%)	12000-50000
Urban Park (400,000- 1,000,000 m^2)	10000	No Limit	>50000

Table 2: Scores given to accessibility distance from main roads and slopes

Intensity Value	Intensity of Importance	Buffer Accessibility Distance From Main Roads (Meters)	Slope Degree (°)
9	Highest	0-100	1-2
8	Very High	100-150	3-4
7	High	150-200	5-6
6	Moderate High	200-250	7-8
5	Moderate	250-300	9-10
4	Moderate Low	300-350	11-12
3	Low	350-400	13-14
2	Very Low	400-450	15-16
1	Lowest	> 500	> 16

The cell sizes were set to a minimum unit of 10 m x 10 m to ensure maximum details on the ground can be included in the analysis. The layers were rasterized for further processing using Analytical Hierarchy Process (AHP) as described in Phase 2 (Figure 2). After rasterizing the layers and before applying AHP, it is important to decide suitable scoring or ranking values to all the three criteria. This step was done by reclassifying the rasterized layers of the park size, accessibility distance from main roads and slope into nine Saaty values. This scoring or ranking is important because it determines the value of the raster pixel and these pixels will determine the suitability index. The higher the score or rank value, the better the suitability of the pixels for parks (Saaty, 2008). For the size parameter, we did not provide any scoring value of parks because according to the JPBD guidelines, the size of parks was fixed, therefore they were already classified into their own hierarchy and they were given a score of 9 (highly suitable). Table 2 shows the scoring and ranking given to distance from main roads and slope for park site selection in this study. Scoring or ranking for distance from main roads and slope were done based on the judgment that the most suitable condition is ranked as 9 while 1 is ranked as the least suitable condition. Regarding slopes, it is clear that 1° to 2° has the highest score and 20.95° has the lowest score. Flat areas were given highest score and are highly considered for park development whereas steep slopes are usually not considered for park development (Washington Interagency Committee for Outdoor Recreation, 2005). Although JPBD have set the maximum distance and slope allowed for parks development, the parameters were slightly adjusted as tabulated in Table 1. This is because the nearer the parks are from the main roads, the better it is for users to access the parks (Figure 3a) as flat surface will be better location for parks (Figure 3b). The next step was to compare the relative importance of the three parameters (pairwise comparison) in determining suitable locations for parks development in IM using AHP.

2.5 Phase 2: Analytical Hierarchy Process (AHP)

In order to identify the best locations that can satisfy the conditions based on size, accessibility distance and slope for each of the six types of parks considered in this study, Analytical Hierarchy Process (AHP) method was applied. AHP is a multi-criteria decision making (MCDM) method under the fuzzy logic technique used to determine the priority of criteria. AHP is suitable for complex decisions which involve the comparison of decision criteria which are difficult to quantify (Saaty, 2008). Table 3 shows the comparison value used to compare the relative importance of each criterion in AHP. The relative importance of each of the three parameters was identified using 'trial and error' method by using any value from 1 to 9 in AHP. The pairwise comparison (Table 4) was run until it satisfies the consistency ratio (CR) value of 0.1 (Kumar and Biswas, 2013). A consistency ratio (CR) is needed in order to ensure that the judgment is logical. In AHP tool of ArcGIS version 10.0, the CR value has been set with values of <0.1 for accurate and significant result. The computation of pairwise comparison produced the Pairwise Comparison Matrix (Table 5). To develop a pairwise comparison matrix, different criteria are required to create a ratio matrix. These pairwise comparisons are taken as input and produced relative weights for each criterion for the output. This step was conducted by the trial and error method by using any value from 1 to 9 and conducted six times for six different types of parks. In this study, the CR was 0.0279 and thus the pairwise comparison matrix was accepted as a logical judgment. The criterion weight values from the pairwise comparison matrix are 0.6586, 0.1562 and 0.1852 for the park size, buffer and slope respectively. The criterion weight acted as the percentage influence which became 66%, 16% and 18% for park size, buffer and slope respectively. These percentage influence values were inserted on each criterion map in the process of weighted overlay analysis.

2.6 Phase 3: Weighted Overlay Analysis

At this phase, all the criteria maps in raster format were overlaid onto each other in Weighted Overlay Tool in ArcGIS version 10.0. The process was conducted six times for each type of park. The percentage influence of each criterion produced from the AHP process was then summed up giving the total of 100%. The output of this process is the result for site suitability analysis. In this study, the results produced two ranges of index consisting of more suitable and less suitable areas.

