UNIVERSITI PUTRA MALAYSIA

INTEGRATION OF GEOGRAPHICAL INFORMATION SYSTEM AND MULTI CRITERIA EVALUATION FOR IDENTIFICATION OF SUITABLE URBAN SCHOOL SITES

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ITMA 2010 9

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By

ZUBAIDAH BINTI BUKHARI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

NOVEMBER 2010

DEDICATION

Dedicated to my husband, kids, mom,
sisters and brothers

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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NOVEMBER 2010

Chairman : Associate Professor Ahmad Rodzi Mahmud, PhD

Faculty : Institute of Advanced Technology

Schools which are located in a strategic, healthy and safe area play an important role in improving students' performance and excellence. To ensure both success and long-term sustainability of the school planning, the finding of suitable sites for school is important and challenging. This study delves into a systematic site selection process to establish a new primary public school. It was carried out through the use of Geographic Information System (GIS) and multi criteria evaluation model (MCE). Decision makers' evaluation and community opinions have been used for developing a set of school siting criteria and school planning data model which were used to design a number of potential sites by using the spatial analysis model. Mukim Batu which is located in the Federal Territory of Kuala Lumpur (WPKL) had been selected as the study area. The demography analysis identified 18.1% of the study area is in rapid growth while the safety analysis identified 17.3% of the area is in a safe zone. Constraint analysis identified 5% of the study area is suitable for school development. Weighted Linear Combination (WLC) technique had been used to combine the 3 analyses namely demographic, safety and constraint analysis to identify 6

potential sites. The accessibility analysis was used to further analyze the potential sites by using community opinions. The potential sites were compared with the field validation data and it was found to be reliable. This study has improved the school planning guideline and has brought a new approach for school site selections which combine the decision makers and community needs in the school site selection on the decision making process.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

INTEGRASI SISTEM MAKLUMAT GEOGRAFI DAN MODEL PENILAIAN PELBAGAI KRITERIA UNTUK MENGENALPASTI KESESUAIAN TAPAK SEKOLAH DI BANDAR

Oleh

ZUBAIDAH BINTI BUKHARI

NOVEMBER 2010

Pengerusi : Profesor Madya Ahmad Rodzi Mahmud, PhD

Fakulti : Institut Teknologi Maju

Sekolah yang terletak di dalam kawasan yang strategik, sihat dan selamat memainkan peranan yang penting di dalam meningkatkan prestasi kecemerlangan murid-murid. Proses pembinaan sekolah merupakan tugas yang penting dan mencabar kerana pelbagai faktor perlu diambilkira sebelum pembinaan sekolah dimulakan. Kajian ini menyiasat mengenai proses pemilihan tapak yang sesuai bagi pembinaan sekolah yang lebih sistematik. Sistem Maklumat Geografi (GIS) dan Model Penilaian Pelbagai Kriteria (MCE) telah digunakan bagi menjalankan kajian ini. Satu set kriteria dan model data sekolah telah dihasilkan dengan mengambilkira pendapat daripada pembuat keputusan dan komuniti di mana ia telah berjaya menghasilkan senarai tapak sekolah yang berpotensi menggunakan model analisis geospatial. Mukim Batu yang terletak di Wilayah Persekutuan Kuala Lumpur (WPKL) telah dipilih sebagai kawasan kajian. Analisis demografi yang dilaksanakan telah mengenalpasti bahawa 18.1% dari keseluruhan kawasan kajian berada di kawasan yang mempunyai penduduk yang padat, manakala analisis sekolah selamat mendapati 17.3% dari keseluruhan kawaan kajian berada di zon

selamat. Peta kekangan pula mendapati hanya 5% dari keseluruhan kawasan kajian sahaja yang sesuai untuk pembangunan sekolah baru. Teknik WLC telah digunakan bagi menggabungkan ketiga-tiga analisis tersebut iaitu analisis demografi, analisis sekolah selamat dan analisis kekangan di mana sebanyak 6 tapak telah dikenalpasti untuk pembinaan sekolah baru. Kesemua tapak tersebut telah dianalisa dengan lebih lanjut menggunakan analisis kemudahsampaian di mana pandangan daripada masyarakat telah diambilkira. Keputusan akhir yang di dapati dari model tersebut telah dibandingkan dengan kajian lapangan dan didapati ianya adalah sesuai. Kajian ini telah menambahbaik garis panduan perancangan perletakan sekolah dan menemukan pendekatan baru di dalam proses pemilihan perletakan sekolah dengan menggabungkan pendapat daripada pembuat keputusan dan kehendak komuniti.

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I certify that a Thesis Examination Committee met on 3 November 2010 to conduct the final examination of Zubaidah binti Bukhari on her thesis entitled “Integration of Geographical Information System and Multi Criteria Evaluation for Identification of Suitable Urban School Sites” in accordance with the Universities and University College Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998 The committee recommends that the student be awarded the Master of Science.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously and is not concurrently submitted for any other degree at Universiti Putra Malaysia or other institutions.

ZUBAIDAH BINTI BUKHARI

Date: 3 November 2010

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LIST OF ABBREVIATIONS

AHP	Analytical Hierarchy Process
API	Air Pollution Index
DBKL	Kuala Lumpur City Hall
DEM	Digital Elevation Model
DEO	District Education Office
EPRD	Educational Planning and Research Development
EPU	Economic Planning Unit
ERD	Entity Relationship Diagram
GIS	Geographic Information System
IDW	Inverse Distance Weighting
JPBD	Town and Country Planning Department of Peninsular Malaysia
JPWPKL	Education Department of Federal Territory of Kuala Lumpur
JUPEM	Department of Survey and Mapping Malaysia
MCDA	Multi Criteria Decision Analysis
MCE	Multi Criteria Evaluation
MODM	Multi Objective Decision Making
MOE	Ministry of Education
MyGDI	Malaysian Geospatial Data Infrastructure
RDMS	Relational Database Management System
SED	State Education Department
SPSS	Statistical Package for the Social Sciences
SQL	Structured Query Language

GLOSSARY OF TERMS

Geospatial Analysis	Quantitative study of phenomena located in space exploiting their spatial component or locations in space
KML	KML, or 'Keyhole Markup Language', is an XML grammar and file format for modeling and storing geographic features such as points, lines, images, polygons, and models for display in Google Earth, Google Maps and other applications. KML can be use to share places and information with other users of these applications. A KML file is processed by Google Earth in a similar way that HTML and XML files are processed by web browsers. Like HTML, KML has a tag-based structure with names and attributes used for specific display purposes. Google Earth acts as browsers of KML files.

CHAPTER 1

INTRODUCTION

This chapter provides the background of the study, the problem statement, the objective, the scope and the significance of the study. The last section explains how the thesis is organized.

1.0 Study Background

Malaysia, as a fast developing country, has given so much emphasis in education. In order to upgrade the educational system in both urban and rural areas, our former Prime Minister, Datuk Seri Abdullah Badawi allocated an effective financial plan to conform Malaysia's aspiration in making human capital as the core national development. In the 9th Malaysia Plan (2006-2010), The Ministry of Education (MOE) of Malaysia has been allocated RM23,198 billion to fund the education development programme within the five years period. From the national budget, 10.5% was allocated to the MOE, placing the second ranking after The Prime Minister's Department. From the allocation given, RM16,963 billion has been located for the education development. During the period, 396 new schools were built. There were 178 primary schools and 218 secondary schools (UHEP, 2007). For the new 2010 budget which was presented on the October 23rd 2009 by the Prime Minister of Malaysia, Dato' Sri Najib Tun Razak, a total of 1.6 billion for the construction of 80 primary and secondary public schools to allocate the education development. This figure shows that school planning is important and a big allocation has been allocated for a school planning.

A perfect and systematic school planning can determine a safe, effective and conducive learning environment to strengthen the foundation of students' excellence. The Minister of Education, Tan Sri Muhyidin bin Mohammad Yassin mentioned that the ministry would emphasize three major aspects in building new schools. The first aspect to be considered is the site should have a minimum physical constraint such as landslides. The second aspect is the location should be accessible to basic amenities such as water and electric supply. The third aspect is the school construction should meet the demand of the local people to avoid small enrolment of students.

Nearly 5 million students and 260 thousands school teachers (Educational Planning and Research Division, 2009) spend 5 to 8 hours or more of the nation's approximately 10,000 public schools. They need to attend academic classes in the morning and co-curriculum activities in the evening. They spend almost half of their age in the school environment since five or six years old (when entering the kindergarten) until 18 years old (when almost all of them complete their secondary level). In order to protect these young generation, schools should be in safe and healthy conditions. Most of these schools are well located. However, there are the existence of several schools which are located in risky areas such as an industry area, main road, highway, floodplain or other hazardous areas that threaten the health and safety of children and school workers ee(McConnell et al., 2006; 2008).

Current research shows that there have been increasing numbers in children disease such as cancer, asthma and learning disabilities (Gauderman et al., 2005; McConnell et al., 2006). In Malaysia, 67,792 new cases of cancers has been reported in the years 2003-2005 which 29,596 represented the number of males (43.7%) and 38,196 represented the number of female (15.9%). These figures have estimated that in every 7 males there will be 1 male who is infected by cancer, and 1 in every 6 females. It was also reported that the most frequent cancers in males by age groups (0-14) were Leukaemia (47.6%), Brain (11.2%), Lymphoma (9.5%), Kidney (3.9%), Bones (3.7%), Testis (3.2%), Eye and Adnexa (3.2%), Connective Tissues (3%), Adrenal Gland (2) and Nasopharynx (1.8%). Ten most frequent cancers in females by age groups (0-14) were Leukaemia (45.4%), Brain (14.3%), Lymphoma (6.2%), Bones (4.3%), Kidney (3.6%), Connective Tissues (3.5%), Liver (3.3%), Eye and Adnexa (3.1%), Ovary (2.3%) and 1.6% represent other ill-defined sites (2008). One of the causes of a childhood leukemia is an exposure to external risk factors such as ionizing radiation, chemicals and drugs (Sadanandan, 2009). Meanwhile, a research done by McConnell et al.(2006) found that a larger risk of asthma is associated with long-term residence within 75 m of a major road.

Malaysia has 9,844 schools, 5,416,924 students and 264,259 school teachers (Educational Planning and Research Division, 2009). According to the Department of Statistics (2000), these figures would rapidly increase. The population growth rate was 2.3% by the year 1970 to 1980 and 2.6% by the year 1991 to 2000. This rate shows that the total population of Malaysian students would double in every 23 years. As the population grows, the rising expectations from parents and community are creating challenges for education planning. One of the challenges is to find suitable school locations that can accommodate the students' population growth.

