SITE SUITABILITY FOR PUBLIC PARK USING ANALYTIC HIERARCHY PROCESS AND GEOGRAPHIC INFORMATION SYSTEM

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ABSTRACT

Optimal locations for public parks are significant issues in a town planning. The current distribution of public park in Kota Bharu, not reflect their current population densities. Therefore, Kota Bharu Municipal Council (MPKB) administration area was selected as the study area where the land suitability model was applied to determine the suitable area for public parks. This study was carried out using an Analytical Hierarchy Process (AHP) as a multi-criteria evaluation approach by integrating it with the Geographic Information System (GIS). The IDRISI GIS package was used to calculate the weights based on four alternative scenarios; (a) population density, (b) existing public parks, (c) industrial area and, (d) land availability. Based on the findings made in this research, suitable locations for future public park development is highly helpful in the future land use planning in Kota Bharu, Kelantan.

Keywords: *site suitability, AHP, GIS, public park*

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INTRODUCTION

In many countries, public parks and open spaces are nowadays regarded as an integral part of land use planning decisions. The provision of the public open space has to be planned and realised together with the planning of other urban functions like housing, transport, infrastructure, etc. However, there is no general agreement on the desirable planning criteria as to how much open space is needed, where open space should be located or how it should be used (Maruani & Cohen, 2007). Rusli and Ludin (2010) mentions the current layout of the public park and open space in most areas tends to be the result of opportunistic provision, rather than a planned approach and will often not reflect current population densities nor provide an equitable distribution of facilities. Within the context of urban planning, the provision of open spaces issue is associated with the requirement mentioned in any proposal plan or development plan. The current practice shows that the Federal Department of Town and Country Planning (JPBD) has set a policy of 10 percent for open spaces for each development application (JPBD, 2000). In general, however, the 10 percent policy is merely a base reference only.

Referring the current situation in Kota Bharu, Kelantan, JPBD Negeri Kelantan (2010) have highlighted inadequate provision of their public parks and open spaces.The report also addresses the issue of the loss of open spaces to give way to other developments apparently occurs in the main city center of Kelantan. It has been suggested that there is much to be desired of the quality of these spaces as the developers' notion of the parks often means 'leftover spaces' and not based on scientific analysis thus, attention to problems of public parks provision is necessary (Qelichi M. et al., 2012). Therefore, the main objective of this paper is to balance the loss of these spaces by creating a replacement in the form of a public park in Kota Bharu Municipal Council (MPKB) administration area by suggesting the most optimal and suitable area for thefuture public park based on an integrated GIS multi-criteria evaluation technique.

LITERATURE REVIEW

A park is an open space, area of natural, semi-natural, or planted space set aside for human enjoyment and recreation or the protection of wildlife

or natural habitats. According to (JPBD, 2000), park and open space are specifically for public use or benefit. Under the Town and Regional Planning Act (Amendment) 1995 (A933), open space is defined as any land either gated or not, which had been expressly and comprehensively reserved or a part of it. Generally to be used as gardens, children playground, playfield, sports ground, botanical garden, landscaped and planned area and as well as public parks. In general, it refers to land or space allocated as an area for relaxation, picnic, and recreation. In this paper, the terms open spaceand public park were used interchangeably and presumed to be synonymous. JPBD (2000) presents the hierarchy and characteristic (size and catchment area) of open space which can be classified as a national park, regional park, town park/urban park, local park, neighborhood park, playing field and playlot. Maruani and Amit-Cohen (2007) classified parks into two broad categories, such as the conservation of natural values and the provision of recreation, services to society.

