A Geographic Information System and Multi-Criteria Decision Analysis in Proposing New Recreational Park Sites in Universiti Teknologi Malaysia

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Abstract

Nowadays, human life is being sustained by recreation and leisure, which play an important role in the human lifestyle. Urban areas with recreational facilities such as green spaces attract the dwellers to pass their leisure time in such spaces where they can enjoy the benefits of nature. In any modern university like Universitit Teknologi Malaysia (UTM), recreational activities are very important activities that can improve the quality of students' lives and the learning environment as a whole. The recreational parks in UTM are not favourable in relation to their distances and locations from the students' residential zones. It becomes necessary to investigate suitable locations for a new recreational park in order to encourage students' participation in the activities of passive recreation. Therefore, this research was conducted on the UTM students with the aim of identifying whether the current recreational parks are efficient in relation to distances, locations, and facilities. Field survey has been conducted, which helped the researchers in coming up with some set of criteria. GIS tools were used in creating different datasets of the study area and the set of criteria generated were integrated into the Multi criteria Decision Process (MCDP). Pair-wise comparison method of Analytical Hierarchy Process (AHP) was used to evaluate the criterions obtained, and weightings were assigned and calculated. The results of the weightings obtained from this method finally identified the most suitable sites to locate the proposed recreational park.

Keywords: Geographic information system, Analytical hierarch process, Recreational park, Weighting system

1. Introduction

Organic and forest locations observed as recreational spaces have persistently received a greater significance for fairly some time (Lynn and Brown, 2003). Currently, human life is being sustained by recreation and leisure as they play an important role within the human day by day lifestyles. Consequently, demand has increased for recreation diversity with enhancement in transportation. Haphazard urban locations with recreational locations and facilities like green spaces motivate a lot of urban dwellers to pass their leisure time in the organic spaces where they can enjoy the benefits of nature rather than the urban areas (Gül and Gezer, 2004). As a result, the utilization of the natural green areas is of paramount importance. Organic locations that offer numerous recreational prospects provide people with lots of benefits physically and psychologically (Aslanboga and Gül, 1999). Hence, Planning for recreation is all about evaluating the demand, both the actual or present demand and the future demand; about evaluating the land capability to meet those demands; and about utilizing the resources which are available wisely (Bell 2001). The aim of recreational planning is to achieve a balance between the available resources and the requirements of the people based on the objectives of the planning body so as to improve the life of individuals.

Campuses are designed to be spacious and park-like naturally, in order to replicate nature and to be beautiful and beneficial (Turman, Morrison, & Gonsoulin, 2004). Campus recreational facilities tend to be mostly active in nature such as game facilities like badminton courts, basket courts, football pitch, beach ball, interior soccer, gymnasium and so on (Turman, Morrison, & Gonsoulin, 2004). More so campuses likewise have passive recreational facilities for example recreational park together with picnic places, sit-outs (along with or perhaps without canopies), stairways, water bodies, water fountains, beautiful green open areas and so forth. These facilities enable college students to refresh their own emotional feelings just like picnicking, studying in a very less formal way and many others. College recreation profoundly plays a part in enhancing students' learning skills and well being. Also it offers college students as well as experts along with life time studying opportunities (James C. Turman et al, 2009). The distribution of these services together with facilities to guarantee their effective management is another area of interest. People tend to be heterogeneous in character because of their individual differences; therefore, their own access to recreational services is definitely affected simply by the actual distribution of those facilities. Access to some services with fixed facilities is restricted by the distribution of the services in a given environment. Hence, GIS as a tool assists in dealing with recreational planning issues. According to Bruce (2001), "GIS is really a computer-based technology and methodology for collecting, managing, analyzing, modelling, and presenting geographic information for wide range of applications."

This paper presents the use of GIS technology in the selection of the most suitable sites for the proposed campus recreational park in UTM.

2. Study Area

The study area illustrated in figure 1 is located in Johor Bahru, which is located at the southern tip of Peninsula Malaysia and is the state capital of Johor. It is connected to Singapore via road and railway, and thus Johor represents Peninsula's southern gateway. The study area is the main campus of Universiti Teknologi Malaysia (UTM), which is located in Skudai, Johor. It is situated between the city of Johor Bahru and the Sultan Ismail Airport of Johor Bahru. The campus has a total of 1,145 hectares of land which is connected through Pontian-Johor Bahru expressway and its total built-up area is 600 hectares. In the year 2009, total number of building has increased to 580 from 295 in 1996 with estimated 893,000 m2 of floor space available.

Basically, the area of UTM Skudai campus is a mountainous area. The level of the height is between 12 meters until 150 meters from sea level. Located in the middle of the area of UTM is a number of small hills and between those hills, there is a small river which crated the recreational lake and river in UTM nowadays. Because of the existing hill in the center of UTM area, the development concept of centralization is applied. This concept is applied based on the original topography of UTM. This concept uses the main road and the ring road to circle all the facilities that have been located mainly in the center of UTM. UTM campus has a low development density where the development direction of UTM campus is outside the UTM center. The type of development shows the total separation between the different land uses such as student's hostels which are located far away from administrative area, faculty buildings, library and other infrastructure. The separation between the faculty buildings and the student's residential hostels encourage the use of personal vehicles. The arrangement of land use in UTM is based on zoning where faculty and administrative buildings are located inside the ring road and residential buildings are located outside the ring road. According to the UTM campus plan 1995, the UTM physical basic planning concept divided UTM campus into seven land use zones. The land use map is illustrated in figure 2.

3. Definition and Categories of Recreation

Understanding the correct meaning of the concept of recreation will allow us to understand the importance of recreational activities; hence have the ability to eliminate negative feedback (JPBD, 1997). The word recreation comes from the Latin word recriatio, which means "something refreshing and healing". Notwithstanding, the definition of recreation is according to opinion and philosophy that has been expressed about recreation. Therefore, the entire globe is a recreational space that was developed to offer actions like on-campus activities designed to attract all users to physical exercise and rest.

3.1. Categories of Recreation

There are mainly two classes of recreation, namely active and passive recreation. The active recreation is described as the mixture of uses like the neighbourhood park with various recreational activities (RPAP, 2006); whereas recreation which is stated to be passive is also a combination of uses on a land which is not fully built up but slightly improved for calm recreational activities, such as a neighbourhood park with aesthetic and ornamental sit-outs, pedestrian paths, garden, fountain, natural or artificial water bodies and with the exclusion of staffs for recreation (RPAP, 2006).

4. GIS and Multi-criteria Decision-Making

As GIS-based MCDM becomes one with the most helpful techniques for spatial planning and management (Joerin et al., 2001; Karnatak, et al., 2007; Chen et al., 2007; Chen et al., 2009), the request for tools supporting collaborative decisions have spiralled over the last decade (Chen, Y et al, 2009). GIS could be utilized to support spatial decision-making as it has excellent capabilities for dealing with spatial issues. Solving a complex multiple criteria problem without spatial analytical and visualization tools could be computationally challenging, if not impossible (Jones, 1997). Strategies with the Multi-criteria decision making as an independent tool have been computerized towards the extent that lots of software could be accessed and utilized. Though, it is unusual that such type of software programs will be capable of dealing with spatial problem within the form of maps. There exist two strategies: loose and tight, for coupling of GIS with MCDM techniques (Jankowski1995). In the loose coupling, it depends upon a file exchange mechanism which provides an interface between the two types of software program to communicate. Likewise, individual tasks are carried out in each of the software program. In performing land suitability analysis, choosing a set of criterions with their scores to ensure that the choice table could be exported into MCDM plan, GIS is utilized.