3. Results and Discussions

3.1 Suitable Locations for Urban Parks

Potential areas suitable for parks development in IM are shown in Figure 4. Areas marked as less suitable show <50% suitability which means these areas are still suitable to be developed as parks but some criteria's were not satisfied. For example, if the size satisfies the criteria for park development, but the surface is steep or far away from the main road, then it will be difficult for users to access the parks. All the three processed layers consisting of six park sizes, buffer roads, and slope were converted from vector to raster mode.

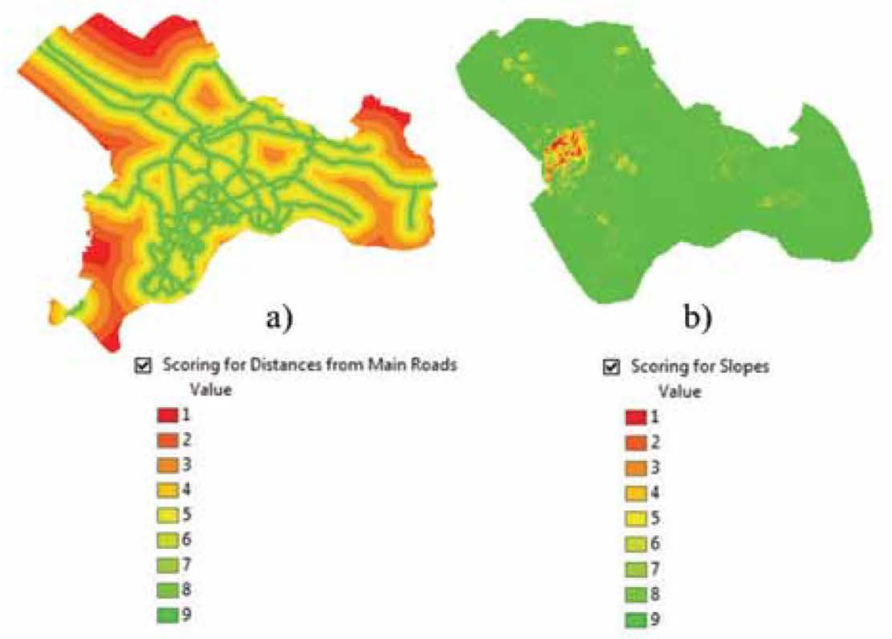

Figure 3: (a) The intensity value (scores) of the classified and rasterized main roads of Iskandar Malaysia; and (b) The intensity value (scores) of the classified and rasterized slopes of Iskandar Malaysia (refer Table 2 for more details)