Another challenge for education planners is to plan a good location for school with the existing resources that provide students with good infrastructures and accessibility. By locating schools proximity to existing infrastructures and utilities such as streets, water and electricity supply, the planners can reduce the cost and the need for new facilities. The integration of schools into existing infrastructure and neighborhoods also provide students with practical opportunities and accessible to natural resources. Traditionally, public schools in Malaysia were located near to the students' residence. As a result, many of them can walk or cycle to schools. However, the rapid development and expansion of city causes schools are commonly located on inexpensive land nearby or on contaminated property and beyond the reasonable walking or cycling distance. Parents are in need to find transportation for their children to be at school. This scenario leads to the raising of traffic and congestion whilst contributing to air and water pollution.

Several studies have focused on school sites issue but they focused in different kinds of objective (Abdullah, 2008; Aziz, 2004; Fauzi, 2005; Ibrahim, 2005). Abdullah and Aziz emphasized in relocating school siting, Fauzi focused in existing school analysis while Ibrahim focused in generating school siting for future school. Apart from all the research above there are still lacks of research to identify school site selection that can safeguard schools children safety, accommodate the enrolment growth and population with good infrastructures and accessibility. The previous study focused in solving the school siting issues without integrating the community needs and they did not emphasized to build a school planning data model which is the important contribution to education planning. This study is intended to improve the quality of the school location's decision and solution by integrating school planning guidelines, community needs and Geographic Information System (GIS) into the decision making process.

1.1 **Problem Statement**

School site selection process is important and challenging because there are various factors that need to be considered before school construction projects begins. There are growing needs to protect children against hazard threats as numerous schools can be found closely located to a potential polluted environment. In order to mitigate the hazards, schools should be well planned according to the proper guide line to ensure that schools are far from polluted environment such as vehicular-traffic related emissions which one of the major source of air pollution, especially in urban areas. There are also serious needs to find a suitable location for future school that can accommodate the enrolment and population growth with proper infrastructures and accessibility.

The school planning in the strategic area can help students to increase their knowledge and excellence. However the development rapidity especially in town area causes the school location closely placed to a busy road and the industrial area. Students cannot walk or cycle to schools because the safety issue. This problem is being compounded with the rapid growth of vehicles on road which cause severe general road congestion daily especially during peak hours.

The planning activity and school construction need to be plan every five years in conjunction with the Malaysia Five-year plan and it require complete and up-to-date information to reflect the education scenario and development issue. In order to get the up-to-date information, planners at the Ministry of Education level need to rely on the report prepared by the State Education Department (SED), which in turn have to wait for the list from District Education Office (DEO) (Figure 1.1).

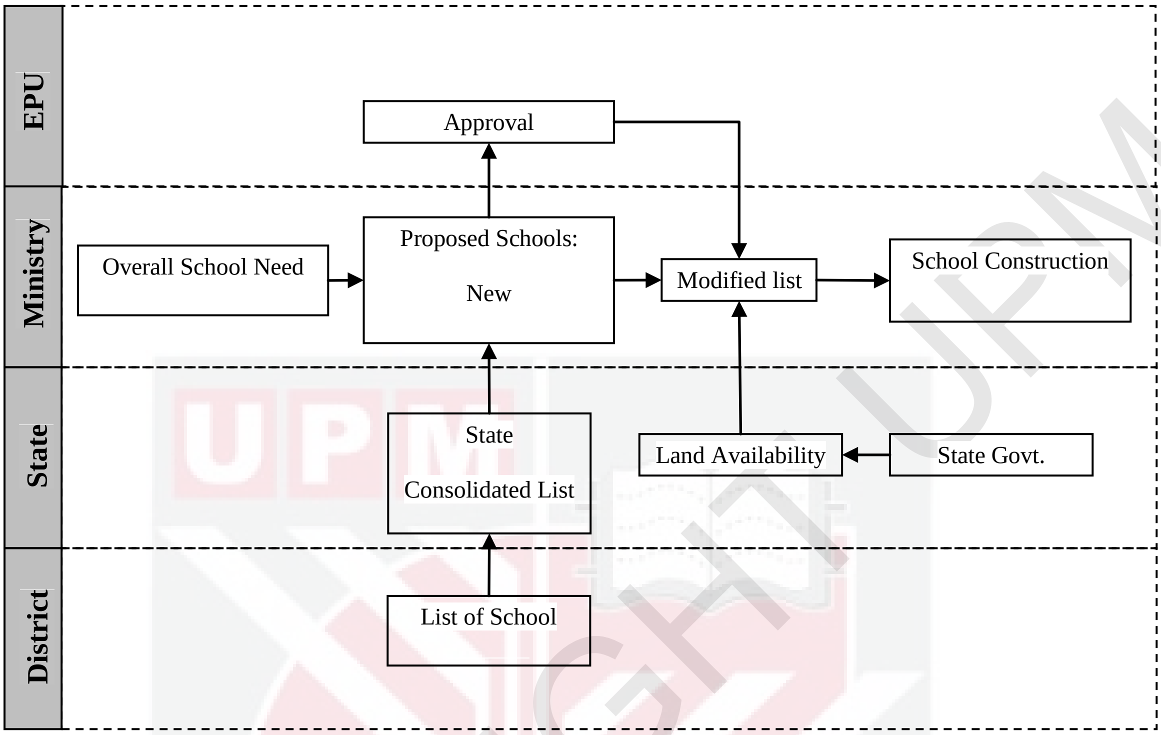


Figure 1.1: School Planning Process
Source:(Aziz, 2004)

The planners usually agree the list of suggested school projects prepared by the State Education Department (SED) provided that the overall estimated cost does not exceed the allocation for that particular state. After the proposed list is approved by the Economic Planning Unit (EPU), the planners have to go back to State-level officers to discuss about the approved projects. The SED in turn has to consult the State Government for land acquisition. This is the major problem because planners at the ministry level have to wait for the information from the lower levels and the time taken to reach the Ministry is considerably long.

The school planning in Malaysia is currently based on specific criteria in the Town and Country Planning Department Peninsular Malaysia, JPBD (1997) guidelines to determine the most suitable site for a school siting. The criteria are both constraints and factors for an ideal school sites. However, some difficulties arise to translate the school planning guidelines to school planning criteria and parameters, since there are lacks of standards in the guidelines. Most of the guidelines do not use compulsory language. Instead, the advisory language or suggestive one is commonly used. Therefore, there are strong needs to investigate and to compare the guidelines used by other countries in order to find a complete and reliable list of criteria in finding the most suitable school location focusing on children's safety, demography, infrastructure and accessibility.

1.2 Aim

The aim of the study is to effectively identify a suitable school location for primary school siting by using Geographical Information System(GIS) and Multi Criteria Evaluation(MCE) which focusing on children's safety, demography, infrastructure and accessibility.

1.3 Objectives of the Study

The objectives of the study are:

i. To develop a school planning data model for educational planners especially in Educational Planning and Research Development (EPRD) for planning and speeding up the decision making process.

ii. To translate and improve school planning guidelines into planning criteria and parameters, so that it can provide a platform for a systematic planning management

iii. To identify a strategic primary school location using the multi criteria decision analysis (MCDA) and geospatial analysis.

1.4 Significance of the Study

The study of school siting is necessary for improving the educational system specifically on the school site selection. The concern is that, there have been lacks of research in school siting focusing in school safety, demography and accessibility. This study hopes to:

i. establish a school planning framework that allows flow of data from top-bottom and vice versa for planners to speed up the decision making process.

ii. increase the efficiency of the school planning system by providing a set of suitability criteria for locating a better school site selection.

1.5 Scope of the Study

The scope of the study covers and limited to the following:

i. The study will be limited to one Mukim only. The proposed study area is Mukim Batu.

ii. Only national primary schools have been considered in this study.

iii. The planning is confined to a location planning only. Other aspects of planning involving manpower and costs are not considered.

iv. The basic of planning is only based on the Ministry of Education requirement.

1.6 Study Area

The case study is focused on Mukim Batu (Figure 1.2) located in Malaysia of Federal Territory of Kuala Lumpur (WPKL) which covers approximately 5300 ha, It has an estimated population of 250,000 in 2000. Located geographically between 3º10'- 3º15' North and 101º36' - 101º41' East, it consists of 49 areas with Sentul covers almost 13% of the area, followed by Jinjang Utara (10%), Segambut Jaya (8%), Jinjang Selatan Tambahan (5.5 %), Kg Palimbayang (5.5%) and Segambut (5%). The other area contributed less than 5% of the study area.