The MCDM component is used in executing the assessment of the multi-criteria and the outcome is conveyed again into the GIS environment for display. On the other hand, the tight coupling technique in its place is realized by way of a typical interface and database for GIS and MCDM. Combining GIS and MCDM is a powerful method in land suitability assessments (Chen, Y et al, 2009). In a nutshell, it implies that the multi-criteria evaluation functions are fixed into the GIS software program which will in turn help in carrying out projects with much less difficulty (Dano U.L et al, 2011). The benefit here is the fact that all the necessary functions are in place and problematic data trading is avoided. Although not all proprietary or licensed GIS have formed such a profound facility in its fundamental version, there are few examples like IDRISI, which make use of pair wise comparison and Analytic Hierarchy Process to assess weight scores (Clark Labs).

Another software, Spans, by Tydac Technologies has inbuilt weighted overlay functions, which are comparable to weighted summation Multi-criteria Evaluation (MCE) method (Carver, 1991). ESRI software program offers a cartographic modelling tool referred to as a Model Builder, which has the capability of dealing with comparable choice issues-that is why it demands some initial input of work. Generally, multi-criteria evaluation in relation to GIS could be done in two phases. Phase (i) field survey and phase (ii) preliminary site identification. During the initial phase, a site is screened for feasible alternatives using deterministic decision criteria. Here, all the areas that fall within the alternatives are regarded as having exclusion criteria (constraints) and are pointed out and excluded from the analysis. This phase is referred to as suitability analysis, usually performed manually i.e. manual map overlay; the former is modernized that is why these days there are GIS digital maps. Secondly, preliminary site identification as the number two phase is carried out by MCE techniques.

First of all, secondary locating elements will be detailed and weighted based on their own order of significance. The second stage allows dealing with multiple objective issues (Carver, 1991); (Jankowski, 1995). The idea behind the multiple criteria overlay was proposed by (McHarg, 1969), who recommended classifying the physical, economical and environmental criterions to be able to guarantee social and economic feasibility of the development.

4.1 Evaluation Criteria

Criterion evaluation is a term which encompasses each objective as well as attributes of multi-criteria decision issue (Malczewski, 1999). Some other writers described them as decision criteria or factors and scores correspondingly (Voogd, 1983); Carver (1991). Right here the objectives actually demonstrated the desirable state associated with a geographical space. They come up using the criteria that need to be satisfied in order to ensure they have the ability to make much better decision by either “minimizing” or “maximizing” some variables. Moreover, within the attributes, one will find some measures used in assessing the achievement degree of the criterion by each option. These evaluation criteria are displayed in GIS as thematic maps, which are otherwise referred to as theme or data layers. Decision attributes are needed to complete or attain several requirements. Within the initial location, the decision attributes are required to be quantifiable like assignment of numerical values that will perfectly evaluate the references or the achievement level of each objective. Secondly, in order to make it nice, understandable and unambiguous to decision makers, an attribute should clearly indicate to what degree the objective is accomplished. Therefore, for the choice of a correct set of evaluation criteria, literature study, analytical studies or survey of opinions ought to be carried out which will later be represented in the decision table. The decision table would have rows representing the alternatives, columns representing the criteria and fields for criterion scores. The field values are derived from spatial analysis. An additional table is constructed to weigh every criterion and then the total score for each alternative is calculated (Jankowski and Richard 1994).

4.2 Criterion Maps

Criterion maps form an output regarding evaluation criteria identification stage. This follows right after input of information into GIS (acquisition, reformatting, geo-referencing, compiling as well as documenting related data) saved in graphical and tabular type, manipulated and analyzed to acquire desirable info. Generally, with the help of numerous GIS techniques, a base map of the study area is created and utilized to produce a number of criterion maps. Each criterion is represented on a map as a layer in GIS atmosphere. Every map represents one criterion and can be known as a thematic layer or data layer. They signify in what way the attributes are distributed in space and how they assist in achieving the objectives. In other words, a layer represents a set of alternative places for a decision. The alternatives are divided into a number of classes or are assigned values to represent the level of preference of the alternative upon given criterion, which helps an individual to visualize many more and less desirable alternatives.

4.3 Assigning Weights

All data integrated into the spatial database require some manipulation and reclassification to create a standard scoring technique (I. Nyoman Radiarta et al, 2008). Criterion weights are usually determined in the consultation process with choice or decision makers (DM), which resulted in ratio value assigned to every criterion map. They reflect the relative preference of a criterion more than another. In such a case, they can be expressed in a cardinal vector of normalized criterion preferences:

w = (w1, w2… wj) and 0 <= wj <= 1

Normalization implies that the numbers sum up to 100 or to 1, depending on whether they are presented in percentage or ratio. Another way to express preferences is with regard to criterion scores, which have a form of cut-off values (minimum and maximum threshold) or desired aspiration levels (Jankowski, 1995). The second approach is more preferable in formulating location constraints. The task of assigning weights (deciding the importance of each factor) is usually performed outside GIS software; unless such a module is specially programmed or embedded in the proprietary GIS (compare Carver 1991, Jankowski 1995, Rapaport and Snickars 1998, Grossardt et al. 2001). The values of weights are then incorporated into the GIS-model. There are several techniques for assigning criterion weights. Some of the most popular include: ranking methods, rating methods, and pair-wise comparison method. A common characteristic of them is that they imply subjective judgment of the decision maker about relative importance of the decision factors. The basic idea of rating methods is to arrange the criteria according to its relative importance. Therefore in this study, the Analytical Hierarchy Process (AHP), which was proposed by Saaty in 1980, was used. AHP utilizes pair-wise comparison method for criterion weighting.

4.3.1 Analytical Hierarch Process

Analytical Hierarchy Process (AHP) has been incorporated into the GIS-based land use suitability procedures (Marinoni, 2004). It calculates the weightage of the required factors associated with criterion map layers adopting a preference matrix where all identified relevant criteria are compared against each other with reproducible preference factors (Chen, Y et al, 2009). The method is carried out in three steps. Firstly, pair-wise comparison of criteria is performed and results are put into a comparison matrix. The matrix is populated with values from 1 to 9 and fractions from 1/9 to ½ representing importance of one factor against another in the pair. The values in the matrix need to be consistent, which means that if x is compared to y, it receives a score of 5 (strong importance), y to x should score 1/5 (little unimportance). Something compared to itself gets the score of 1 (equal importance). The linguistic explanation of scores is attached to the table. The next step is to calculate criterion weights. Firstly, values from each column are summed and every element in the matrix is divided by the sum of the respective column. The new matrix is called normalized pair-wise comparison matrix. Finally, an average from the elements from each row of the normalized matrix is calculated. The consistency ratio (CR) is calculated in order to ensure that the comparison of criteria made by decision makers is consistent. The rule is that a CR less than or equal to 0.10 signifies an acceptable reciprocal matrix, whereas greater than 0.10 is not acceptable. Weights obtained by this method are interpreted as average of all possible weights. Moreover, the advantage of this method is that only two criteria need to be compared at a time (Malczewski, 1999).

5. Methodology

The methodology adopted in this research work is essential as it outlines the procedures necessary for relevant data collection and analysis. The study used primary and secondary sources of information. The primary data collection involved the field survey, which was based on the physical state of the current recreational parks on campus and the facilities present. Furthermore, questionnaires with a sample size of 180 students were used. These were distributed among the students in order to know whether the existing recreational parks are favorable in terms of locations, facilities provided therein, and accessibility. The second aspect involved secondary data collection, which comprises the collection of the existing base-map of the study area and the literature review. The collected data were run into a computer compatible format using ArcGIS 9.3. The following procedure was adopted in ArcGIS 9.3 for database development and analysis:

i. Spatial data collection and digitization in GIS: The data from the master plan map of the study area was obtained, scanned and digitized into ArcGIS 9.3 format. More so, data collected from field survey were also integrated and transferred into the GIS as well.

ii. Mapping-out the locations of the existing recreational parks together with the existing students' residential areas and available networks: This stage actually involved mapping-out the current recreational parks together with existing students' residential areas and available networks in the study area through digitizing so as to identify their various locations, and to typically understand their level of distribution.

iii. Database and criteria development: Here, database of the study area was developed based on the available datasets in a tabular form. Similarly, criteria and sub-criteria were developed together with the potentials and constraints based on the information obtained from the students through the questionnaires administered.

iv. Determination of weightages and suitability values of the recreational park's criteria: Here, the criteria were assigned weightings based on their order of importance that indicated high score during the questionnaire administration.