According to Qelichi M. et al. (2012), a public park is an essential element in a city that serves as an outdoor recreational place which attracts the community to pass their leisure time, enjoy aesthetic and the benefits of nature (Kong et al., 2007; Carr, 1992). Lawal et al. (2011)point out the importance of public park in generating the economic and social values as well as promoting a healthy lifestyle for the local community. This open spaces can provide a favorable environment for rearing children, developing social integration, keeping tranquility; they are also considered as an indicator of improving the life space quality and social development (Sarvar, R. et al., 2012; & Chiesura, 2004). Public parks are important components of urban environments, and they can improve and ameliorate microclimates, reduce air pollution, and alleviate heat island effects (Carr, 1992).Thus, it can be said that a public park asis an important non-renewable component of urban landscape planning with enriched environmental, skeletal, social and cultural dimension. Undoubtedly, public parks and open spacesplay social, economic and ecological roles the urban environment which contribute to sustainable urban environments (Dudek, 2000; & Hagla, 2008; Sarvar, R. et al., 2012). The necessity to develop new urban applications, essential to meet the ever-increasing needs of citizens, gradually has decreased the share of open spaces in the cities which in turn is followed by the limited urban population's accessibility to nature (JPBD, 2000; Sarvar, R. et al., 2012). Developers should provide 10 percent of open space and recreational

areas for all types of residential, commercial, industrial, mixed-use, tourism and institutional development with a minimum requirement of 0.2 hectares (JPBD, 2000).

Kovacs (2005), highlights the responsibility of city parks and recreation departments for deciding the amount, the number and the size of parks within the area of a city. As Kovacs argues: "The city planner supposedly try to find the size, number and the amount of land for parks in the city to maximise the overall net benefits to the public" (Kovacs, 2005). Qelichi M. et al. (2012) suggest that the aspects such as "amount of public open space per inhabitant" are often mentioned as important factors to make the city livable, pleasant and attractive for its citizen's. This view is supported by Lawal, Matori, and Balogun (2011), who writes that planning for open space is all about evaluating the demand, both the actual or present demand and the future demand; about assessing the land capability to meet those needs; and about utilising the resources which are available wisely.

The Federal Department of Town and Country Planning, Peninsular Malaysia has produced a planning standard guideline to supervise the implementation of the open space policy in Malaysia.Town and Country Planning legislation governs the requirement and provision of open spaces as an integral part of all new developments. One of the measures is to provide adequate public open spaces through adopting the standard of two hectares per a 1,000 urban population by the year 2020. This vision can be seen as the Government attempt to ensure the sustainability of open spaces in Malaysia. This standard is also contained in Murni.net indicators for assessing a sustainable city. According to Rusli and Ludin (2010), the policy also calls for open spaces to be gazetted, for environmentally sensitive areas to be protected, for their development to be monitored, and for open spaces to be established as buffer zones to limit urban development.

However, there is also much to be desired of the quality of these spaces as the developers 'notion of open spaces often means 'leftover spaces.' Sometimes the provision of open spaces is mere to meet the approval requirements set by state governments and local authorities.In a densely populated urban center, where high land costs make it difficult to create new open spaces, the quality of our existing open spaces and the smaller scale urban parks could play a vital role in alleviating urban stress. It is our

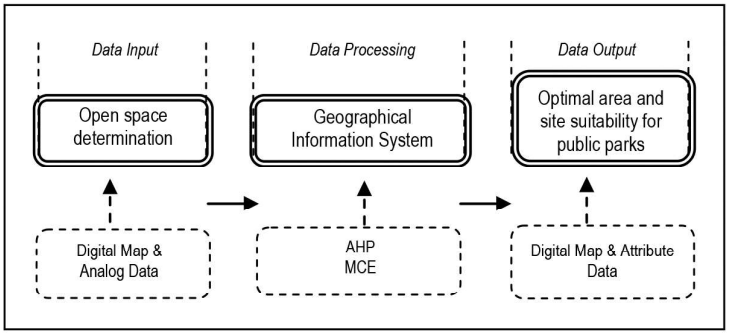
responsibility to recover, replace, retrofit, and further enhance these spaces so that they remain relevant to our modern daily life. Chandio, Matori, Lawal, and Sabri (2011) points out that less attention is paid to protect the public parks and their sustainability. Without careful urban land use planning, the public park and open spaces will be filled with residential and commercial buildings to cater for rapid development growth.