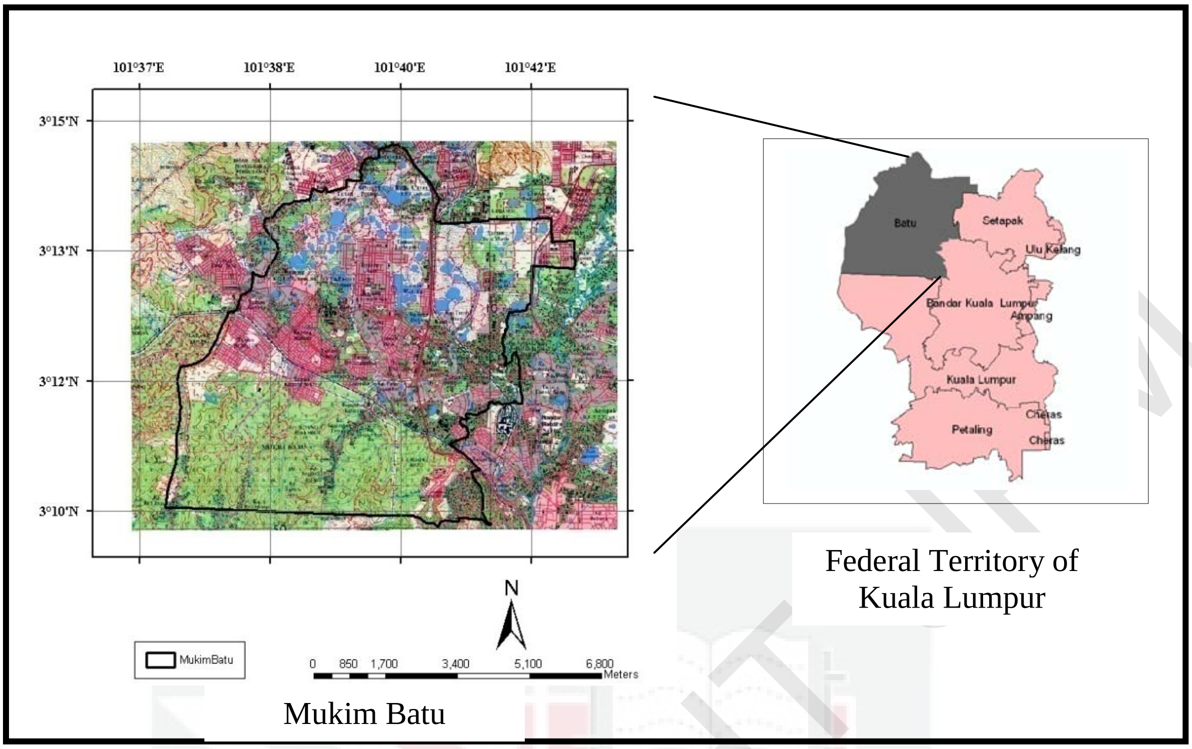


Figure 1.2. Study Area

1.7 Thesis Organization

This thesis is divided into 5 chapters. The first chapter contains introductory materials. These comprise the background of the study, problem statements, the objective of the study and the scope of the study. In chapter 2, a literature review of researchers and guidelines related to proposed study is presented. Chapter 3 explains on the methodology of the proposed model for a school site selection. Chapter 4 describes the analysis done using the proposed methodology. Chapter 5 examines and concludes the result of the analysis done in the proposed methodology.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter starts with the definition of public schools in Malaysia. The discussion then moves to investigation and comparison of the school site selection guidelines from the local government guidelines and other selected countries guidelines. This is followed by the definition of geospatial analysis, spatial data model, entity relational diagram (ERD) and Spatial Multi Criteria Decision Analysis (SMCDA).

2.1 National Education System

Malaysia as a fast developed country has played an important role in education. Within the 52 years since independence, education system in Malaysia has undergone great changes and development. From a various and fragmented system of education based upon public needs, it has evolved into an organized national education system, responding to national aspirations, economic progress and hi-tech developments by transforming its philosophy and focus over the years.

The National Education System at the school level under the government education institution category consists of:-

i. Pre-School Education: This education program is for children between four to six year olds. Kindergarten provides secure and stimulating environment that prepares children for their first year in school which have been set up throughout the country by both government and non-government agencies and the private sectors. Among the objectives of pre-school education are fostering loves for the country, instilling moral values and developing character, developing basic communication skills, respecting the national language and acquiring the basics of the English Language.

ii. Primary Education: Primary schooling starts at seven years of age, and possibly completed within five to seven years; it consists of national schools or national-type schools. National schools use Bahasa Malaysia as the medium of instruction and English is a compulsory subject. National-type schools use Mandarin or Tamil as the medium of instruction. Bahasa Malaysia and English are compulsory subjects. Among the objectives of the Primary school curriculum are to speak and write in Bahasa Malaysia, to develop and improve intellectual capacities which include rational, critical and creative thinking

iii. Secondary Education: Secondary school offers a comprehensive education program which consists of the lower secondary education and the upper secondary education. The secondary education that is available consists of academic schools, technical and vocational schools, and religious national schools. Among the objectives are to increase proficiency in Bahasa Malaysia and English Language, to develop and enhance intellectual capacity and to acquire knowledge and develop mastery skills.

iv. Post-Secondary Education: The education that is provided for individuals who have completed lower and upper secondary education, but excludes higher education.

Schooling under the Government-aided Education Institution Category covers Fully Residential Schools under the authority of the Fully Residential Schools Unit, School Division. Other education institutions which have been established at the school level are Special Education Schools under the responsibility of the Special Education Department and Sports Schools under the responsibility of the Sports Division. Source: (Educational Planning and Research Division, 2001)

2.2 School Planning

A systematic school planning can determine comfortable, safe and healthy environment for school children and teachers. Schools should be planned in a proper and systematic way because poorly planned schools may have serious future implications. Planners need to consider a lot of parameters and criteria when planning for a school site. Ward (1971) stresses out that planner should consider the life span of schools. Schools may be used at least 50 years, and should improve the learning experience in future. This is also agreed by Basil (1982) in saying that imperfectly planned schools will lead to obsolescence.

Existing schools need to be improved and upgraded in order to meet the changing requirement in education programs. These activities make schools planning in continuing process. It is mentioned that no school system has ever completely or permanently solved all of the problems relating to school sites (North Carolina Department of Instruction, 1998). The maintenance of existing schools has commonly become the agenda of the schools administrator. In the rapid population growth area, finding and building new schools is a continuing process to meet the community of long life learners.

One of the schools planning challenging is to decide the location for new schools. A good, well-developed site and a well-equipped, functionally designed school plan is a basic physical tool for a proper quality education. Poorly planned schools will lead to many problems such as mislocating areas such as a hilly area, a flood area or near to the industrial area. Schools should be located such that the travel distance for students to the schools is minimized and the number of students registered to each school does not exceed the school capacity (Aziz, 2004).

Therefore, a planner should be well known about designing and evaluating a school site to ensure the schools are well planned. Failure to do so will result in a poor site selection and gain higher expenses. The next section deals specifically on the school planning policy.

2.2.1 School Planning Policy

An educational planning is an important aspect in the development plans at the state and district level. A structure plan is written in Part III of the Act 172 (Revised 2000) and sections 4, 5, 6, a written statement that explains the policies and strategic proposals in the respect of land development and land use in urban and rural areas. While the provisions of Part III of the Town and Country, 1976 (Act 172) stipulates that each local authority is required to provide Local Plan Area (section 12 (1) Amendment 2001) which interprets the policy in the structure plan of the state to district level in more detailed.

In planning the implementation of educational facilities, there is some legislation provided by Federal and State authorities. Implementation of community facilities shall comply with the acts adopted by the Federal and State authorities, namely:

a) National Land Code (Act 50/1965) (Section 2A and 204D);
b) Town and Country Planning Act 1976 (Act 172);
c) Town and Country Planning Act (amendment) 1995) (Act A933);
d) Law of 1984 Uniform Building

Local authorities should enforce the use of guidelines and standards provided by the Planning Department of Town and Country Planning, Peninsular Malaysia (JPBD) in the approval application for a planning permission and the approval of layout plan. The implementation of community facilities shall comply with the policies and guidelines are set in the strategic development of the Structure Plan and Local Plan. In Kuala Lumpur Structure Plan, the projected population distribution and population distribution need to be identified for the projected future needs of education. The approval from MOE must be obtained before a new school is built.

Local authorities should ensure that public lots are returned to the government after getting the approval from the State Authority by the land owner for development. The authority shall ensure that all sites for community facilities in the development plan have been approved by the local authority which then shall be returned back to the government. All land must be in a state ready to be developed by the force (such as the provision of drainage, leveling the land, planting grass and prepare the way in) before the certificate of fitness is issued to the executor for the purpose of the planned development

2.2.2 JPBD School Planning Guidelines

The Town and Country Planning Department of Peninsular Malaysia (JPBD) has developed guidelines for a school site selection. Under those guideliness the school site should:-

i. Located in the optimum distance from population catchment's area.
ii. Not to be located on the sensitive area such as swamp, hilly, flood or land slide area.
iii. Located in the conducive for teaching and learning, far from the industrial and highways.
iv. Located far from noise, air pollution and other disturbing elements.
v. Not to be located on arterial or major collector roads.
vi. Should be located near the connectivity to the other facilities for example; bus transportation.
vii. Not to be placed on sites which involve journey through quiet or remote lanes.
viii. Convenient and readily accessible to present and/or future school populations to be served, and to the public for community educationally or recreationally
ix. Should be located based on students population.
x. Avoid high-volume traffic flow near elementary school entrances and exits.

xi. The routes to and from the school site should not expose children to hazardous environmental materials or safety hazards.

xii. The usable site should be large enough to hold the necessary building (s) and spaces for outdoor instruction, recreation, parking and any future expansion to building(s) and play areas.

xiii. Conducive to the possibility for interrelationships and joint planning with other public facilities

xiv. The overall size of a school site is important to the design and layout of the necessary facilities (buildings, roadways, parking lots and recreational areas).

Source: (Town and Country Planning Department of Peninsular Malaysia, 1997)

2.3 General Criteria for School Site Selection

The best site comes from carefully chosen selection criteria because it can efficiently screen the set of potential site (LaGro, 2008). It also plays an important role in confirming a sustainable school development because it justifies fewer inputs of resources and generates fewer negative outputs such as noise and air pollution (LaGro, 2008). Planners and decision makers in the Ministry of Education (MOE) of Malaysia uses guidelines which have been produced by the collaboration of JPBD and MOE to determine the most suitable site for a school siting (see previous section). The criterion which has been stated in the guidelines are both constraints and factors for an ideal school siting but these guidelines do not establish criteria and standards for the site selection of school sites. Most of the guidelines use advisory language or suggestive, rather than compulsory. For example, schools should not be located on the sensitive area such as swamp, hilly, flood or land slide area. This statement can be interpreted differently or wrongly by planners and decision makers. What is the safe and acceptable distance between school site and the sensitive area? Is 500 meter or 1 km should be the right distance? The guidelines are not clear to propose a quantifiable way for local school planners to apply them. In order to set up a complete and measurable criterion, the comparison between local guidelines and other country has been carried out. The comparison guidelines can be seen in Appendix 1. The criteria are meant for school in the urban areas and are briefly explained in the following paragraphs.

2.3.1 **Demographic factors**

Demographic factors such as future demographic trend, projection of school-age population and the current enrolment trend should be carried out in order to give equal opportunity to every school children and to avoid the problem of growth or decline in children population. The statement is highly supported by the Utah State Office of Education (2007) and the Vermont Department of Education (2005). As stated in Vermont School Construction Planning Guide, in order to build a new school, school district should submit a full report regarding the facility analyses which include demographic data, enrolment projections, and a space utilization schedule. A ten-year projection enrolment student data should be carried out. A five-year time series of existing student has been used by Aziz (2004) to obtain the average student growth of each school in the study area. This is important to do the trend analysis and to focus the enrolment growth in future. Based on the principle, MOE of Malaysia should collaborate with the Department of Statistics (DOS) in preparing all the projection data.