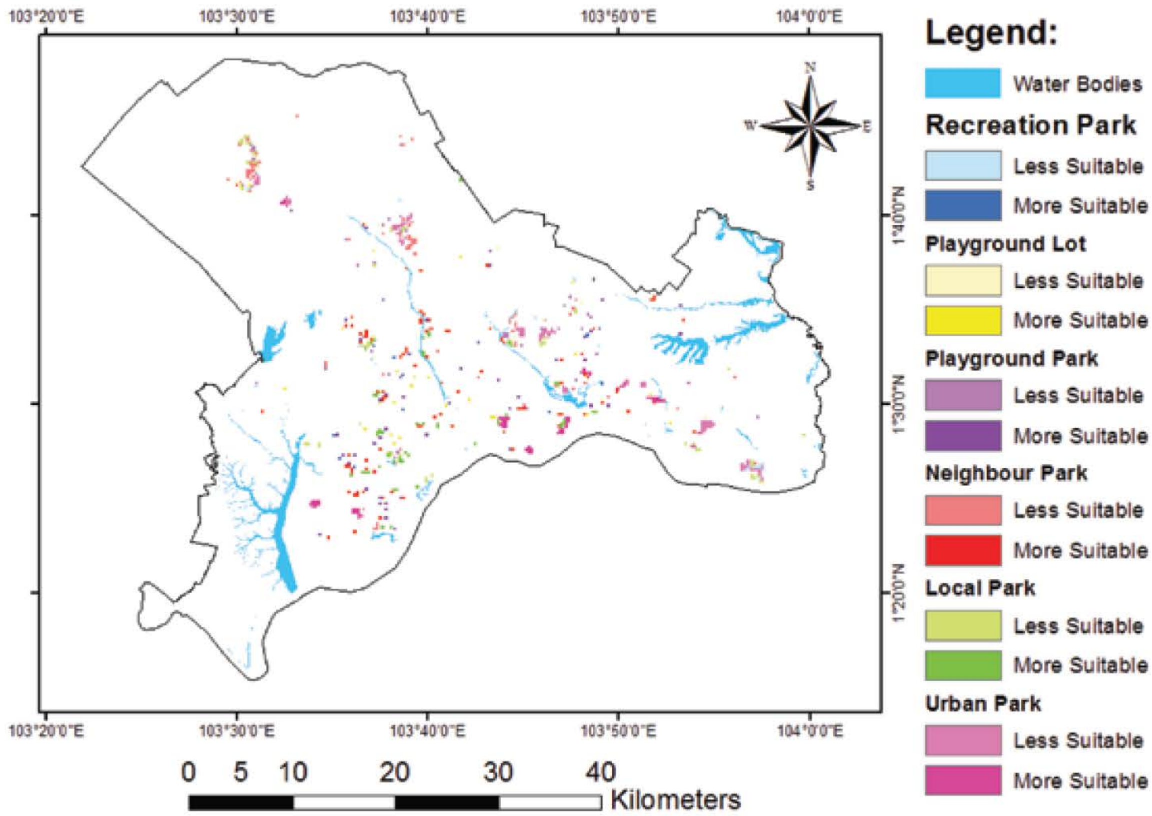

Figure 4: Final site suitability map for Iskandar Malaysia

Table 3: Comparison values of the relative importance of site suitability based on Saaty (2008)

Intensity of Importance	Descriptions of Intensity of Importance
1	Equal importance
2	Equal to moderate importance
3	Moderate importance
4	Moderate to strong importance
5	Strong importance
6	Strong to very strong importance
7	Very strong importance
8	Very to extremely importance
9	Extreme importance

Table 4: The pairwise comparison of size, slope and buffer accessibility distance

Criteria	Comparisons
Size	Size is five (5) times important than buffer
Slope	Size is three (3) times important than slope
Distance	Slope is one (1) time important than distance (equally important)

Table 5: The pairwise comparison matrix

Criteria	Park Size	Buffer	Slope
Park Size	1	5	3
Buffer	0.2	1	1
Slope	0.3333	1	1

Meanwhile 'more suitable' areas represent the highly suitable areas that get high score for each of the three (3) criteria used in this study. In the final site suitability map, it reveals that although 623 areas show high suitability for park development, only 27 of them lie near the water bodies where all the water bodies in this study consist of rivers (Table 6). There are 27 numbers of open space in IM identified as suitable to be developed as recreation parks from which 16 of them are less suitable and the rest are categorised as more suitable (Figure 4). However, from the 27 suitable areas for recreation parks, only one area (less suitable) was found to lie near the water bodies. We overlaid water bodies' layer onto the final suitability map to identify areas that lie near the natural water bodies within 100 meter. Water bodies data were added later as an additional layer to identify linear urban parks that can add cooling effect to the parks. Water bodies are excellent medium of cooling as the presence of water bodies in parks has been found not only to reduce the surrounding temperature (Tominaga et al., 2015), but also strongly influences environmental psychology, landscape design, tourism research and human health (Völker and Kistemann, 2011). A total of 41 areas of open space were found to be suitable as playground lots in the first place after the analysis where 27 of them are more suitable whereas the rest of 14 are less suitable (Table 6). From these areas, only one of less suitable and one of more suitable lie near water bodies. For playground parks 90 areas of open space were found to be suitable. 41 of them are less suitable and 49 are more suitable. Out of this number only six with less suitable and two areas with more suitability were found to be near to water bodies. Next, Neighbour Park produced 174 areas of open space as suitable areas out of which 80 have less suitability and the rest with more suitability. In this result, there are 4 of less suitability and only 1 of more suitability that are found near water bodies. There are 128 areas of open space that are suitable to be developed as local park whereas 70 of them are less suitable and 58 are more suitable. But only 5 of less suitability and 3 of more suitability are near the water bodies. Lastly, for urban parks, 164 areas of open space were found to be suitable. 97 of them are less suitable and 67 are more suitable. Out of this number only 3 with less suitable and 1 area with more suitability were found to be near to water bodies (Figure 4 and Table 7). In the final site suitability map, it was revealed that although 623 areas show high suitability for park development, only 27 of them lie near the water bodies where all the water bodies in this study consist of rivers. This shows that there are less suitable areas for parks near water bodies in IM. Alternatively artificial water bodies such as fountains or ponds can be constructed but the process of constructing these features can contribute to pollution and increase the temperature with the use of materials such as bricks, steel and cement.