Therefore, there is a need for proper open space planning to ensure that the provisions of open spaces are adequately for current and future generations. Through balancing the loss of these spaces by suggesting the most optimal and suitable area locate future public park based on an integrated Geographic Information System (GIS) multi-criteria evaluation technique (MCE) and Analytic Hierarchy Process (AHP). Bruce (2001) concludes that GIS is a computer-based technology and methodology for collecting, managing, analysing, modeling, and presenting geographic information for a broad range of applications. GIS tools were used in creating different datasets of the study area, and the set of criteria generated were integrated into the multi-criteria evaluation (Lawal et al., 2011). The integration of the GIS with AHP combines decision support methodology with powerful visualisation and mapping capabilities which in turn facilitates the creation of land use suitability map. Pair-wise comparison method of AHP was used to evaluate the criterions obtained, and weightings were assigned and calculated. The results of the weightings obtained from this approach finally identified the most suitable sites to locate the proposed future public park. Based on the analysis and findings made in this research, determining appropriate locations using the land suitability model for future public park development is highly helpful. It can be useful in the planning of the public facilities and sustainable land use planning in Kota Bharu Municipal Council (MPKB) administration area.

METHODOLOGY

In this research, the evaluation of the required criteria for the location of parks was an attempt to create maps and data layers for each of the criteria in the GIS. Based on the issue and problem that were discussed previously, the objectives to be achieved in this study are (i) mapping the existing open space area, (ii) determine the adequate open space through adopting the

standard of two hectares per 1,000 urban population suitable land, and (iii) determine the most optimal and suitable site to locate the public park based on an integrated GIS multi-criteria evaluation technique and AHP (Figure 1).



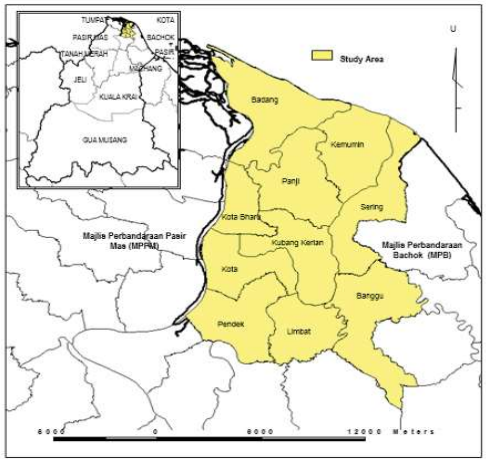
(*Source: Author*)

Figure 1: Conceptual Diagram

The GIS plays a vital role in planning for many decades of land-use suitability mapping and modeling (Malczewski, 2004 & Malczewski, 2006). Then for modeling, each data layer was assigned a weight based on the AHP model. AHP generates a weight for each evaluation criterion according to the decision maker's pairwise comparisons of the criteria. The AHP, introduced by Saaty (2007), is a useful tool for dealing with complex decision making and may aid the decision maker to set priorities and make the best decision. Maps with the overlay method were combined and using the multi-criteria decision-making techniques, the best place for parks in the case study area was proposed (Aragonés-Beltrán, Chaparro-González, Pastor-Ferrando & Pla-Rubio, 2014). The AHP is a systematic method to guide decision-makers in making decisions to solve the problems based on priorities (Miller et al., 1998). This paper addresses a scientific approach to determine suitable land for healthy urban development. This method will help in the revision of policy and preparation of development plans in the study area and for other cities as well.