The study criteria were obtained through an extensive literature review and field survey. Some of the results of the questionnaire findings are illustrated in chart forms as shown figure 3 and 4. These include the questions pertaining to the best location to locate the proposed recreational park, which was used as one of the criteria. Secondly are the expected features to be present in the proposed recreational park.

The following criteria were used in the recreational park site selection decision making-: SHB: Students Hostel Buildings; ACB: Academic Buildings; Road: Road networks; Pedes: Pedestrian networks; LU: Land Use and Slope: Slope. The production of weights for the criteria was based on the following sequence of steps, as detailed in table 3 and 4.

Step I: Square pair-wise comparison matrix was formed as depicts in table 3 with judgments produced by summing the columns of the matrix.

As revealed from table 3 matrix interpretation, the Students Hostel Building (SHB) is the most important criterion; it is absolutely more important than the other criteria.

Step II: The matrix was then standardized by dividing each column entry by the column's sum, and the arithmetic average of each row in the standardized matrix was computed.

Step III (a): Because of the reason that individual judgments will never agree perfectly, the degree of consistency achieved in the ratings is measured by a Consistency Ratio (CR) indicating the probability that the matrix ratings were randomly generated. The rule-of-thumb is that a CR less than or equal to 0.10 signifies an acceptable reciprocal matrix, and ratio over 0.10 implies that the matrix should be revised- in other words it is not acceptable. The computation of Consistency Ratio was carried out in a few steps as follows; the weighted sum vector was determined by multiplying the matrix by the vector of the criterion weights (each column was multiplied by the corresponding criterion weights and the products were summed over the rows). The computation is illustrated in table 5:

Step III (b): The consistency vector was determined by dividing the weighted sum vector by the criterion weights; and the average value of consistency vector was computed.

Step III (c): Here the Consistency Index (CI) was determined. The calculation of CI is based on the observation that is always greater or equal to the number of criteria. If the pair wise comparison matrix is a consistent matrix, accordingly the number of criteria can be considered as a measure of the degree of inconsistency. This measure was standardized as follows:

Consistency Index (CI) = (λ-n)/ (n-1)

STEP III (c) : CONSISTENCY INDEX (CI)

$$CI = \frac{\lambda - n}{n-1} \quad 0.01$$

Step III (d): To compute the Consistency Ratio (CR);

Consistency Ratio (CR) = CI/RI

Where RI is the random index representing the consistency of a randomly generated pair wise comparison matrix. The value of RI depends on the number of criteria being compared.

STEP III (d): CONSISTENCY RATIO (CR)

$$CR = \frac{CI}{RI}$$,Where

N	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
RI	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

$$CR = \frac{0.01}{1.24} = 0.01$$, CR < 0.1: REASONABLE

The value of CR = 0.01 falls much below the threshold value = 0.1 and it indicates a high level of consistency.

For this reason the weights can be accepted.

6. Recreational Suitability Model

The Recreational Suitability Model as shown in figure 6 was developed based on study criteria namely, pedestrian paths, road networks, buildings, land use and contour. In building the model, the road and pedestrian networks were set at a distance and calculated, a process which produced road and pedestrian distances as the output results. Subsequently, the road and pedestrian distances were reclassified and produced the output result showing road and pedestrian reclassified. Secondly, in dealing with the students' residential buildings and the academic buildings, the building layer was used by selecting the students' residential buildings and academic building layers using the select function under extract in the ArcGIS 9.3. Distances were set and calculated based on the result of the field survey, and subsequently produced an output result named the students' residential building and academic building distances. The students' residential and academic building distances were reclassified based on their order of importance and produced a result called students' residential buildings and academic buildings reclassified. Moreover, the land use layer was converted to raster, whereby the output named as land use raster was reclassified. Here, only three categories of the land use were considered namely students' residential zone, academic area zone, and the green area zone. Based on the field survey conducted, most of the respondents voted the students' residential zone as the best location to site the proposed recreational park. The reclassification was done in order of importance. More so, the contour layer was as well converted to triangular irregular network (TIN) and produced an output called contour TIN. Subsequently, slope was calculated and an output named 'slope' was generated. These were then reclassified based on the degrees mentioned previously. Therefore, weighting of each criterion was calculated using pair-wise comparison method as explained above. The weightings which were obtained using Microsoft Excel were integrated into ArcGIS 9.3 in which a raster calculator was used by selecting all the reclassified layers of the criteria. Each criterion was multiplied by its weight plus another criterion. Hence, after the careful calculation, the first result for the most suitable sites to locate the proposed recreational park was generated. Furthermore, in showing the only available lands on which the suitability result falls, an 'erase' function of the ArcGIS 9.3 was used to erase the built-up areas, road networks with 15m buffer, existing recreational parks and the water bodies. But the limitation here is the utility line data which was not available. So, after the removal of the aforementioned existing layers, the final suitability results that fall on empty available lands were generated. Figure 6 illustrates the recreational suitability model obtained using a Model Builder function of the ArcGIS 9.3.

7. Results and Discussion

In generating the results for the suitable sites to locate the proposed recreational park, a raster calculator was used to calculate all the weightings assigned to each criterion in this study. Raster calculator is a Spatial Analyst function that provides a tool for performing multiple tasks. It allows one to perform mathematical calculations using operators and functions, set up selection queries, or type in Map Algebra syntax. The calculator is located on the Spatial Analyst toolbar drop down menu. It uses both "operators" and "functions" to perform tasks. Map algebra operators work with one or more inputs to develop new values; they are generally the same operators found on scientific calculators. The operators used most often are arithmetic, relational, Boolean, and logical. Figure 7 shows the illustration of how the calculation was done in the Raster calculator for all the criteria.

For clear understanding of the criterions in the Raster calculator, below are their complete denotations;

Acad_Class- Academic Area Buildings Reclassed

Hostel_Class- Student Residential Zone Reclassed

Ped_Class- Pedestrian paths Reclassed

Road_Class- Road Networks Reclassed

Slope_clas- Slope Reclassed.

LU_Class- Land Use Reclassed

As revealed clearly from figure 8 are the first suitability results that illustrate the most suitable and the non-suitable sites after a series of analyses explained previously. These results were achieved using a raster calculator based on the aforementioned weightings produced by pair-wise comparison techniques. The figure 8 portrays the results; the red color represents the most suitable sites to locate the proposed recreational park, which falls within the students' residential buildings, whereas the black color represents the non-suitable sites to locate the proposed recreational park. However since the proposed recreational park cannot be developed on the built-up areas, the final suitability map was produced. This is by using the ERASE function of the ArcGIS 9.3 to erase the built-up areas so that only the vacant and developable lands will remain. These processes were demonstrated in the recreational suitability model. The layers that were erased are the building layers, road layers, water bodies, and the existing recreational parks. More so, the analysis was limited by lack of relevant data such as utility line data.

Lastly, figure 9 portrays the final result of the analysis after erasing the built-up areas. As revealed from the diagram (fig 9), there are most suitable, suitable, moderately suitable, less suitable, and not suitable sites. The Students' areas as the most suitable sites are represented in red color which falls close to the students' residential buildings. These areas are in turn close to places like Kolej 15, Kolej 17, Kolej 14, Kolej Tun Fatima, Kolej Tun Razak, Kolej Tun DR Ismail, Kolej Tun Hussain, Kolej Tun Councellor, Kolej 9 and 10. Secondly, the Students' areas suitable sites represented in yellow color, which falls close to Kolej 16, between Kolej 13 and 14, Kolej 11, Kolej 9 and 10. Similarly, the rest of the layers such as the academic buildings layer and green area layer were as well illustrated and ranked into most suitable, suitable, moderately suitable, least suitable, and not suitable sites as portrayed previously. Therefore, the final result implies the outcome of the field survey that was integrated in the analysis is fully reflected in the GIS's final analysis result. This is because most of the respondents (students) preferred the proposed recreational park to be very close to their campus residential buildings rather than academic and green areas.