Table 6: Number of parks identified as less suitable and more suitable in Iskandar Malaysia

Parks	Less suitable	More suitable	Less suitable area near water bodies	More suitable area near water bodies
Recreation Parks	16	10	1	0
Playground Lots	14	27	1	1
Playground Parks	41	49	6	2
Neighbour Parks	80	94	4	1
Local Parks	70	58	5	2
Urban Parks	97	67	3	1

Table 7: Park areas that are still available for further development as of December 2014

Type of Parks	Coordinate	Description
Playground Lot	1°28'50.65"N 103°52'51.58"E	Located in Masai area which is quite near Pasir Gudang Highway and situated near Masai river
Playground Park	1°30'1.70"N 103°41'9.01"E 1°35'13.45"N 103°53'11.89"E	Located in Tampoi which is quite close to Persisiran Perling and near to Sekudai river Located in Ulu Tiram town and near the Tiram river
Neighbour Park	1°29'3.65"N 103°47'12.28"E	Located in Plentong and near the EDL Highway
Local Park	1°32'34.73"N 103°39'50.90"E 1°33'6.65"N 103°44'20.70"E	Located in Skudai and near the Sekudai river Located in Nasa City Tebrau and near the Tebrau river
Urban Park	1°30'9.24"N 103°52'12.05"E	Located in Bandar Baru Seri Alam and near the Masai river.

In order to validate the results obtained in this study (suitable locations for parks development), the suitable areas were checked against the latest Google Earth data (2014) to find out if the areas are still available as open space or have been used for other purposes (Table 7). For recreation parks, all the areas suitable for parks development have already been used for settlements and residential areas have been developed before now. This is because recreation parks consist of only small size of 1 to 2 km^2 which are usually found near residential areas and far from natural water bodies. Details of the identified locations for parks are shown in Table 7. The parks within the cities can act as a very good medium of cooling with the presence of trees to store and sequester excess CO_2 and the presence of water bodies to reduce the ambient air temperature. However, the final decision to consider these suitable locations for future developments of parks depends on many factors. For example, although we discovered that there is one location in Bandar Baru Seri Alam suitable to be developed as urban park, the Pasir Gudang Municipal Council does not intend to develop any new parks currently due to financial constraint, and the municipality wishes to focus on enhancing the existing urban park of Taman Bukit Layang- layang (Personal communication with Ms. Zanariah Kadir, the head of Landscape Department Pasir Gudang Municipality Council, 2015).

4. Conclusion

This study was conducted to identify suitable locations to be developed as parks in Iskandar Malaysia (IM) region in the south of Peninsular Malaysia. Results from the Analytical Hierarchy Process (AHP) and GIS showed specific locations for developing parks in IM. The selections of the sites were based on only three factors namely the accessibility from main roads, slope of the area and size of area. The integrated approach combining AHP and GIS was adopted to provide weightages for each of the parameter layer by providing scoring and ranking to each parameter and conducting weighted overlay analysis to identify suitable locations for six different types of parks in IM. As a result, specific suitable locations to be developed as parks near the water bodies for the high cooling effect consist of one playground lot, two playground parks, one neighbour park, two local parks and one urban park. Water bodies layer were not added as a parameter in this study as it was not mentioned in the guideline provided by the JPBD. However, it can be recommended for future study. We acknowledge that this study is only limited to only three quantitative parameters therefore future study can be improved with more parameters such as the distance from industrial area, population size and distance from water bodies considering both quantitative and qualitative analysis in AHP.

Acknowledgment

We acknowledge the Ministry of Education Malaysia through research grant Q.J130000.2427.02G20 and R.J130000.7301.4B145 for providing funding to conduct the study. We acknowledged the Science and Technology Research Partnership for Sustainable Development (SATREPS) project to support this study. We thank the Iskandar Regional Development Authority (IRDA), Johor and Department of Town and Regional Planning (JPBD), Johor for providing data and their personnel's assistance on this research.

References

Ahmadi, A. M., Darabkhani, M. F. and Ghanavati, E., 2015, A GIS-based Multi-criteria Decision-making Approach to Identify Site Attraction for Ecotourism Development in Ilam Province, Iran, *Tourism Planning and Development*, 12 (2), 176-189.