Study Area

The study area is the administrative unit of Kota Bharu Municipal Council (MPKB), Kelantan as exhibited in Figure 2. It is located in the North Kelantan region between latitude 6º 01 'N and 6º 13' N and longitude 102º 13 'N and 102º 20' T. The study area comprising 10 districts namely Badang, Banggu, Kemumin, Kota, Kota Bharu, Kubang Kerian, Limbat, Panji, Pendek and Sering with a total area of 21,830.21 hectares. The vicinity of MPKB is a strategic place of development for Kelantan state with the study area as its center of administration, trade, and finance. Pengkalan Chepa acts as an industrial center and Kubang Kerian as institution center. The concentration population pattern is one of the reasons for selecting MPKB as the study area. According to JPBD Negeri Kelantan (2010), a high population growth due to high migration rates has resulted in an increase the demand for housing and open space. The study area is a catalyst and key components for the development in Kelantan with the highest density of population concentration compared to other areas. The Kota Bharu Local Plan 2020 (JPBD Negeri Kelantan, 2010) have highlighted inadequate provision of open spaces in MPKB administrative area.



(*Source: Author*)

Figure 2: The Study Area, MPKB Administrative Area

The results of a study conducted by JPBD Negeri Kelantan found the total of existing open space in 2010 was 140,262 hectares compared to a population of 336,200 people, as shown in Table 1. Based on the target needs of open space, 2 hectares to 1000 population (0.002 hectares per population), the existing open spaces provided in the study area are just 21 percent. Based on population, the total amount of open space needed is an area of 672.4 ha. This shows the inadequacy of open space of 532.138 hectares in 2010 due to the current small scale open spaces which are not subject to the requirements of standards and scattered housing development in MPKB administrative area (JPBD Negeri Kelantan, 2010).

Table 1: Open Space Provision based on the Number of Residents in the Study Area in the Year 2010

District in MPKB administrative area	Population in The year 2010	Open Spaces Needed	Existing Open Spaces	Inadequacy of Open Spaces
		Hectare		
Badang	32,370	64.74	1.846	62.894
Banggu	20,260	40.52	0	40.52
Kemumin	38,010	76.02	85.046	-9.026
Kota	21,450	42.9	0.561	42.339
Kota Bharu	34,970	69.94	20.429	49.511
Kubang Kerian	56,430	112.86	2.751	110.109
Limbat	18,870	37.74	18.597	19.143
Panji	75,300	150.6	9.631	140.969
Pendek	17,990	35.98	0.899	35.081
Sering	20,550	41.1	0.502	40.598
Total	**336,200**	**672.4**	**140.262**	**532.138**

(*Source: Author*)

The complexity of the development issues and the increase in population are seemingly the fundamental problems that contribute to the sustainable environmental matters in the study area. Based on a scenario of moderate population growth projections, the study area is expected to have a total population of 394,330 people in 2020. Accordingly, the population needs to open spaces will also increase in 2015 and 2020. Due to the entire population in 2015 was 359,880 people the needs to open space is 719.76 hectares and specifically in additional of 47.36 hectares in 2015 and 68.9 hectares in 2020 (Table 2).

Table 2: The Need for Open Spaces

Year	Total population	The need for Open Space (ha)	Additional population	Additional open space needed (ha)
2015	359, 880	719.76	23,680	47.36
2020	394, 330	788.66	34,450	68.9

(*Source: Author*)

The study area is also chosen as it is the capital city of Kelantan which still has the abundance of undeveloped land to be developed as public parks compared to the other main cities in Malaysia. It is believed that the presence of sufficient public parks and open space areas with adequate accessibility in the city contributes to the happiness of the citizens towards a sustainable quality of life.

Data Collection and GIS Data Base Development

The spatial and non-spatial data was collected from the Department of Town Planning, MPKB. Getting data through formal requests was easy. There were some limitations, e.g., time constraint and sensitive area information. The base map of MPKB administration area was scanned, and geo-referencing was fixed to change it into earth coordinates, then it was digitised in ArcGIS 9.2 software to develop the data layers.