2.3.2 **Environmental**

According to JPBD guidelines, schools should be located far from noise, air pollution and other disturbing elements. The routes to and from the school site should not expose children to hazardous environmental materials or safety hazards. Alaska clearly justifies that noise from air traffic, vehicle traffic and industrial is below 65 db from proposed school site, while the Department of Environment (DOE) of Malaysia states that, in noise sensitive areas such as schools and hospitals, the sound decibel levels should be below 50 dBA in a day time and below 40 dBA at a night time (Department of Environment, 2007). Air Pollutant Index (API) has been used in many countries such as Malaysia, China and Hong Kong as the indicator of the air quality. The API scale for healthy levels is between 50 (Good) to 100 (Moderate) (Department of Environment, 2004).

California clearly justifies the distance from proposed school site to electric power line easements (see Appendix 1). It also requires the risk analysis if the school site is within 1500 feet above ground or underground pipelines. California requires consultation from water/air quality management agencies if the hazardous air emissions within ¼ miles of site to form a written finding to the acquire site presently zoned for agricultural production; if the site is within 2,000 foot of significant disposal of the hazardous waste site the school district must contact the Department of Toxic Substances Control for the determination of regulatory status.

2.3.3 **Physical / Geological**

According to the JPBD guidelines, school should not be located on the sensitive areas such as swamp, hilly, flood or land slide areas. The Indiana State Board of Education (2002) clearly states no school can be built within 500 feet (152.4 meter) of a stream while the Utah State Office of Education (2007) strictly states that school site shall not be located in an area with a history or high possibility of flooding, high ground water, and snow or earth slides of earthquake fault. The West Virginia Board of Education (2002) and the Georgia Department of Education (2003) state that school site must be located above 100 year flood plain.

The area of the site is an important factor in many site selection studies (LaGro, 2008). For example, site area is a threshold criterion in evaluating sites for public schools in the state of Alaska. Moreover, the preferred land area for a public school site varies with the type of school that will be constructed. According to the local guidelines, the preferred land for school building can be seen in Table 2.1

Table 2.1. Proposed school area
Source: (Town and Country Planning Department of Peninsular Malaysia, 1997)

Type of schools	Area	Student per classroom
Primary School	2.4 hectare for flat area or 3.2 hectare for hilly area.	30 – 35 students per classrooms
Secondary School	3.6 hectare for flat area or 4.5 hectare for hilly area.	

As stated in the local guidelines, school should be located in the conducive for teaching and learning, far from the main road or highways in order to avoid school children to be exposed to both noise and air pollution. As stated in the School Site Selection and Approval Guide, California (2004) and School Facility Guidelines, Indiana (2002), there is no school can be built within 500 feet (152 m) of the edge of the closet traffic lane of a freeway or a busy traffic corridor, while New Mexico in the Facilities Adequacy Standards Planning Reference Guide (2006) states 400 feet (122 m) from the main road. Based on the previous studies, the focus on pollutants in vehicular exhaust are high near roadways, but decline markedly within 150-300 meters (Salvesen et al., 2008).

The school site should be far from the industrial areas to avoid school children to be exposed to noise and air pollution, and high traffic on the road is caused by industrial transportation. Schools also need to be located far from commercial areas to avoid a traffic congestion and also to avoid school children to spend their time loitering at shopping complexes of video arcades (Aziz, 2004). Georgia Department of Education (2003) and California Department Of Education (2004) states school site should not be located in areas zoned for commercial or industrial development; risk/hazard analysis within 3 mile (4.8 km) radius.

2.3.4 **Utility**

Utilities essential to the operation of a modern school plant must be available. Georgia specifies that electricity, telephone services and public water and sewage service are essential to the operation of a school plant and must be accessible to the proposed site, but should be far from oil wells, gas wells, mines and quarries, sink holes, high pressure or oil line, fiber optic lines, high voltage electrical lines, air port and radio and communication tower. These utilities can present several hazards for the school site for example electric and magnetic fields which are produced by the high voltage can affect school students' health.

2.3.5 **Land use**

The California Department of Education (2004) specifies that no school constructions on a current/former hazardous waste disposal sites or solid waste disposal sites unless the site is a former solid waste site and all wastes have been removed. The Florida Department of Education (1999) discourages K-12 school to be built on or adjacent to a known contaminated site unless steps have been taken to ensure that children attending the school or playing on school property will not be exposed to contaminants in the air, water, or soil at levels that present a threat to human health or the environment. The Utah State Office of Education (2007) strictly states a school site shall not be located in an area that is a repository for hazardous.

2.4 Geographical Information Systems and School Planning

GIS has been used in schools system around the world recently. GIS which also known as smart mapping software enables schools to centralized and analyzed information according to their physical location. Integrating schools data with important data such as population and housing statistics, planned land use and zoning, aerial photography will give a clear depiction of exactly what is occurring within the area (Cropper, 2006).

The following scenarios demonstrate the capabilities of GIS (Cropper, 2006):

i. A district is experiencing overcrowding in some schools and under crowding in others, huge socioeconomic gap and increasing transportation costs. Student densities can be put on the map to determine how many kids live in various areas of district. Boundary lines can be redrawn to maximize facilities use and ensure that students are not traveling farther than they need to.

ii. A district wants to increase awareness of security threats. A list of crimes from the local police department can be mapped and overlaid with bus stops. The district can then notify and enhance bus drivers and administrators awareness of their surroundings.

iii. A district wants to develop a process for responding to emergencies and disasters. With GIS, a district is able to have a multitude of datasets available in the event of an emergency. Information such as transportation and utility can help the district quickly responds to an emergency if one arises.

Fayetteville Public School District in Arkansas joins a host of forward-thinking school system by adopting GIS technology to provide data-driven approach from potential construction sites to school district zoning (Murray, 2004). It is said that, the geographic tool has become a central cog in the district's decision making process because it helps redrafting school boundaries to maximize the potential revenue from state tax breaks.

Most recently, the concept has been further improved by a team led by Dejong (2006) who developed the educational facility master plan using GIS. A master plan provides an objective criterion for planning educational facilities that meet the changing needs of a community and allocate facility resources. GIS database helps to overlay the data about present school locations which have students attribute and land use data from local agencies for further planning such as determine a suitable land for a new school.

In Malaysia, there were also researches about using GIS in school planning. Early research done by Yusof (1989) used school mapping technique as a micro planning activity for investigate whether the schools in the area under stuy conformed to education needs in terms of location and to study the level of education and physical facilities available. In her study, she found that school mapping has not been fully utilized and there is no policy to support the application of school mapping. She suggested that school mapping be applied in planning physical development.

Another research done by Kadir (2001) investigates the using of GIS to identify community demand in primary and secondary schools. The result of the analysis has proved that the number of schools in her study area were enough but the distribution of the school were not suitable for physical activities since there were unpreferable place which is close to road.

The school siting research has been further improved by Ibrahim (2005). Through a planning support system using 'What If' software, he successfully generated a school siting scenario in Johore Bharu, one of big cities in Malaysia. He found that the development alternative can be generated in fast, easy and can be done based on population and job opportunity. The result produced more systematic future school distribution.

Research done by Aziz (2004) focused on school efficiency which he successfully generated 3 simulations. The simulations were done for further improved in existing school scenario which resulted to be more suitable in student travel pattern, systematic in allocation and distribution of students and systematic in finding new school location. By using gravity model approach, he found the new location using existing schools location which incidentally situated very near to the commercial area. He claimed that the actual choice of the site must not be too rigid because it may depend on a combination of factors and the decision makers should look further how to determine a location.

Another research done by Abdullah (2008) focused on relocation of special school which located in busy environment and rapid development in Kuala Lumpur. Using suitability analysis, she found the most suitable relocation for 2 special schools in Kuala Lumpur which located far from the busy city road. Although the result of the study shows the importance and a suitable place for relocation the 2 schools, another field of study should be done to focus in cost effective analysis. Another problem may occur about how to bring students from the housing area to the school because some of the kids have mental problem and the others may have physical problems. The long distance travel can be an extra burden to the special kids.

Many researches with respect to this issue were found in Malaysia, but they focused in different kinds of objectives and none of them focused on developing the school planning data model. Kadir (2001) focuses on using GIS to identify a suitable numbers of schools to feed the community needs, Abdullah (2008) and Aziz (2004)used similar objective in relocating school siting but Aziz (2004) did an extra research in doing analyses and simulation, while Ibrahim (2005) focuses on generating the future school scenario based on population and job opportunity. A part from all the researches above, there is still lacks of researches to identify the school location in a safe environment and to feed community needs (Yusof, 1989) and at the same time has easy accessible using the existing education allocation provided by local authorities. This weakness has led to the failure of the implementation of the GIS system in locating the suitable schools. This study has identified, formulated and integrated important criteria for selecting the best school site using comparison between local guidelines and other selected country guidelines. It has also designed and developed the school planning data model for better and accurate analysis. This study also designs and develops demography analysis model, a safety analysis model and an accessibility analysis model for selecting the best school siting.

2.5 Geospatial Analysis

Geospatial analysis or general known as a spatial analysis is a quantitative study about phenomena locations in space (Buyong, 2007). It is a process for looking at geographic data patterns and the relationships between features (Mitchell, 1999). It can help to get more accurate and up-to-date information, and even create new information that is unavailable before for deeper understanding of a place, better choices or a preparation for future events (Mitchell, 1999).

Geospatial analysis has been used for scientific discovery and decision making. A research done by a group of researchers in 1987, has developed a map by applying the geospatial analysis to map the incidence of childhood leukemia in northern England (Openshaw S et al., 1987). By placing a number of circles representing the number of cases, two large targeted of locations have been found that has lead to the identification of causes of the decease. One of the locations is British Nuclear Fuels which has various kinds of leaks of radioactive materials. The other location may cause by other local causes that need to further analysis.

Geospatial analysis is also used inductively to examine empirical evidence or general principles or by using deductively focusing on the testing of new theories or principles against data (Longley et al., 2005). This study will use the third application which is known as normative that will use the geospatial analysis to develop a better design for the best location of schools by integrating geospatial and MCDA.

To perform a suitable school site selection, this study has used combinations of geospatial analysis such as map overlay and buffering, the distance analysis and the interpolation method in both raster and vector data. Subsequent sections detail out the geospatial analysis that have been used in related previous work.