Aliniai, K., Yarahmadi, A., Zarin, J. Z., Yarahmadi, H., and Lak, S. B., 2015, Parking Lot Site Selection: An Opening Gate Towards Sustainable GIS-based Urban Traffic Management, *Journal of Indian Society Remote Sensing*, 43 (4), 801-813.

Allahi, S., Mobin, M., Vafadarnikjoo, A. and Salmon, C., 2015, An Integrated AHP-GIS-MCLP Method to Locate Bank Branches, *Proceedings of the 2015 Industrial and Systems Engineering Research,* 1-10.

Breeze, P. S., Drake, N. A., Groucutt, H. S., Parton, A., Jennings, R. P., White, T. S., Balzan, L. C., Shipton, C., Scerri, E. M. L., Stimpson, C. M., Crassard, R., Hilbert, Y., Alsharekh, A., Al-Omari, A. and Petraglia, M. D., 2015, Remote Sensing and GIS Techniques for Reconstructing Arabian Palaeohydrology and Identifying Archaeological Sites, *Quaternary International*, 382, 98–119.

Chang, N. B., Parvathinathan, G. and Breeden, J. B., 2008, Combining GIS with Fuzzy Multicriteria Decision-Making for Landfill Siting iiin A Fast-Growing Urban Region, *Journal of Environmental Management*, 87, 139-153.

Ebrahimi, A., Mehdipoor, A. and Azmsha, T., 2015, Analysis Locating Sport Gyms through Geographical Information System and AHP model (Case Study: Ahvaz City), *International Journal of Sport Studies*, 5(3), 333-340.

Erden, T. and Coskun, M. Z., 2010, Multi-Criteria Site Selection for Fire Services: The Interaction with Analytic Hierarchy Process and Geographic Information Systems, *Natural Hazards Earth System Science*, 10, 2127-2134.

Eskandari, M., Homaee, M., Mahmoodi, S., Pazira, E. and Genuchten, M. T. V, 2015, Optimizing Landfill Site Selection by using Land Classification Maps. *Environmental Science and Pollution Research*, 22, 7754-7765.

Foroughian, A. and Eslami, H., 2015, Application of AHP and GIS for Landfill Site Selection (A Case Study: City of Susa), *Journal of Scientific Research and Development*, 2(5), 129-134.

Hadipour, A., Vafaie, F. and Hadipour, V., 2014, Land Suitability Evaluation for Brackish Water Aquaculture Development in Coastal Area of Hormozgan, Iran, *Aquaculture International*, 23, 329-343.

Hamdani, H. and Wardoyo, R., 2015, A Review on Fuzzy Multicriteria Decision Making Land Clearing for Oil Palm Plantation, *International Journal of Advances in Intelligent Informatics*, 1(2), 75-83.

Hazra, P. B. and Acharya, A., 2015, Geoinformatics for Industrial Siting – A Case Study of Puruliya District, West Bengal, *International Journal of Advanced Remote Sensing and GIS*, 4 (1), 817-827.

Ho, C. S., Matsuoka, Y., Simson, J. and Gomi, K., 2013, Low Carbon Urban Development Strategy in Malaysia - The case of Iskandar Malaysia Development Corridor, *Habitat International*, 37, 43-51.

Jafari, H., Karimi, S., Nahavandichi, M. and Balist, J., 2015, Nuclear Power Plant Locating by WLC and GIS (Case Study: Iran, Hormozgan Province), *International Journal of Basic and Applied Sciences*, 4 (1), 132-139.

Jalaliyoo, N., Arastoo, A. and Pirouti, A., 2015, Land Selection; using Multiple Criteria Decision Making, *International Journal of Academic Research in Management (IJARM)*, 4(1), 14-23.

Jalao, E. R., Wua, T. and Shunk, D., 2014, A Stochastic AHP Decision Making Methodology for Imprecise Preferences, *Information Sciences*, 270, 192-203.

JPBD, 2013, *Planning Guidelines* [online]. from http://mytownnet.blogspot.com/p/planning-guidelines.html. [Accessed 31 March 2014].

Kamali, M., Alesheikh, A. A., Khodaparast, Z, Hosseinniakani, S. M. and Borazjani, S. A. A., 2015, Application of Delphi-AHP and Fuzzy-GIS Approaches for Site Selection of Large Extractive Industrial Units in Iran, *Journal of Settlements and Spatial Planning*, 6(1), 9-17.