Development and Computation of the Pairwise Comparison matrix

Although the results of the literature review show that there are many other factors to be taken into account in determining the suitability of an area for public park development, the limitations of the study led to only four factors be considered in this study (Table 3). The IDRISI GIS package was used to calculate the weights based on four alternative scenarios. Computed composite weights were inserted into the spatial analysis function of the GIS and produced four scenarios of suitability maps, i.e.: (a) population density, (b) existing public parks, (c) industrial area and, (d) land availability.

Matrixes of pairwise comparisons were created by the experts on condition that judgments were evaluated to find suitable alternatives to estimate associated absolute numbers from 1 to 9, the major scales of the AHP (Saaty, 2007) exhibited in Table 4. Four alternative scenarios were produced by using the AHP in the proper site selection of public parks.

Table 3: The Scenario of Suitability Maps

Scenarios	Parametres	
Social	Population Density (kernel density estimation)	High
		Medium
		Low
Accessibility	Major roads	< 1000 metres
	Local roads	> 1000 metres
Land use	Existing parks	< 1000 metres
		> 1000 metres
	Industrial area	Heavy < 500 meters
		Medium < 250 metres
		Light < 50 metres
Land Availability	Vacant land (including abandoned agriculture, water bodies)	

(*Source: Edited from JPBD, 2000*)

Table 4: AHP Scale of Relative Importance

Intensity of relative importance	Definition	Explanation
1	Equal importance	Two activities combine equally to the objective.
3	Moderate importance of one over another	Experience and judgment slightly favor one activity over another.
5	Essential or strong importance	Experience and judgment strongly favor one activity over another.
7	Demonstrated importance	An activity is strongly favored and its dominance is shown in practice.
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation.
2, 4, 6, and 8	Intermediate values between the two adjacent judgments	When compromise is needed.

(*Source: Saaty, 2007*)

Table 3 exhibits the criteria and sub-criteria, considered in the land suitability analysis to create four scenarios by using the ArcGIS 9.2 spatial analysis tool. The weights of factors and parameters were successfully calculated quickly for land suitability with the Idrisi Kilimanjaro software keeping in view the consistency ratio (CR) (Figure 3). If the CR was satisfactory, it did not exceed the desired range, i.e., >0.10. If the CR value was in an undesirable range, the obtained judgment matrix needed to be reviewed till these values improved were satisfactory. Later on, to compute the composite weights, literature stated two procedures for multi-criteria evaluation: the concordance discordance analysis and the weighted linear combination. The function of a Weighted Linear Combination (WLC) procedure where each factor and parameter (Vi) are multiplied by the weight of the suitability parameters (Wi) to get composite weights. WLC is a straight forward linear method calculating composite weights. Similarly, the results of composite weights based on alternatives (scenarios) are used in a weighted sum spatial analysis function. This function multiplies and sums up the layers to produce scenario suitability maps for parks by the following formula:

$$E = \sum_{i=1}^{n} wi^{*}vi$$

Where: relative importance or weight of factors/parameters = relative weight of parameters and = total number of parameters related to the study.

GIS-based Land Suitability Analysis

The land suitability analysis was performed in the raster format. The raster data model is the more suitable technique because the structure of raster data is grid cell based, which can easily delineate suitable sites. Raster data facilitates the user in carrying out a weighted overlay on many layers. Suitability maps were created under a raster GIS environment, based on various scenarios. The suitability for each land use was analysed in ArcGIS 9.2 to locate suitable areas for parks.

RESULTS AND DISCUSSION

The AHP method is used to evaluate the weight of each factor and sub-criteria (parameters). The AHP and the GIS are integrated to assess suitable land for public parks in the study area for the year 2015 and the year 2020 (Figure 3 and Figure 4). All four scenarios were combined to determine potential land. As stated in Figure 3(a) 0.9%; of the area was ranked by a suitability value 6, 11.5 % with a suitability value 5, 30.6% with a suitability value 4 and 54.7% with a suitability value 3. The total population projection for the year 2015 is 359,880 people and the estimation of the need to open space and recreation in that year is 719.76 hectares. Priority has been given to areas with the highest suitability value and in regards to land availability shown in Figure 3(b), to the proposed new public park with 47.36 hectares in Figure 3(d).