2.5.1 **Buffering**

Buffer operation is one of the most important transformations available in GIS which can be used in both raster and vector data formats. By identifying areas within a certain specified distance of objects, the buffer operation in the vector data formats builds a new object as shown in Figure 2.1, while the result of raster is the classification of cells according to whether they lie inside or outside the buffer (Longley et al., 2005). Many researchers have used buffering operation technique such as to determine a suitable site selection from identified factors (Abdullah, 2008; Che'Ya, 2007) identifying the protected area for environmental sustainable purposes (Zucca et al., 2008) and developing a policy for suitable harvest zone (Ismail, 2009).

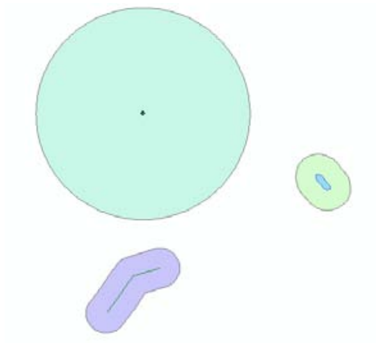


Figure 2.1. Buffers Drawn Around a Point, a Line and a Polygon

2.5.2 **Distance Analysis**

The distance between points in a space is determined by a rule called metric (Longley et al., 2005). The distance analysis helps to find out what's occurring within a set distance of a feature and what's within travelling range. GIS calculates the distance, (d) based on a straight line metric between 2 points (x_1, y_1) and (x_2, y_2) using the formula:

$$d = \sqrt{(x_1 - y_1)^2 + (x_2 - y_2)^2} \qquad (2.1)$$

The straight line metric or Pythagorean metric gives a simple and straightforward solution for a plane, but the assumption of a flat plane leads to significant distortion for points widely separated on the curved surface of the earth (Longley et al., 2005). Although there are arguments about the accurate distance from the straight line approach, and due to the effects of the earth's curvature, it has been widely used in many applications. A research done by Ismail (2009) uses the raster based data for determining the distance between raster cells such as the distance from river buffer and lake buffer. By utilizing the raster data format, he successfully developed a policy for suitable harvest-zone in the Peninsular of Malaysia.

2.5.3 **Interpolation**

Spatial interpolation is a persistent procedure in GIS which uses intelligent guess work and reasonable estimation for unmeasured value (Longley et al., 2005). It can be used in estimating rainfall and temperature, estimating the elevation of the surface between measured locations of a DEM and guessing where to place contours between measured locations (Longley et al., 2005). One of the well known interpolation function is ***Inverse-distance weighting*** (IDW). IDW estimates unknown measurements such as weighted averages over the known measurements at nearby points, giving the greatest weight to the nearest point.

Although there are many better methods of spatial interpolation, but the ease of programming of IDW and its conceptual simplicity makes this function popular and have been using in many applications. Nurzaidi (2009) used IDW for interpolate rainfall for estimating the rain through the year. Many other researchers have used the geospatial analysis in their spatial related works. This study will further use the geospatial analysis in school site selection in order to find the most suitable location that can integrate decision makers' opinion and community needs in an integrated environment of GIS and MCDA.

2.6 Spatial Data Model

The process of defining real-world phenomena or geographic features in terms of their characteristics and their relationships with one another is a spatial data modeling. It is the heart of GIS which represents the depth of understanding of the spatial data and geoprocessing function that need to carry out. It is a model for storing data that consists of structure, regulations and workflow of the organization. It also represents the relationship between organizations and associated rules. Figure 2.2 illustrated GIS Information Communication model which shows that spatial data model is one part of the conceptual design process. The spatial data model is a template for data relational, object-oriented, coverage, shape file and a framework into which specific details of relevant aspects of the earth's plane can be fixed. (Longley et al., 2005; Thurston and Ball, 2008). It is important to understand the spatial data model and the representations to determine the correctness design and use of geographic information system. (Zeiler, 1999).

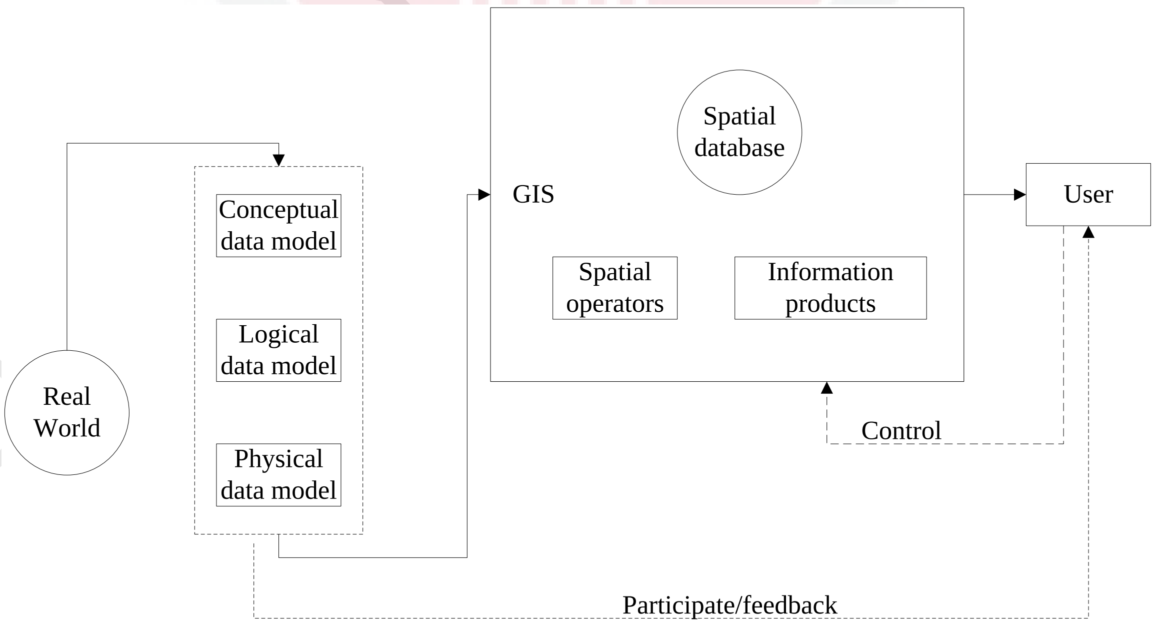


Figure 2.2. Model of GIS Information Communication
Source: Lo & Yeung (2006)

There are a lot of recent studies that shows the importance of spatial data model. The article reported by Calkins (1996) presented an extension to the basic Entity-Relationship modeling technique for describing the process of GIS database design. Research done by Lambers & Sauerbier (2003) used data model for Nasca Palpa project. The data model is used to store the existing geometrical and archaeological data in a structure that allows a combined as well as an independent analysis of both kinds of data. Research done by Li et al.(2010) develop spatial data model for Decision Support System in traceability in cucumber production. In his research he divided classes into four stereotypes that are table class, table operator class, algorithm class and interface class.

Some of the importances of spatial data model are listed as follows:

i. Support some design process

The spatial data model can help and support users to design the processes needed. In the case of finding the best location of a fire engine, the spatial model helps the decision makers and planners to put the selection processes in the visualization model.

v. Replica Experiment

A user can experiment a replica of the world rather than on the actual object. It is a very practical approach when the experimenting costs with the actual object are expensive or when undesirable impacts would effect, or when results can be obtained much quicker with a model. Medical students rather learn how to do surgery with the digital model of a human body which is much safer and more practical.

vi. What-if scenarios investigations

Users can investigate the *what-if* scenarios more easily. Policy regarding a particular issue can be plugged into a model in order to evaluate their outcomes.

vii. Dynamic Simulation

The model can be viewed to examine dynamic outcomes, since it evolves and responds to the inputs. Models can be used to do the dynamic simulation.

viii. The key to integration

Spatial data model facilitates the integration of data to and from other systems and can collaborate with other users. For example, there are standard data model for such data type such as address and transportation. There are also standard data models for such communities as agriculture, forestry, geology and local government. Personnel from different communities can integrate and extend the standard data models for their needs. The commonalities of the model can also lead to easier and more reliable analysis.

2.6.1 Spatial Data Modeling In the Context of Database Design Technique

The database design is defined as a design of conceptual, logical and physical structure to accommodate needs of users for a set of applications. The database design process follows five steps which are planning and analysis, conceptual design, logical design, physical design and implementation. The data model is one part of conceptual designs. A careful design of spatial database via data modeling will determine the successful development of any GIS system project (Raja, 2006). A conceptual data model plays a fundamental role in spatial databases, and controls the view of the world which the user ultimately receives (Goodchild, 1992). Using graphical tool to draw the model help users to understand and describe the contents of the database and for the developers it helps to improve the processes of programming and system maintenance (Raja, 2006). A research done by Chalasani & Azhausen (2005) develops a conceptual data model for integrating transport data and spatial for further understanding the interaction between the datasets obtained from different surveys.

There are many techniques to represent the conceptual data modeling for database design such as Entity-Relationship diagram (ERD), Data flow diagram (DFD), Systems flowcharts, Workflow modeling, Unified Modeling Language (UML) and Structured Charts (Davies et al., 2006). Of the many specific spatial database technique developed, the ERD technique developed by Chen (1976) is the most popular high level conceptual data models (Calkins, 1996; Davies et al., 2006). There are many software that support a data modeling such as Microsoft Visio, Rational Rose, Oracle9i Developer Suite, iGraftx FlowCharter, AllFusion Erwin Data Modeler and WorkFlow Modeler (Davies et al., 2006). Among them, Visio is the most frequently and preferred tool of choice for data modeling (Davies et al., 2006). In this study, ER Model will be used for representing the data modeling and Microsoft Office Visio 2007 will be used as a tool for drawing the ERD.

2.6.2 **Entity Relational Diagram (ERD)**

Generally, ERD is a conceptual data model that views the real world as entities and relationships among entities, and the attributes of both entities and their relationships. Normally it is expressed as entity-relationship diagram, which is a graphical representation of an ER model. The constructs used in the ERD can easily be transformed into relational database. It can also be used by a database designer to communicate the design to end users. In addition, the model can be used by database developers to apply a data model in specific database management software. The basic constructs of ERD are entities, relationships, and attributes. Entities represent concepts, real or abstract about which information is collected. Relationships are associations between the entities. Attributes are properties which describe the entities.