8. Conclusion

This research work has highlighted the efficacy of integrating GIS and Multi-criteria Decision Making in optimal sites selection for the proposed recreational park in the study area. The analytical strength of GIS and the accurate weighting capabilities of the Analytical Hierarchy Process (AHP) have been duly utilized. Consequently, it made it possible to identify the most suitable sites to locate the proposed recreational park. Therefore, areas that can be used in locating the proposed recreational park have been determined, such as the students' residential areas of the study area (Universiti Teknologi Malaysia). Passive recreational activities in the study area will ensure a viable one, considering the variety of regulations and guidelines imposed in planning for recreation in Malaysia obtained from the literature review, which formed part of the study criteria adopted.

References

Antonella Zucca et al. (2007). Application of spatial multi-criteria analysis to site selection for a local park: A case study in the Bergamo Province, Italy.

Aronoff. (1989). *Geographic Information System, A Management Perspective.* Ontario, Canada: WDC Publication.

Aslanboğa I and A Gül. (1999). Kemalpaşa ormanlarının rekreasyonel değeri (Recreational values of Kemalpaşa forests). Kemalpaşa Çevre ve Kültür Sempozyumu, Kemalpaşa Kaymakamlığı ve E.Ü. Araştırma ve Uygulama Merkezi, Izmir, Turkey, pp. 397–405.

Azilah Kasim, H. D. (2003). *Campus Recreation Univerisiti in North India.* Malaysia: Penerbit Universiti Utara Malaysia.

Bafna, S. (2003). Space Syntax: A Brief Introduction to Its Logic and Analytical Techniques. *Environment & Behavior* 35, no 1: 17-29.

Beale, L. (2001). *Review Report Modeling Access with GIS in Urban Systems (MAGUS).*

Berglund, S. (2001). Path-Based Accessibility. *Journal of Transportation and Statistics* 4(2/3).

Beale, L., H. Matthews, et al. (2003). Modelling Access with GIS in Urban Systems (MAGUS): capturing the experiences of wheelchair users. Area 35 (1).

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

Chen, Y. et al. (2009). *A GIS-Based Sensitivity Analysis of Multi-Criteria Weights.*

Clark, L. (1997). *The Effects of Compulsory Competitive Tendering on Grounds Maintenance,* Institute of Leisure and Amenity Management, Lower Basil don.

Dano Umar Lawal et al. (2011). *Framework for Recreational Park Suitability Sites.*

Forman and Godron. (1986). *Landscape ecology.*

Gehl, J. (1987). *Life between Buildings: Using Public Space.* New York, Van Nostrand Reinhold.

Gowda and Sridhara, 1999, p. 8).(Gowda, K. and Sridhara, M.V. (1999). Open space and green areas in Mysore City and planning strategies for the 21st century, Shelter, Vol. III No. 1, p. 22.).

Greenhalgh L and Worpole, K. (1996). *People, Parks and Cities,* HMSO, London.

Gül, A and A Gezer. (2004). Kentsel alanda kent ormanı yer seçimi model önerisi ve Isparta örneğinde irdelenmesi (Modeling proposal for the selection of urban forest location and its evaluation using Isparta city example). I. Ulusal Kent Ormancılıgı Kongresi (First National Urban Forestry Congress in Turkey) Ankara, pp. 365–382.

I. Nyoman Radiarta. (2008). GIS-based multi-criteria evaluation models for identifying suitable sites for Japanese scallop (Mizuhopecten yessoensis) aquaculture in Funka Bay, southwestern Hokkaido, Japan.

Jacek Malczewski. (2006). *GIS-based multicriteria decision analysis: a survey of the literature.*

James C. Turman et al. (2009). *Planning Principles for College and University Recreation Facilities.*

JPBD, J. P. (1997). Standards for Planning of Recreation ground Ministry of Housing and Local Government, Malaysia.

Lynn N. A., R. D. Brown. (2003). Effects of recreational use impacts on hiking experiences in natural areas. *Landscape and Urban Planning* 64:77–87.

M. Shahadat Hossain. (2009). GIS-based multi-criteria evaluation to land suitability modeling for giant prawn (Macrobrachium rosenbergii) farming in Companigonj Upazila of Noakhali, Bangladesh.

Marco Vizzari. (2010). *Spatial modeling of potential landscape quality.*

Molnar and Rutledge. (1992). *Anatomy of park.*

Mozafar Sharifi et al. (2009). Integrating multi-criteria decision analysis for a GIS-based hazardous waste landfill sitting in Kurdistan Province, western Iran.

San francisco department of recreation and parks. (2006). *Recreation and Park acquisition policy.*

Sharifi, M.A., van Herwijnen, M., van den Toorn, W. (2006). *Spatial Decision Support Systems.*

Turman Morrison & Gonsoulin. (2004). *Planning Principles for College and University Recreation Facilities.*

Welch, D. (1995). *Managing Public Use of Parks, Open Spaces and Countryside,* Pitman, London.

Table 1. Accessibility Criteria

Data Layers	Values	Total Scores of given points	Ranking
Students' Residential Buildings	0-250m	39	5
	251-500m	11	3
	501-750m	8	1
Academic Buildings	0-250m	19	3
	251-500m	30	5
	501-750m	6	1
Road Network	0-100m	20	3
	101-200m	28	5
	201-300m	2	1
Pedestrian Network	0-50m	31	5
	51-100m	14	3
	101-150m	7	1

Table 2. Natural and Physical Features Criteria

Data layers	Classes	Total Scores of given points	Ranking
Land Use	Students' residential zone	39	5
		33	4
		2	2
		6	3
	Green areas zone	36	5
		22	4
		17	3
		9	2
	Academic Areas zone	28	5
		24	4
		16	3
		10	2
Slope	0-10°	7	5
	11-20°	5	3
	>20°	3	1

According to I. Nyoman Radiarta et al, 2008, all data integrated into the spatial database need some manipulation and reclassification to create a standard scoring method. Similarly, the data in Table 1 and 2 above illustrate the field survey findings which were assigned a rank based on the score of each criterion. These were as well integrated into the GIS for spatial analysis and manipulation, and the final results were reclassified into standardized scorings for each criterion. The ranking was given from 1, as the least suitable to 5, the most suitable. Therefore, the above rankings were used in the GIS analysis of each criterion as will be seen in the pair-wise analysis using the steps in Fig. 5.

Table 3. First step in weightings calculation

STEP I						
	SHB	ACB	Road	Pedes	LU	Slope
SHB	1.00	4.00	4.00	2.00	0.50	4.00
ACB	0.25	1.00	0.50	0.33	0.25	0.33
Road	0.25	2.00	1.00	0.50	0.25	0.50
Pedes	0.50	3.00	2.00	1.00	0.50	3.00
LU	0.25	4.00	4.00	2.00	1.00	3.00
Slope	0.25	3.00	2.00	0.33	0.33	1.00
SUM	2.50	17.00	13.50	6.17	2.83	11.83

As revealed from the above matrix interpretation, the Students Hostel Building (SHB) is the most important criterion; it is absolutely more important than the other criteria.