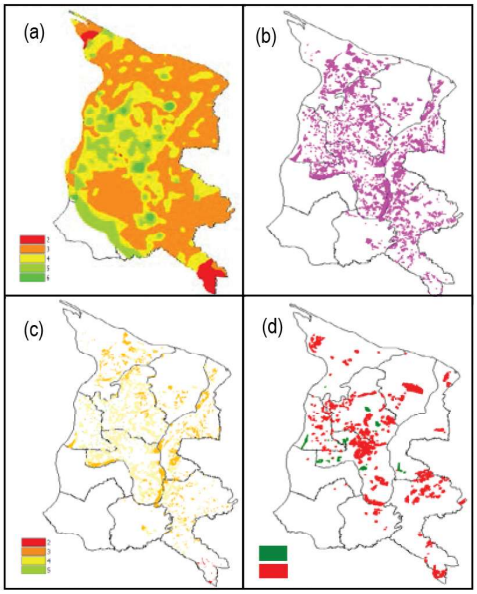


Figure 3: (a) Weighted Overlay (Determine Potential Land), (b) Land Availability, (c) Intersect of Land Suitability and Land Availability, and (d) Land Suitability for New Public Park in 2015

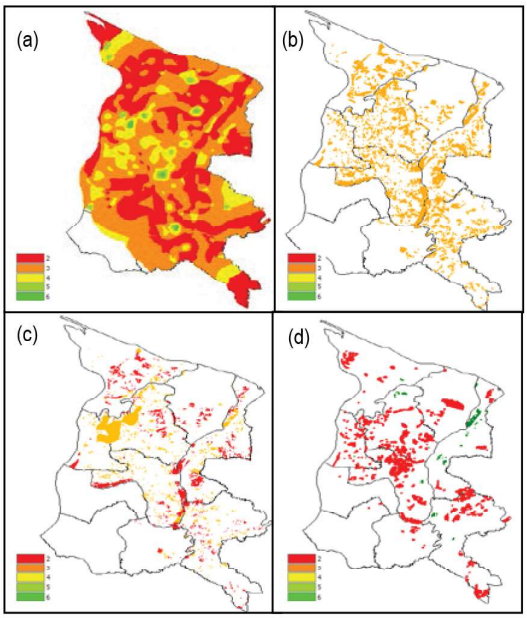


Figure 4: (a) Weighted Overlay (Determine Potential Land), (b) Land Availability, (c) Intersect of Land Suitability and Land Availability, and (d) Land Suitability for New Public Park in 2020

The weighted overlay of all criteria including the distance to the proposed new public park in 2015 produced the suitability map for the year 2020 in Figure 4(a). The total area 0.26% ranked by a suitability value 6, 1.1% ranked by a suitability value 5, 47.8% ranked by a suitability value 4 and 36.6% ranked by a suitability value 3. The total population projection for the year 2020 is 394, 330 people and the estimation of the need to open space and recreation in that year is 788.66 hectares. Priority has been given to areas with the highest suitability value and in regards to land availability shown in Figure 4(b), to the proposed new public park with 47.36 hectares (Figure 4(d).

CONCLUSION

This study has focused the use of integrated AHP with GIS to determine the suitability of the land for parks in the MPKB administrative area. The GIS-based AHP as MCE in the land suitability analysis approach can be useful to identify suitable land in urban development. Planning standards of optimal locations are not the only important consideration in the planning process, but also sustainable distances from facilities to people should also be considered. Therefore, this study presented the advantages of integrated GIS-based land suitability analysis and a solution for such complicated decisions. It can also provide valuable guidance for future land use changes and cost effective solutions in the cities.