2.7 Land Suitability Analysis

Land suitability analysis is one of the useful applications in GIS (Church and T.Murray, 2009; Collins et al., 2001; McHarg, 1992). The definition of suitability analysis echoed by Church and T.Murray (2009) is as follows: "Suitability analysis is a process of systematically identifying or rating potential locations with respect to a particular use". Broadly defined, land suitability analysis aims to identify the most appropriate spatial pattern for future site location according to specific requirements and preferences of some activities. Land suitability analysis is an effective method in planning development based on various specified criteria (Joerin et al., 2001). This method usually used by environment planner and officers in analyzing interaction between locations, development and environmental impacts. It permits various factors which covered physical (topography and soil), social (land owner and value of land), and environmental (sensitive area) to be analyzed and used in helping decision-making process of location for an activity (Samat and Masron, 2007)

In the context of land suitability analysis, it is important to differentiate site selection problem and site search problem. Site selection analysis aim to identify the best site from the set of potential site for activity given which the potential site characteristics (location, size and relevant attributes) are know. Meanwhile, the site search analysis problems arise when there is not pre-determined set of potential site (Malczewski, 2004).

Suitability could be measured in absolute or relative terms. Relative suitability recommended that potential locations differ in some relative sense, with some sites being more attractive than others. Mean while, absolute suitability recommended location is either classified as suitable or not suitable (Church and T.Murray, 2009).

Hand-drawn overlay techniques has been used in land suitability analysis in the late nineteenth and early 20th century used by American landscape architects (Collins et al., 2001). It has been used to visualize the potential location for certain activity. McHarg (1992) advanced the overlay techniques by using various drawing theme maps and overlaid to get the information about environmental impact in the development project.

Today, with the development of Geographic Information System (GIS) and sophisticated computer technology, site suitability analysis becomes a strong need for spatial analysis (Samat and Masron, 2007). GIS capability to manage spatial and attribute data in different theme has increased the site suitability analysis operational. The map output can help planners to choose the most suitable location for an activity according to various identified factor. In recent years, there has been an increasing amount of application on the land suitability analysis.

The land suitability analysis has been applied in a wide variety of situations including landfill site selection (Lunkapis, 2004; Siddiqui et al., 1996; Wang et al., 2009), land evaluation for peri-urban agriculture (Thapa and Murayama, 2008), urban aquaculture development (Hossain et al., 2009), Japanese scallop aquaculture selection potential site selection (Radiarta et al., 2008), public park selection (Zucca et al., 2008) and urban development (Mohit and Ali, 2006).

Using the land suitability approach, Fauzi (2005) has identified the best school siting. She also successfully identified school building that is near to hazard area such as flood, erosion and near to a busy road. She has used the DBKL database for carrying out the school siting analysis. Meanwhile, Abdullah (2008) focused at relocating two schools that are located near a busy road. Using the land suitability approach, she identified two schools that are located very near to a busy road and suggested the schools to be located on a safe area, far from busy road and comfortable for the children schools to learn.

In order to find the most critical schools that need to relocate, Aziz (2004) conducted two suitability analyses. The analyses are school suitability analysis and region suitability analysis. There are 7 identified criteria's for the first analysis; school session, adequate classroom, enrolment growth, school size, site size, water and electricity supply. For the region suitability index, 5 criteria's were identified; the availability of schools in the region, population density, the distance from region centroid to highway, the distance from region centroid to commercial areas and the distance from region centroid to industrial areas. By using the integration of weighted linear combination (WLC), multi criteria evaluation (MCE) and GIS, Aziz (2004) successfully identified the most critical schools and the most critical region.

This study will use the site suitability analysis with the constraint mapping to determine the best school location using the identified criteria. The identified criteria are based from the objective and comparison from local and other country guidelines as stated previously. Simple buffering geospatial analysis tools will be used to indicate whether the new school location has good catchment and accessibility. Further analysis will be carried out at the end of the process to evaluate the potential site.

2.8 Spatial Multi Criteria Decision Analysis

As stated previously, there are a number of identified factors that need to be considered in a school planning. The identified factors need to be weighted according to their relative importance, but assigning weights to the relevant criteria becomes a difficult task when a greater number of criteria are being considered. Furthermore, the planning process may involve a number of stakeholders as decision makers, and often different stakeholders have different thought about what factors are consider and important, how that importance should be measured, and how the various important factors should be combined (Longley et al., 2005). Those processes are termed under multi criteria decision analysis (MCDA) and commonly encountered whenever decisions are controversial. Some stakeholders may decide that physical location is more important which deserves high weight, others may think of environmental is the most important factors, and still others may feel of existing public facility is all-important.

MCDA technique can be divided into Multi Objective Decision Making (MODM) and Multi Criteria Evaluation (MCE) (Eastman JR, 1999; Malczewski, 1999). MODM is used when there is more than one objective to be developed on the land either complementary or contradictory activities (Collins et al., 2001). The complementary means the identified activities can use the same land at the same time such as Bird Park and recreation centre. Meanwhile the contradictory activity cannot be done on the same land such as agriculture and industrial (Samat and Masron, 2007).

MCE involves a process that combines data according to the importance (Voogd, 1983). It provides procedure for collecting, classification and information management analysis (Eastman JR, 1999; Malczewski, 1999). This method allows the decision made from several options based on various criteria including social and environment, and allow the expert opinions, preferences and political views taken into account in making decisions. Between the two approaches, the MCE is widely used in the spatial planning.

MCDA technique has gained more interest and acceptance in spatial problems for forecasting, planning and problem solving (Malczewski, 1999). The spatial multi criteria decision problem is different from the traditional MCDA because it involves the use of geographical data, the decision maker's preferences, and the manipulation of the data and preferences according to particular decision regulations (Malczewski, 1999). Hence, the analysis results depend on the geographical allocation of events (attributes) and the assessment judgments involved in the decision-making process. Two factors need to be considered for spatial multi criteria analysis are (i) the GIS component (e.g., data acquisition, storage, retrieval, manipulation, and analysis capability) and (ii) the MCDA capabilities for aggregating the geographical data and the decision maker's preferences into discrete decision alternatives (Malczewski, 1999). According to Malczewski,(2006) to gain information for decision making, converting and combination of geographical data and value of judgments have been used in GIS-MCDA technique.

Spatial multi criteria analysis involves three-stage hierarchy of intelligence, design, and choice to represent the decision making as shown in Figure 2.3 (Malczewski, 1999). In the intelligence phase, data are obtained, processed, and examined for clues that may identify problems. The design phase involves formulating, developing, and investigating a set of possible solutions to problem acknowledged in the intelligence phase. Generally it involves formal modeling in order to develop a solution set of spatial decision alternative. The choice phase involves choosing a particular alternative from those available. In this phase, precise decision regulations are used to evaluate and rank alternatives. The three stages of decision making however, do not essentially directly flow from intelligence, to design, and to choice (Malczewski, 1999).

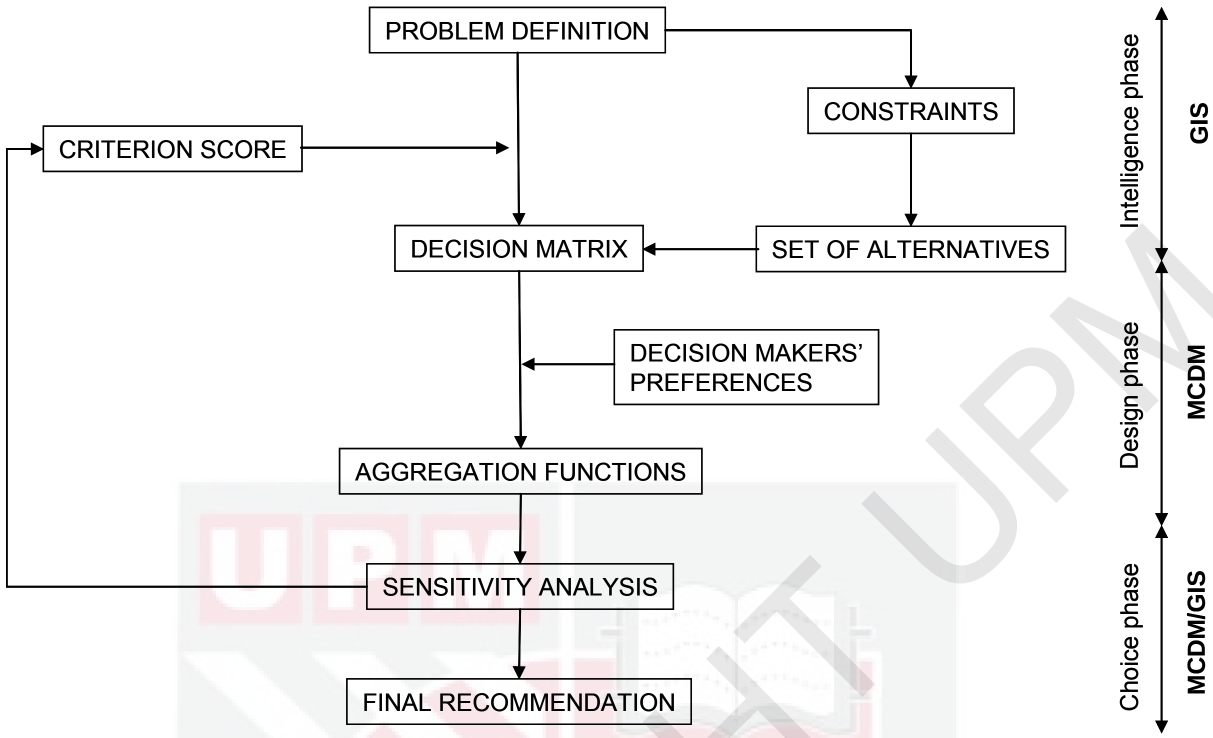


Figure 2.3. Decision Process for Spatial Multi Criteria Analysis
Adopted from: (Malczewski, 1999)

2.8.1 Steps in Spatial Multiple Criteria Decision Analysis

This section will detail the MCDA process using MCE approach (Design phase in Figure 2.3). From the intelligence phase, identification and criterion has been determined. The next step in a design phase, it involves the determination of score for every criterion, the determination of weight or importance of each criterion and the combination all the criteria based on certain rules. Expertise opinions, internet surveys, planners' opinions, politician, engineer and planners reports can be used to score determination. It can be applied either in qualitative or quantitative (Eastman JR, 1999). Standardization should be done in order to measure various criterion scores into one common unit, for example by scoring each criterion in a range value from 0 to 1 (Voogd, 1983). According to Voogd

(1983), the simplest is a linear scaling, using minimum and maximum values as a scaling point:

$$X_i = \frac{R_i - R_{\min}}{R_{\max} - R_{\min}} * m \tag{2.2}$$

Where;
R raw score
m arbitrary multiplier

The next step is giving the criterion weight to express the importance of each criterion relative to other criteria. A weight can be defined as a value assigned to an evaluation criterion which indicates its importance relative to other criteria which is under consideration. Some of the most popular weighting procedure include ranking, rating, pairwise comparison and trade off analysis (Malczewski, 1999). The sum of these importance relative must be 1. These techniques will explain in detailed in the next session.