Table 4. Step II and III in weightings calculation

STEP II						STEP III
SHB	ACB	Road	Pedes	LU	Slope	WEIGHT
0.40	0.24	0.30	0.32	0.18	0.34	0.30
0.10	0.06	0.04	0.05	0.09	0.03	0.06
0.10	0.12	0.07	0.08	0.09	0.04	0.08
0.20	0.18	0.15	0.16	0.18	0.25	0.19
0.10	0.24	0.30	0.32	0.35	0.25	0.26
0.10	0.18	0.15	0.05	0.12	0.08	0.11
1.00	1.00	1.00	1.00	1.00	1.00	1.00

Step II: The above table shows how the matrix was standardized by dividing each column entry by the column's sum, and the arithmetic average of each row in the standardized matrix was computed as shown in table 4 above. Likewise Step III (a) under table 5 below shows how the Consistency Ratio was calculated: Therefore, because of the reason that individual judgments will never agree perfectly, the degree of consistency achieved in the ratings is measured by a Consistency Ratio (CR) indicating the probability that the matrix ratings were randomly generated. The rule-of-thumb is that a CR less than or equal to 0.10 signifies an acceptable reciprocal matrix, and ratio over 0.10 implies that the matrix should be revised- in other words it is not acceptable. The computation of Consistency Ratio was carried out in a few steps as follows; the weighted sum vector was determined by multiplying the matrix by the vector of the criterion weights (each column was multiplied by the corresponding criterion weights and the products were summed over the rows). The computation is illustrated in table 5 below:

Table 5. Consistency Ratio (CR) Calculation

STEP III (a)

SHB	1.00	4.00	4.00	2.00	0.50	4.00
ACB	0.25	1.00	0.50	0.33	0.25	0.33
Road	0.25	2.00	1.00	0.50	0.25	0.50
Pedes	0.50	3.00	2.00	1.00	0.50	3.00
LU	0.25	4.00	4.00	2.00	1.00	3.00
Slope	0.25	3.00	2.00	0.33	0.33	1.00

×

0.30	0.06	0.08	0.19	0.26	0.11

=

							SUM1
SHB	0.30	0.24	0.34	0.37	0.13	0.45	1.83
ACB	0.07	0.06	0.04	0.06	0.07	0.04	0.34
Road	0.07	0.12	0.08	0.09	0.07	0.06	0.49
Pedes	0.15	0.18	0.17	0.19	0.13	0.34	1.16
LU	0.07	0.24	0.34	0.37	0.26	0.34	1.63
Slope	0.07	0.18	0.17	0.06	0.09	0.11	0.69

Step III (b): The consistency vector was determined by dividing the weighted sum vector by the criterion weights; and the average value of consistency vector was computed as shown in table 6 above.