Kanniah, K. D, Sheikhi, A. and Kang, C. S, 2013a, Exploring the Role of Green and Blue Infrastructure in Reducing Temperature in Iskandar Malaysia, International Symposium on

Digital Earth, 26-29 August 2013, Kuching, Sarawak, Malaysia. IOP Conf. Series: *Earth and Environmental Science*, 18, 1- 6.

Kanniah, K. D, Muhamad, N. and Kang, C. S., 2013b, Remote Sensing Assessment of Carbon Storage by Urban Forest, International Symposium on Digital Earth, 26-29 August 2013, Kuching, Sarawak, Malaysia. IOP Conf. Series: *Earth and Environmental Science,* 18 (1), 1-5.

Kanniah, K. D., Sheikhi, A., Cracknell, A. P., Goh, H. C., Tan, K. P., Ho, C. S. and Rasli, F.N., 2015, Satellite Images for Monitoring Mangrove Cover Changes in a Fast Growing Economic Region in Southern Peninsular Malaysia. *Remote Sens.*, *7*, 14360-14385.

Khaki, A. M., Mojaradi, B., Ghobadipour, B., Maghsoudy, S. and Naghibi, F., 2015, Integration of GIS and Analytical Hierarchy Process Method For Locating Road Emergency Medical Services Station, *Geosystem Engineering*, 18 (2), 92-103.

Konijnendijk, C. C., Annerstedt, M., Nielsen, A. B. and Sreetheran, M., 2013, Benefits of Urban Parks: A Systematic Review. A report for The International Federation of Parks and Recreation Administration (IPFRA), University of Copenhagen, Denmark.

Kumar, M. and Biswas, V., 2013, Identification of Potential Sites for Urban Development using GIS Based Multi Criteria Evaluation Technique: A Case Study of Shimla Municipal Area, Shimla District, Himachal Pradesh, India, *Journal of Settlements and Spatial Planning*, 4, 45- 51.

Latinopoulos, D. and Kechagia, K., 2015, A GIS-Based Multi-Criteria Evaluation for Wind Farm Site Selection. A regional Scale Application in Greece, *Renewable Energy*, 78, 550-560.

Lim, S. and Lee, K. T., 2012, Implementation of Biofuels in Malaysian Transportation Sector towards Sustainable Development: A Case Study of International Cooperation between Malaysia and Japan. *Renewable and Sustainable Energy Reviews,* 16, 790- 800.

Mishra, A. K., Deep, S. and Choudhary, A., 2015, Identification of Suitable Sites for Organic Farming using AHP and GIS, *The Egyptian Journal of Remote Sensing and Space Sciences*, 18 (2), 181-193.

Moeinaddini, M., Khorasani, N., Danehkar, A., Darvishsefat, A. A. and Zienalyan, M., 2010, Siting MSW Landfill using Weighted Linear Combination and Analytical Hierarchy Process (AHP) Methodology in GIS Environment (Case Study: Karaj), *Waste Management,* 30, 912-920.

Mousavi, S. H., Danehkar, A., Shokri, M. R., Poorbagher, H. and Azhdari, D., 2014, Site selection for artificial reefs using a new combine Multi- Criteria Decision- Making (MCDM) tools for coral reefs in the Kish Island -Persian Gulf, *Ocean and Coastal Management,* 111, 92-102.

Mustafa, I. S., Din, N. M., Ismail, A., Omar, R. C. and Khalid, N. H. N., 2015, Site Suitability Analysis for Landslide Monitoring Base Station using GIS-Based Multicriteria Evaluation Technique. In Information Technology: Towards New Smart World (NSITNSW), IEEE, 2015 5th National Symposium, 1-6.

NASA, 2015, Global climate change, vital sign of the planet [online]. Available from http://climate.nasa.gov/vital-signs/carbon-dioxide/ [Accessed 3 January 2015].

Nefeslioglu, H. A., Sezer, E. A., Gokceoglu, C. and Ayasd, Z., 2013, A Modified Analytical Hierarchy Process (M-AHP) Approach For Decision Support Systems In Natural Hazard Assessments, *Computers and Geosciences*, 59, 1-8.

Niaraki, M. J. and Malczewski, J., 2015a, Decision Complexity and Consensus In Web-Based Spatial Decision Making: A Case Study of Site Selection Problem using GIS and Multicriteria Analysis, *Cities*, 45, 60-70.