Once the importance relative (weight) of each criterion is obtained, the criteria need to be combined in order to help the decision making process. In spatial environment, the combination operation is well known as map overlay. There are a lot of combination methods such as weighted linear combination (WLC), the analytical hierarchy approach (AHP) or Boolean approach (Malczewski, 2004). By using WLC technique, all the criterion score (x_{ij}) for m factors will be added and multiplied with the relative important weight (w_m) using following formula:

$$S_{ij} = \sum_{m=1}^{M} x_{ij}.w_m \qquad (2.3)$$

Where:

S_{ij} suitability score of *i,j* location

x_{ij} criterion score for *m* factor of i,j location

w_m weightage of relative importance for *m* factor

m consideration criterion or factors

The other important combination method is by using constraint criterion that determines which areas should be excluded from or included in the decision making process. Figure 2.4 shows this technique. This constraint factor used Boolean form, with the value of '1' for the available area and the value of '0' to the unavailable area. The results of this technique will leave out the unavailable land and this technique have been a great impact for zoning the land development (Samat and Masron, 2007).

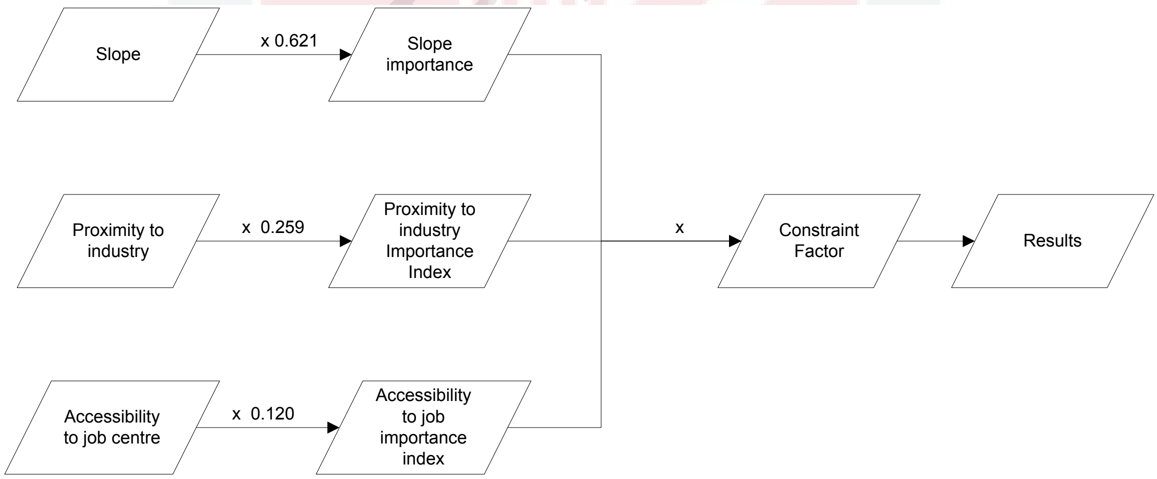


Figure 2.4. Weighted Linear Combination Technique with Constraint Factor
Source: (Samat and Masron, 2007)

2.8.2 Criterion Weights

The criterion weight is used to express the importance of each criterion relative to other criteria. A weight can be defined as a value assigned to an evaluation criterion which indicates its importance relative to other criteria under consideration. Some of the most popular procedure include ranking, rating, pairwise comparison and trade off analysis (Malczewski, 1999). For this study the ranking and pairwise comparison will be used for finding the criterion weights.

2.8.2.1 Ranking Method

This technique is the easiest for evaluating the importance of weights. It is ranked in the order of decision maker's preferences. It is very attractive due to its simplicity. However, the larger the number of criteria used, the less appropriate the method is (Malczewski, 1999).

The importance of the weights is arranged in a ranking order under decision maker's preference either in an ascending ranking (the most important = 1, second important = 2, etc) or in a descending ranking (the least important = 1, next least important = 2, etc) using numerical scale (1,2,3..etc). Once the ranking is established for a set of criteria, several procedures for generating numerical weights from the ranking order information is available. Rank sum weights are calculated according to the formula in 2.4.

$$W_j = \frac{n - r_j + 1}{\sum (n - r_k + 1)} \tag{2.4}$$

Where:
Wj the normalized weight for jth criterion
n the number of criteria under consideration (k = 1,2,..,n)
rj the rank position of the criterion

Each criterion is weighted $n - r_j + 1$ and then normalized by the sum of all weights, that is $\sum (n - r_k + 1)$. Rank reciprocal weights are derived from the normalized reciprocals of a criterion's rank. The following formula is used to calculate the weights:

$$W_j = \frac{\frac{1}{r_j}}{\sum (\frac{1}{r_k})} \tag{2.5}$$

This study will use a ranking method in JavaHP software by using the SMARTER function.

2.8.2.2 Analytical Hierarchy Process and Pair Wise Comparison Method

A common and popular approach to MCDA technique is the Analytical Hierarchy Process (AHP). AHP uses hierarchical structures to represent a problem and then develops priorities for alternatives based on the stakeholders' opinion. (Longley et al., 2005; Mohit and Ali, 2006) It captures each stakeholder's view of the appropriate weights to give to each impact factor. By using pair wise comparison, each stakeholder is asked to compare each pair of factors (with n factors there are $n(n-1)/2$ pairs), and to assess their relative importance in a ratio form. A matrix is created for each stakeholder, as in the example shown in Table 2.2. The matrices are then combined and analyzed by using the weightage method (Longley et al., 2005).

Table 2.2. Pair wise comparison table

Factor/Criteria	Population Density	Slope	Distance from highway
Population Density	1	7	2
Slope	$\frac{1}{7}$	1	$\frac{1}{3}$
Distance from highway	$\frac{1}{2}$	3	1

Within GIS, some criteria evaluation can be done by combining data layers, with each layer contains one objective. The proximity to a housing area and the proximity to high way, for instance, can be computed by generating buffer. Raster data model is suitable to perform this kind of analysis. Each raster cell corresponds to the feasible site of the school location. Weighted value can be assigned to the cell reflecting how close the site satisfies the objective function. Figure 2.5 shows how MCDA process is carried out in raster GIS environment.

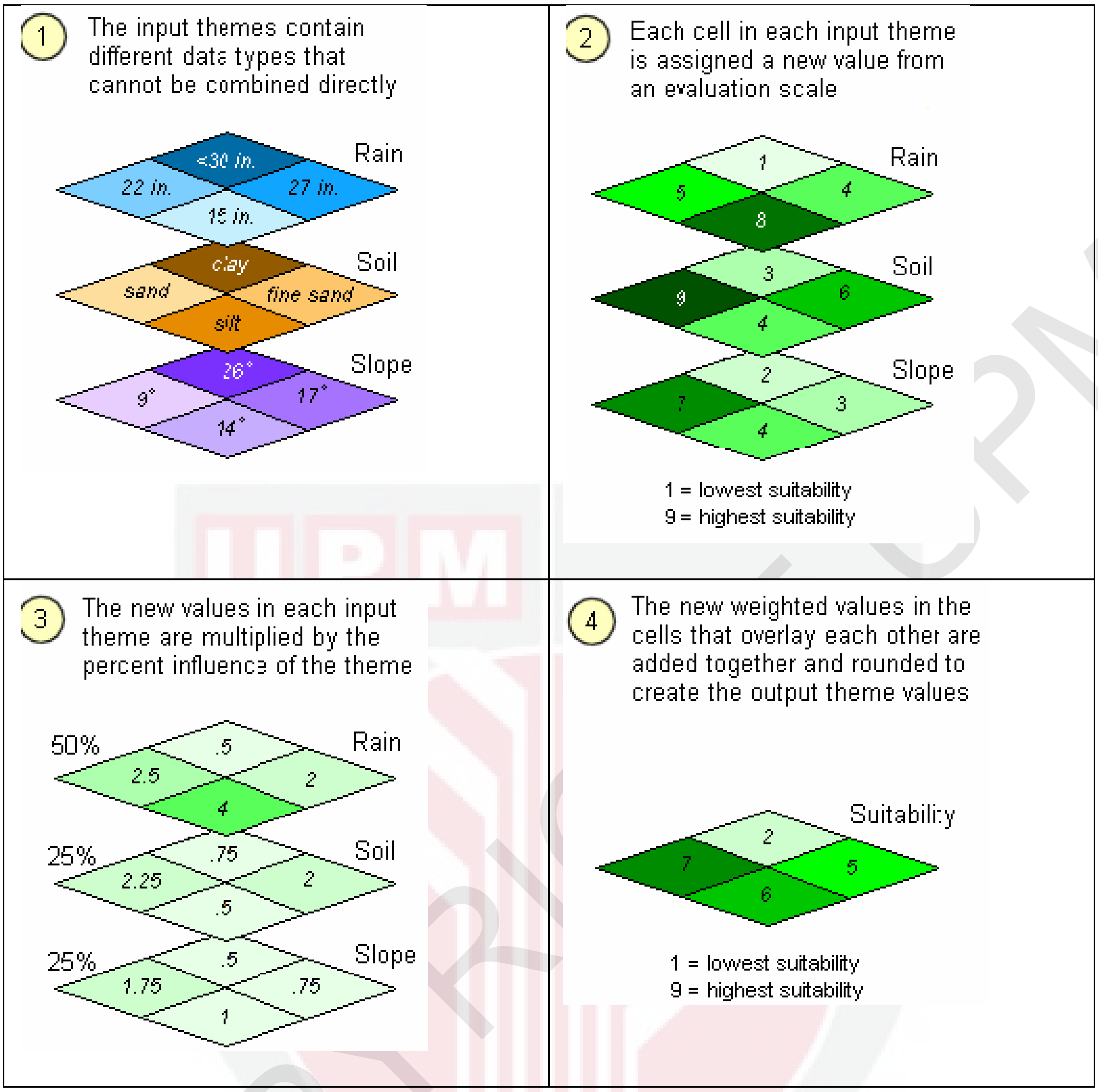


Figure 2.5. MCDA Process in Raster GIS Environment

AHP has been used successfully to develop several alternatives site plan such as finding new neurosurgical emergency hospitals in Sapporo (Ohta et al., 2007). AHP also has shown its flexibility in finding the best location for public facility such as emergency facilities (Indriasari, 2008) and primary school location and relocation (Abdullah, 2008)