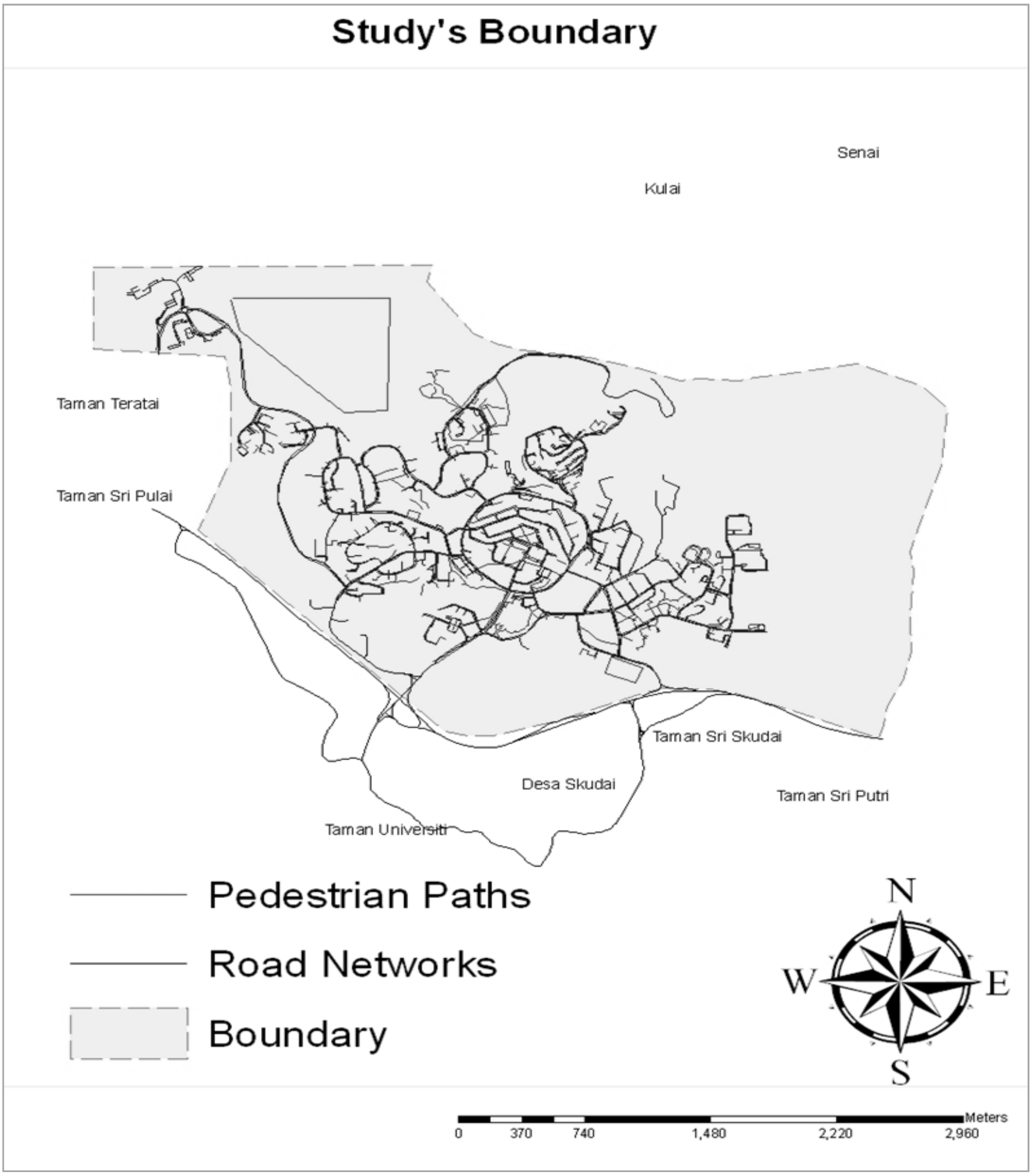

Figure 1. Study Area obtained with the aid of ArcGIS Software

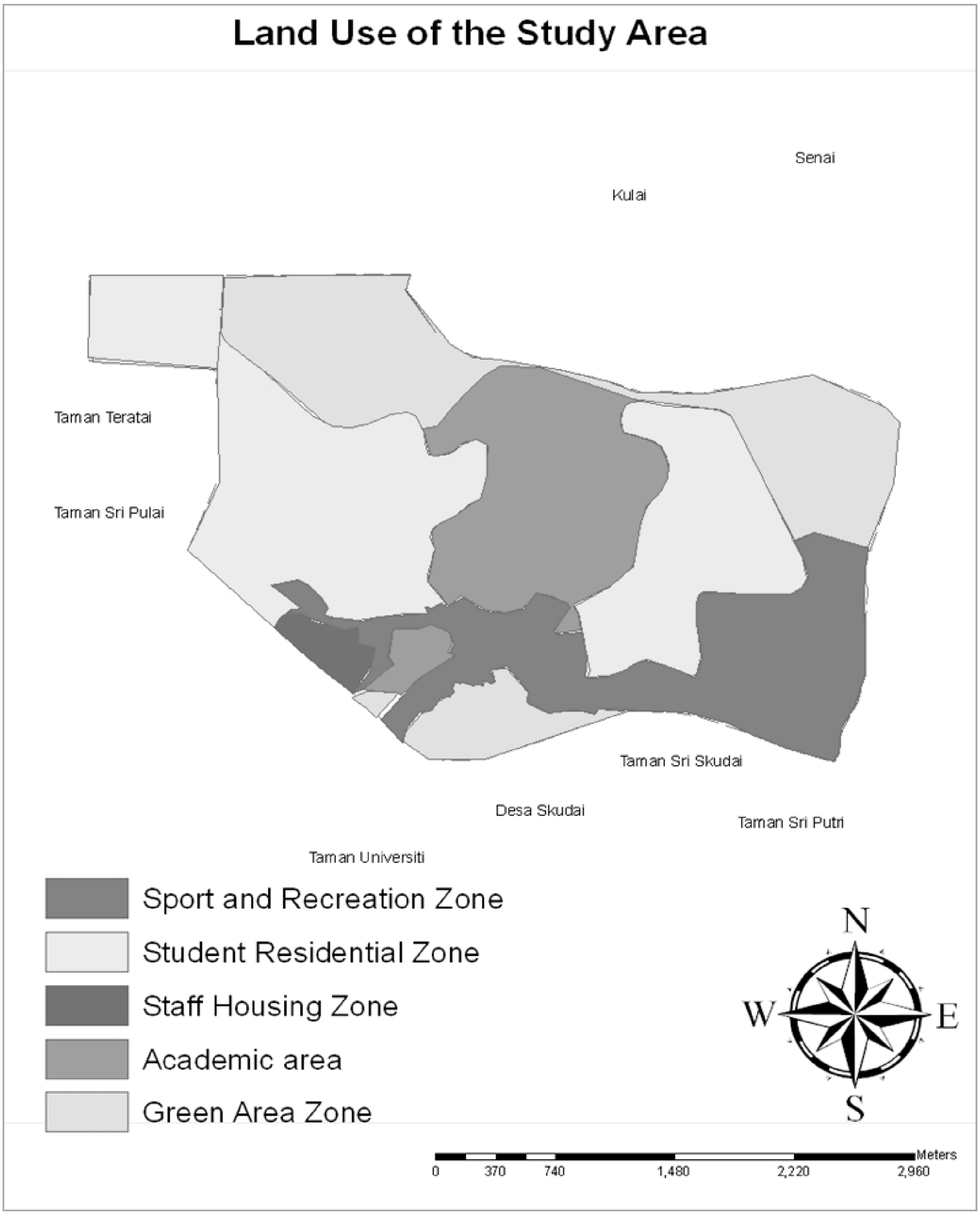

Figure 2. Land use map of the study area obtained with the aid of ArcGIS Software

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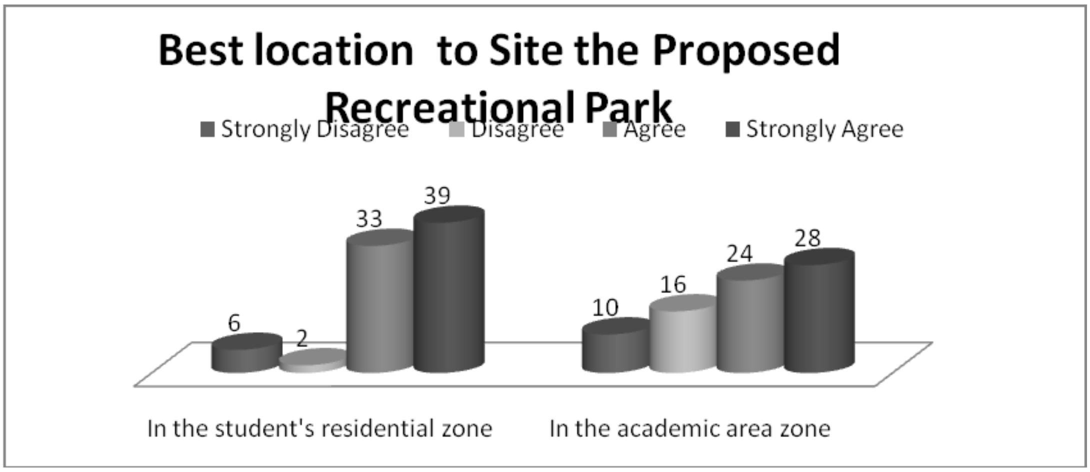

Figure 3. Best location to Site the Proposed Recreational Park

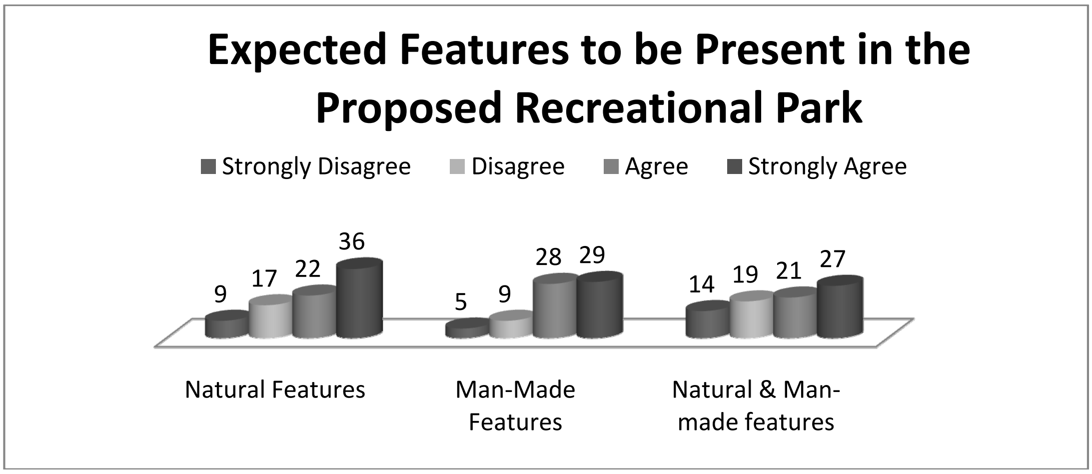

Figure 4. Expected Features to be Present in the Proposed Recreational Park

The above figures, 3 and 4 presents some of the results of the questionnaire findings in chart forms, which include the questions pertaining to the best location to locate the proposed recreational park, which was used as one of the criteria. Secondly are the expected features to be present in the proposed recreational park.

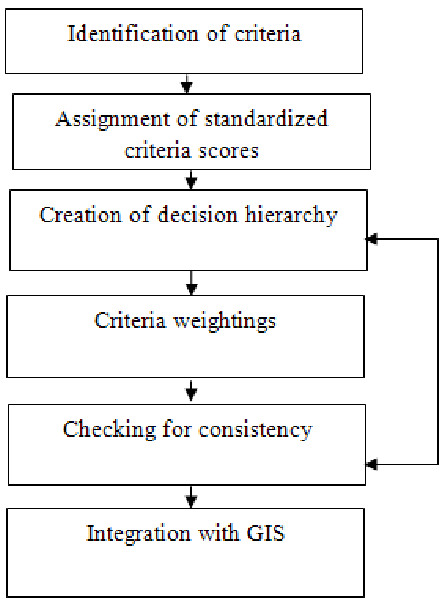

Figure 5. Steps in pair wise comparison method

The above figure presents the steps adopted in the pair-wise comparison method using Microsoft Excel.