Finding an optimal and proper location for various urban uses and urban service rendering centers will decrease costs, on the one hand, and will increase the quality of services and hence, the efficiency rate. Among other things, the urban parks, as the most open and public spaces of cities, play significant roles in improving the social, cultural, economic and environmental conditions of the urban areas. Such spaces have grabbed more attention in parallel with the growth of an area and the population of the urban regions in various countries; hence, various strategies have been invented and used to locate and distribute them appropriately throughout the urban environments.

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REFERENCES

Aragonés-Beltrán, P., Chaparro-González, F., Pastor-Ferrando, J.-P., & Pla-Rubio, A. (2014). An AHP (Analytic Hierarchy Process)/ANP (Analytic Network Process)-based multi-criteria decision approach for the selection of solar-thermal power plant investment projects. *Energy, 66*, 222–238.

Bruce E. Davis. (2001). GIS: A visual approach (2nd Edition).

Chandio, I., Matori, A., Lawal, D., & Sabri, S. (2011). GIS-based land suitability analysis using AHP for public parks planning in Larkana City. *Modern Applied Science, Vol. 5*(No. 4), 177. Retrieved from http://www.ccsenet.org/journal/index.php/mas/article/view/11636

Carr, S. (1992). *Public Space*. Cambridge, New York: Cambridge University Press.

Chiesura, A. (2004). The role of urban parks for the sustainable city. *Landscape and Urban Planning, 68*: 129–138

Dudek, M. (2000). *Architecture of Schools: The New Learning Environments*. Oxford, Boston: Architectural Press.

Hagla, K. (2008). "Towards a Sustainable Neighborhood: The Role of Open Spaces," IJAR, 2:162-177.

JPBD. (2000). Guideline and Planning Standards: Open Space and Recreation. Jabatan Perancang Bandar dan Desa Semenanjung Malaysia

JPBD Negeri Kelantan (2010). Kajian Rancangan Tempatan Jajahan Kota Bharu (2010-2020).

Kong, F., Yin, H., Nakagoshi, N. (2007). Using GIS and landscape metrics in the hedonic price modeling of the amenity value of urban green space: A case study in Jinan City, China. *Landscape and Urban Planning, 79*:240–252

Kovacs, K. (2005). *Amount and Spatial Distribution of Public Open Space to Maximise the Net Benefits from Urban Recreation*.

Lawal, D., Matori, A., & Balogun, A. (2011). A Geographic Information System and Multi-Criteria Decision Analysis in Proposing New Recreational Park Sites in Universiti Teknologi Malaysia. *Modern Applied Science*. Retrieved from http://www.ccsenet.org/journal/index.php/mas/article/view/10853

Malczewski, J. (2006). GIS-based multicriteria decision analysis: A survey of the literature. *International Journal of Geographical Information Science, Vol. 20*, No. 7, 703–726.

Malczewski, J. (2004). GIS-based land-use suitability analysis: a critical overview. *Progress in Planning, 62*, 3–65.

Maruani,T. and Amit-Chen, I. (2007). Open space planning models: A review of approaches and methods. *Landscape and Urban Planning, 81*, 1-13.

Miller, W. C. (1998). An approach for greenway suitability analysis. *Landscape and Urban Planning, 42*, 91-105 .

Qelichi, M., Oroji, H., Asadi, S. (2012). Optimum locating of urban parks and green space using GIS and TOPSIS technique, International Conference of GIS-Users, Taza GISDays, May 23-24, Proceeding Book

Rusli, N. Ludin, A.N.M. (2010). Evaluation of Open Space and Recreation Area in Johor Bahru Tengah Municipal Council, UTM

Saaty,T.L. (2007). Time dependent decision-making; dynamic priorities in the AHP/ANP: Generalizing from points to functions and from real to complex variables. *Mathematical and Computer Modelling, 46,* 860–891.

Sarvar, R., Rashidi Ebrahim Hesari A, Mousavi M.N, Orooji H. (2012). Optimum Location of Neighbourhood Parks in Bonab City Using Analytic Network Process (ANP). *J. Civil Eng. Urban. 2*(6): 226-234.