Niaraki, M. J. and Malczewski, J., 2015b, A Group Multicriteria Spatial Decision Support System for Parking Site Selection Problem: A case Study, *Land Use Policy*, 42, 492-508.

Oikonomidis, D., Dimogianni, S., Kazakis, N. and Voudouris, K., 2015, A GIS/Remote Sensing-Based Methodology for Groundwater Potentiality Assessment in Tirnavos Area, Greece. *Journal of Hydrology,* 525, 197-208.

Pinto, D., Shrestha, S., Babel, M. S. and Ninsawat, S., 2015, Delineation of groundwater potential zones in the Comoro Watershed, Timor Leste using GIS, Remote Sensing and Analytic Hierarchy Process (AHP) Technique, *Applied Water Science*, 1-17.

Qaddah, A. and Abdelwahed, M. F., 2015, GIS-based site-suitability modelling for seismic stations: Case study of the northern Rahat volcanic field, Saudi Arabia, *Computers and Geosciences*, 83, 193-208.

Razak, M. F. A., Said, M. A. M., and Yusoh, R., 2015, The Development of a Site Suitability Map for RBF Location using Remote Sensing and GIS Techniques, *Jurnal Teknologi*, 74(11), 15-21.

Saaty, T. L., 2008, Decision making with the Analytic Hierarchy Process, *International Journal of Services Sciences*, 1, 83- 98.

Sheikhi, A., Kanniah, K. D. and Ho, C. S., 2015, Effect of Land Cover and Green Space on Land Surface Temperature of a Fast Growing Economic Region in Malaysia, *Proceeding of SPIE Vol. 9644, Earth Resources and Environmental Remote Sensing/GIS Applications VI*, 964413, 16 October 2015, Toulouse, France.

Sharifi, M., Hadidi, M., Vessali, E., Mosstafakhani, P., Taheri, K., Shahoie, S. and Khodamoradpur, M., 2009, Integrating Multi Criteria Decision Analysis for a GIS- Based Hazardous Waste Landfill Sitting in Kurdistan Province, Western Iran. *Waste Management*, 29, 2740-2758.

Siddayao, G. P., Valdez, S. E. and Fernandez, P. L., 2015, Modeling Flood Risk for an Urban CBD using AHP and GIS, *International Journal of Information and Education Technology*, 5 (10), 748-753.

Svoray, T., Levi, R., Zaidenberg, R. and Beny Yaacoby, 2015, The Effect of Cultivation Method on Erosion in Agricultural Catchments: Integrating AHP in GIS Environments, *Earth Surface Process and Landforms*, 40, 711–725.

Tominaga, Y., Sato, Y. and Sadohara, S., 2015, CFD Simulations of the Effect of Evaporative Cooling from Water Bodies in a Micro-Scale Urban Environment: Validation and Application Studies. *Sustainable Cities and Society*, 19, 259-270.

Ullah, K. M. and Mansourian, A., 2015, Evaluation of Land Suitability for Urban Land-Use Planning: Case Study Dhaka City, *Transaction in GIS*, 20 (1), 20-37.

United Nation, 2015, United Nations Population Information Network [online]. Available from http://www.un.org/popin/index.html [Accessed 28 July 2015].

UTM- Low Carbon Asia Research Centre, 2014, *Low Carbon Society Blueprint for Iskandar Malaysia- Summary for Policy Makers*, Johor , UTM- Low Carbon Asia Research Centre.

Uyan, M., 2013, GIS-Based Solar Farms Site Selection using Analytic Hierarchy Process (AHP) in Karapinar Region, Konya/Turkey, *Renewable and Sustainable Energy Reviews,* 28, 11–17.

Völker, S. and Kistemann, T., 2011, The Impact of Blue Space on Human Health and Well-Being - Salutogenetic Health Effects of Inland Surface Waters: A Review, *International Journal of Hygiene And Environmental Health*, 214, 449-460.

Wang, G., Lib, Q., Guoxuea, L. and Lijunc, C., 2009, Landfill Site Selection using Spatial Information Technologies and AHP: A Case Study in Beijing, China, *Journal of Environmental Management*, 90, 2414-2421.

Zamorano, M., Zamoranoa, M., Molerob, E., Hurtadoa, A., Grindlay, A. and Ramos, A., 2008, Evaluation of a municipal landfill site in Southern Spain with GIS-aided methodology, *Journal of Hazardous Materials*, 160, 473-481.