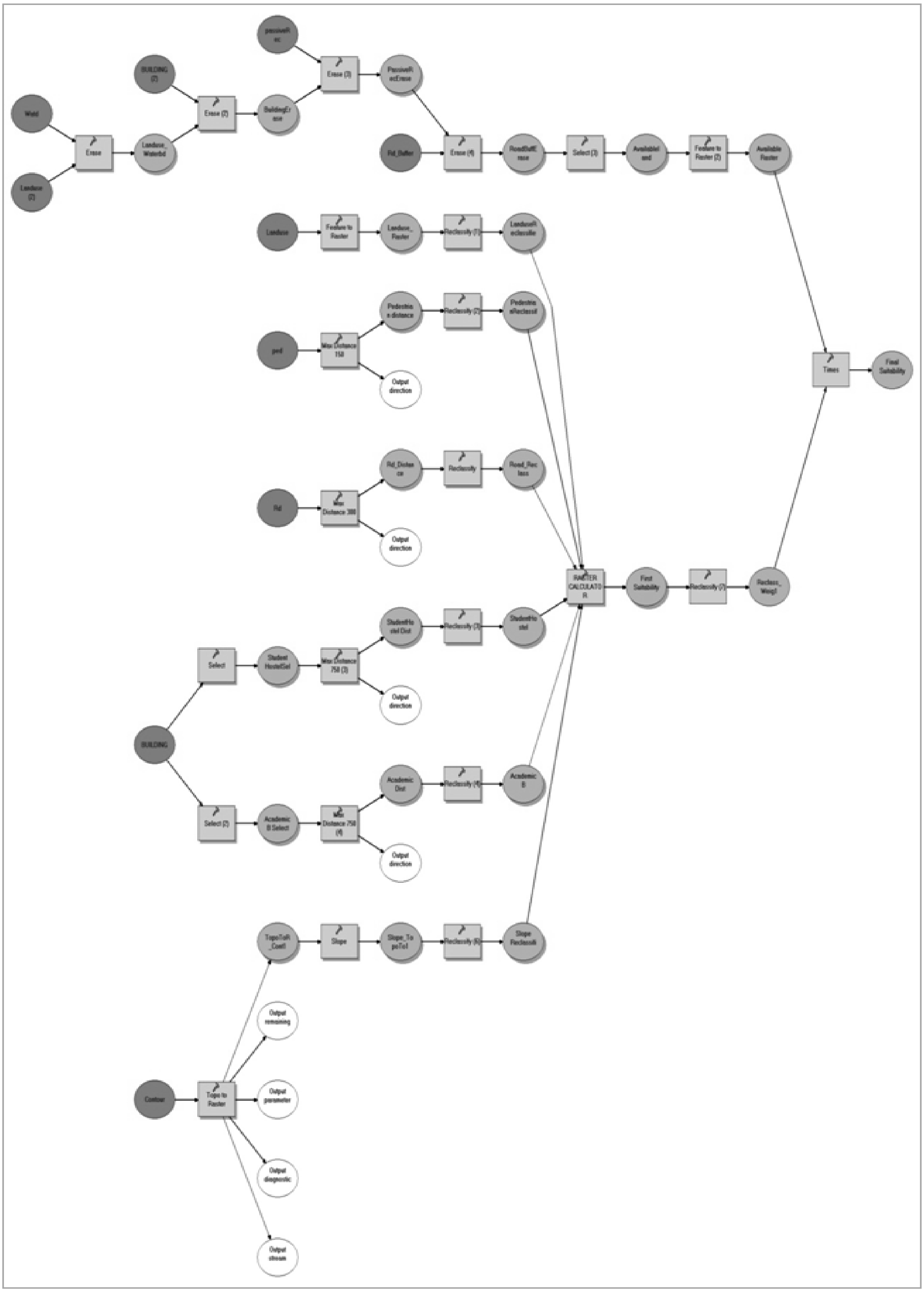

Figure 6. Recreational Suitability Model

The above figure illustrates the Recreational Suitability Model, which was developed based on study criteria namely, pedestrian paths, road networks, buildings, land use and contour.

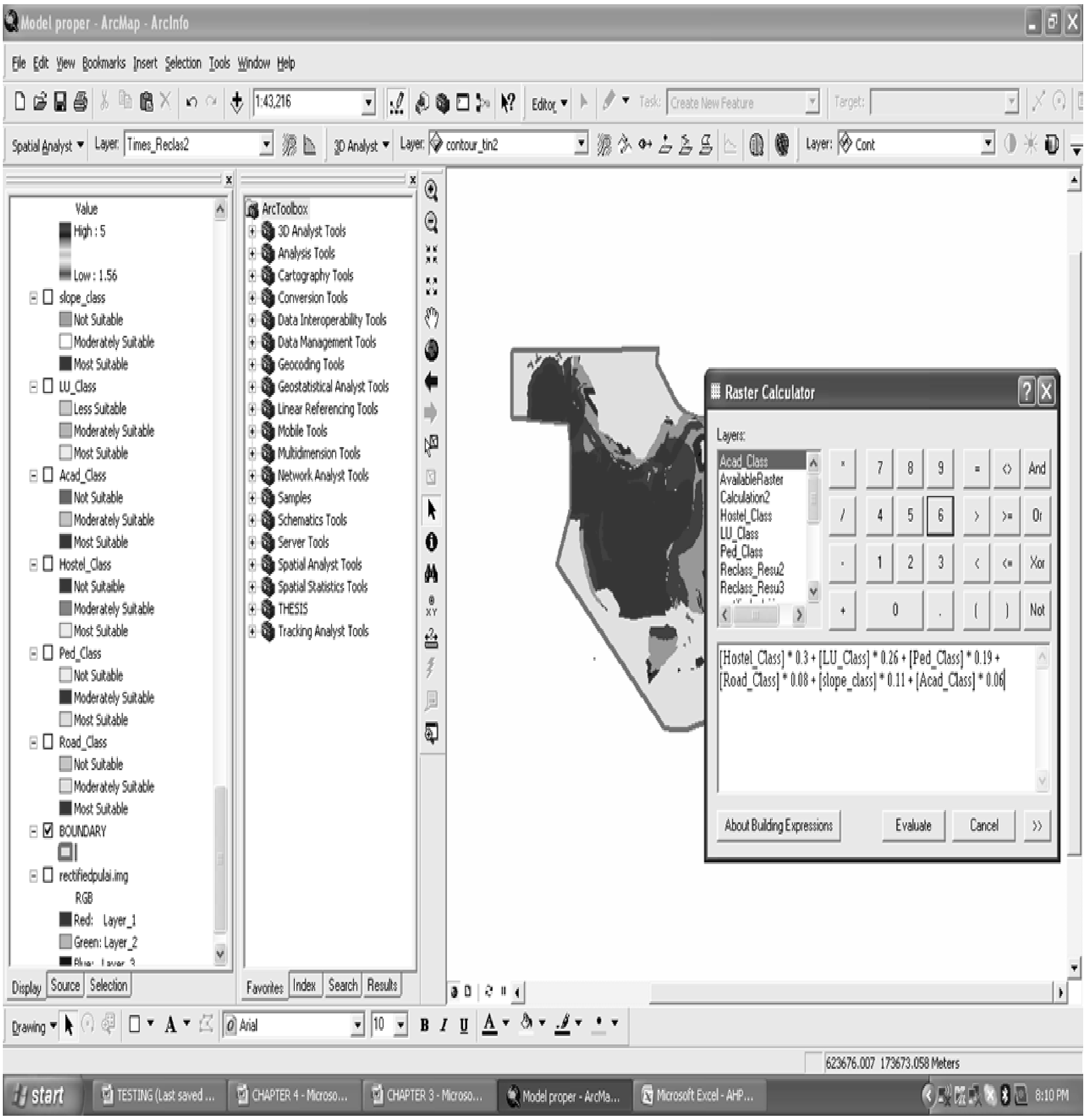

Figure 7. The Raster calculation

The above figure illustrates how the raster calculator embedded in ArcGIS 9.3 was utilized in generating the results for the suitable sites to locate the proposed recreational park. The raster calculator was used in calculating all the weightings assigned to each criterion in this study.

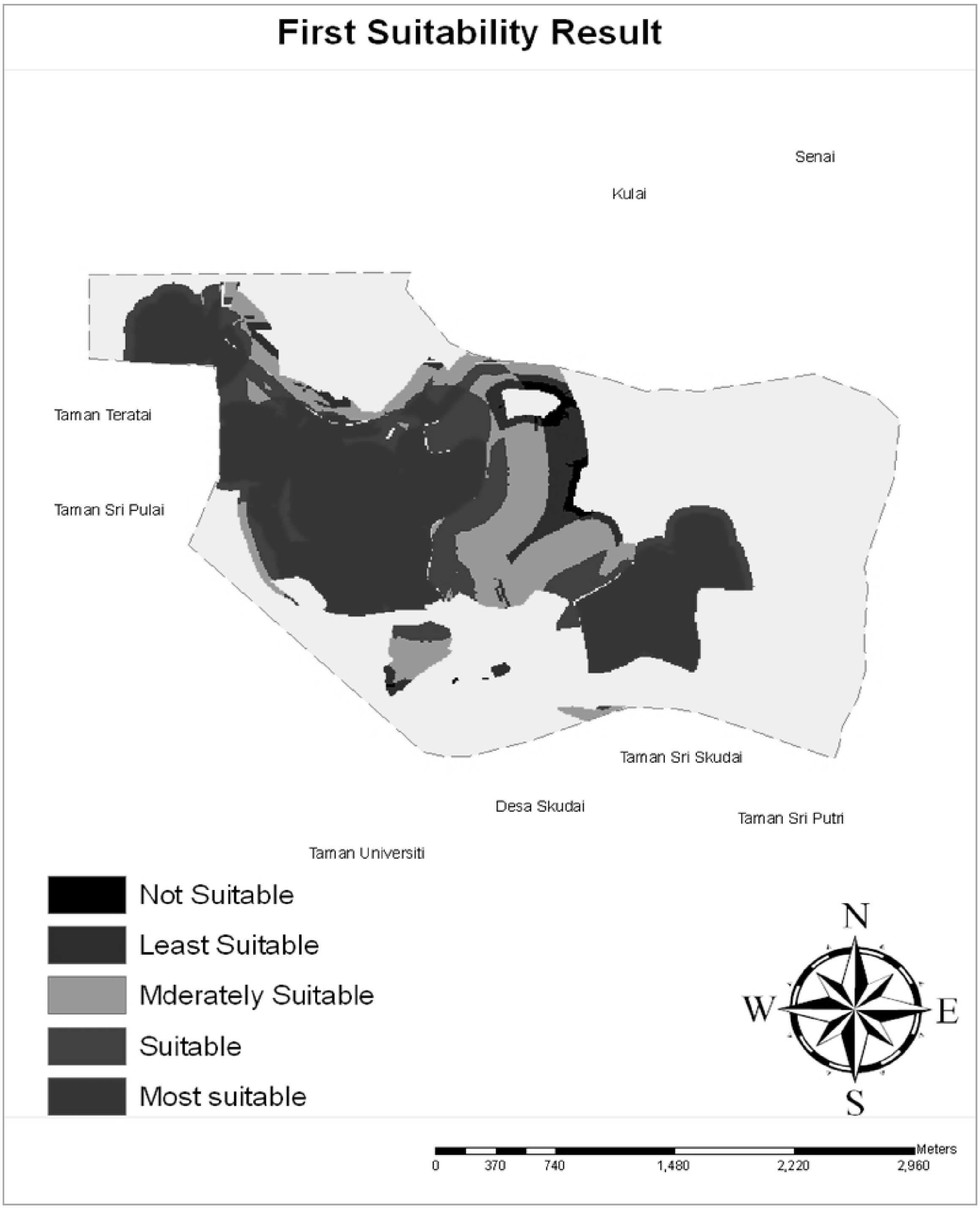

Figure 8. First Suitability Map

As revealed clearly from the above figure are the first suitability results that illustrate the most suitable and the non-suitable sites after a series of analyses explained previously. These results were achieved using a raster calculator based on the aforementioned weightings produced by pair-wise comparison techniques

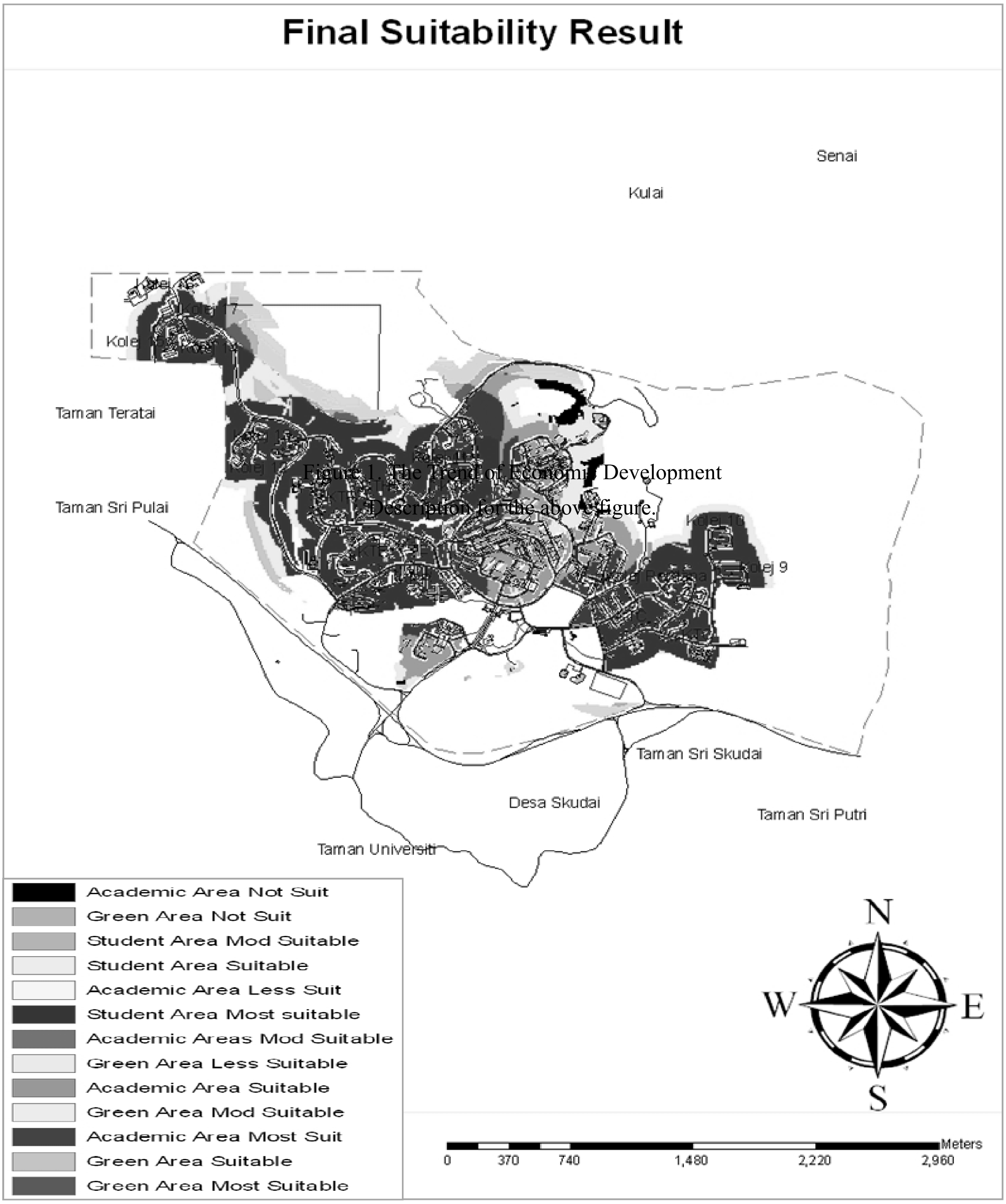

Figure 9. Final Suitability Map

The figure above portrays the final result of the analysis after erasing the built-up areas. As revealed from the diagram above, there are most suitable, suitable, moderately suitable, less suitable, and not suitable sites.