2.9 Accessibility Analysis

Accessibility can be defined as the degree of ability to go to certain location in trying to participate in a particular activity or set of activities. In a simple term it refers how easy is to go to a site. As an example it helps investor to determine how suitable site is for a new business. Johnson et al. (2000) and Morris et al. (1979) had defined accessibility as "which activities to reach from a certain place with a certain system of transport". Accessibility can be measured in many ways (Talen and Anselin, 1998). Several types of accessibility measures are used in urban planning and transportation planning studies, for example container (e.g. the number of green spaces in each neighborhood unit); coverage (e.g. the number of schools in 200 m from residential area); minimum distance (e.g. the distance from residence units to the nearest transportation); travel cost (e.g. average distance between transporation services and neighborhood area) and gravity (e.g. all neighborhood facilities divided by distance). In this research, the coverage method had been chosen for the accessibility analysis. Using the simple Euclidean Distance, areas with public facility was examined using simple overlay analysis based on circular buffers around the potential school site. This simple approach has been used at Centre for Traffic and Transport at the Technical University of Denmark for the last couple of years to examine and optimize stop locations along new railway and light rail lines (Andersen et al., 2006).

Landex & Hansen (2006) compared the Euclidean distance method with Network Analyst to examine the catchment areas for stops in high quality public transport systems based on the actual street network in the examined area. In his research, he found that the Network Analyst method improves the detail-level and accuracy in catchment area analyses.

Although many researchers (Indriasari, 2008; Landex and Hansen, 2006; Liu and Zhu, 2004) have used the Network Analyst for examine the accessibility and the catchment area, this research used the Euclidean Distance because it is simple method and easy to be implemented (Landex and Hansen, 2006).

2.10 Summary

From the review, it showed that planning for school is very important because schools educate our youth to be lifelong learners and it also involves huge capitals investment. Errors in deciding a school site will lead to serious implications such as relocation of school site or transportation costs. The review found that there are still lacks of standard and important criteria in school planning. A complete and reliable list of criteria in finding the most suitable school location focusing on children's safety, demography, infrastructure and accessibility has been developed after investigation and comparison between local guidelines and other country guidelines. The review has listed the importance of spatial data model, geospatial analysis technique and the well known spatial multi criteria analysis. The spatial data model will need to develop in order to make a better decision. The review also found that there are still lacks of analysis model for better school site selection process. The next chapter explains in detail the methodology to fill in the gap in order to effectively identify a strategic primary school location.

CHAPTER 3

METHODOLOGY

3.0 Introduction

The previous chapter has reviewed the guidelines for locating and evaluating the best school siting. Guideline comparisons between selected country and local country also have been done to ensure a complete and reliable list of school planning criteria. This chapter describes about the planning and decision making process for school site selection. The planning stages and activities framework that was used in the study is discussed.

Multi Criteria Decision Analysis (MCDA) approach is incorporated in the whole site selection process. Starting with the objective and criteria definition, a geodatabase has been developed for systematic and proper future used. Geoprocessing technique for analysis model development is also discussed. By using weighted linear combination technique (WLC) formula, a suitability index has been developed and a set of potential site has been identified. Each of these stages and activities is explicated further in the subsequent sections.

3.1 Planning and Decision Making Framework

Decision making is a sequence process which starts from a problem definition and ending with recommendations. The sequence and quality of the activities will influence the quality of the decision. Two major common approaches in organizing decision making sequence and activities are valued focused approach and alternative-focus approach. The valued focused approach uses the values (objectives and criteria) as the fundamental element of the decision analysis. The alternative-focus approach focuses on generating of decision alternatives (Keeney, 1996). The differences between the two approaches are related to the question of whether alternatives should be generated first and then the value structure should be specified, or conversely, the alternatives are derived from the value structure. This study was guided by the value-focuses approach framework (Table 3.1) which has been modified from Malczewski (1999) and Zucca et al. (2008) and the flowchart can be seen in Figure 3.1.

Table 3.1. Sequence of Activities Performed in the Study

Phase	Activities
Intelligence	a. Conceptual framework including • Main objective and sub-objectives identification • Criteria definition that can be used to satisfied each sub-objective • Constraints definition of areas unsuitable for the school site. b. Database design • Conceptual • Logical • Physical c. Database development • Data collection • Data editing • Topology development • Data format interchange • Build Geodatabase
Design	d. Design proper location for the school by: • Performing a spatial multi criteria evaluation to produce a suitability map; • Designing alternative potential school
Choice	e. Evaluation and ranking of the designed alternatives • Definition of a new criteria structure for the evaluation phase • Performing spatial multi criteria evaluation. • Identification of the most appropriate location for new schools.

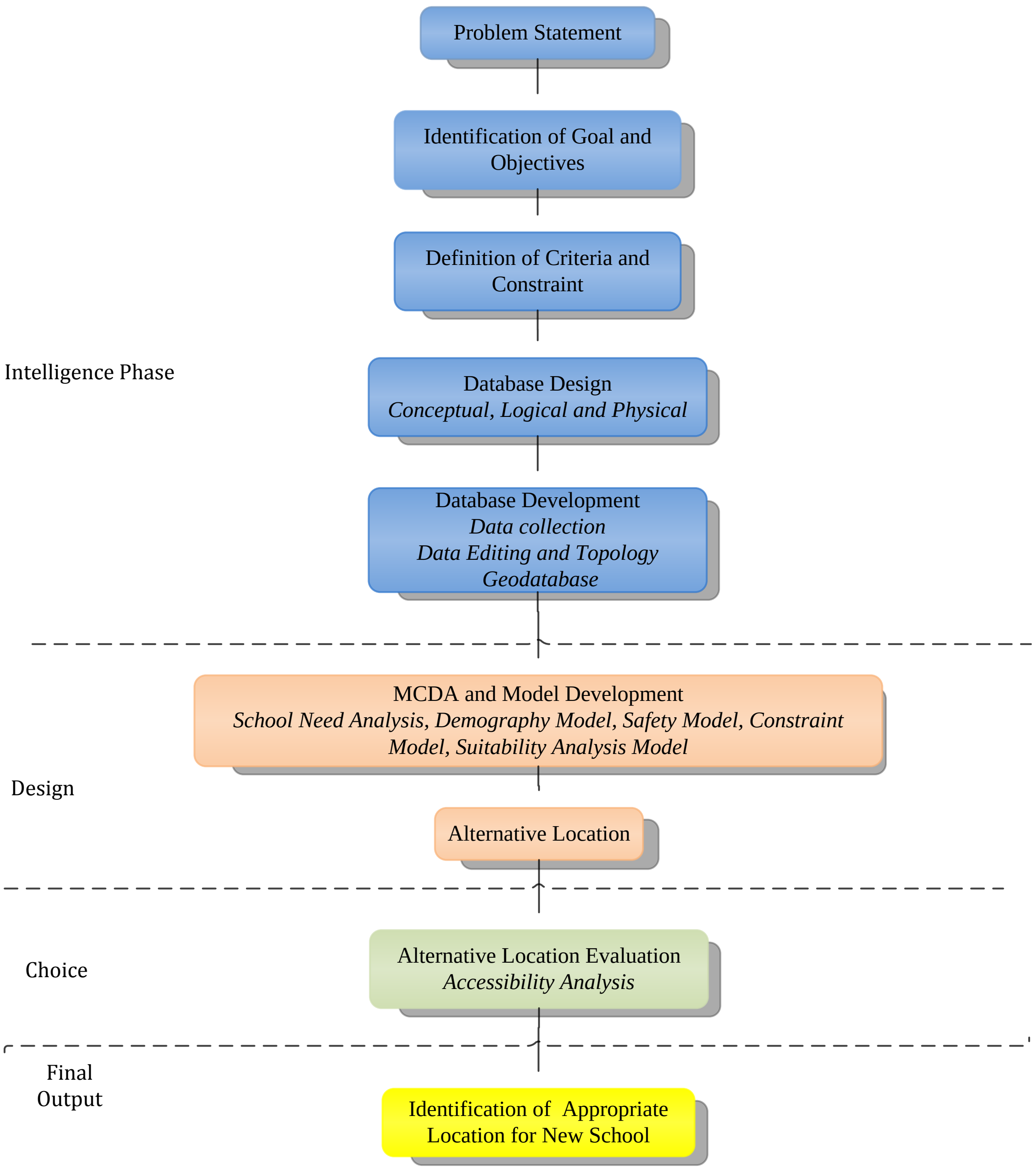


Figure 3.1. Overall Stages of the Site Selection Process

3.2 Intelligence Phase

3.2.1 Development of a Conceptual framework

A conceptual framework is designed based on the main goal and objectives. It can be viewed graphically in Figure 3.2. The main goal of this study is to determine the suitable location for a new primary public school. The goal could be met through the following factors:

i. Schools location can accommodate population.

Well-planned schools should accommodate students and population growth to ensure on equal education opportunity will be given to all school children in the community. Based on the circular issued by MOE, every Malaysian parents who lives in Malaysia must ensure that if their children have reached the age of 6 years on the first day of January in the current school year, they should be registered as primary school children and continue to be students in a primary school during the period of compulsory education (Mahat, 2002). Thus, the new challenge for MOE is to find a suitable location for future school site to accommodate the population growth. The above factors can be measured by using a calculation of population, projected population, student population and projected student population.

ii. The school site should be in a safe location.

Safety is the first consideration in the selection of school sites. The schools should be in a location that is far from environmental hazards. Thus school should be far from industrial and commercial areas which have high air pollution index and noise level. This is very important factors because children spend upwards of six hours per day in school, from ages 5 (when entering kindergarten) to 18 (when most children graduated from secondary school). Furthermore, children's bodies easily absorb 50% of the hazard material compared to adults who absorb 10-15% (Fishback, 2006). The safety school site can be measured by using criteria such as infrastructure, environmental and physical.

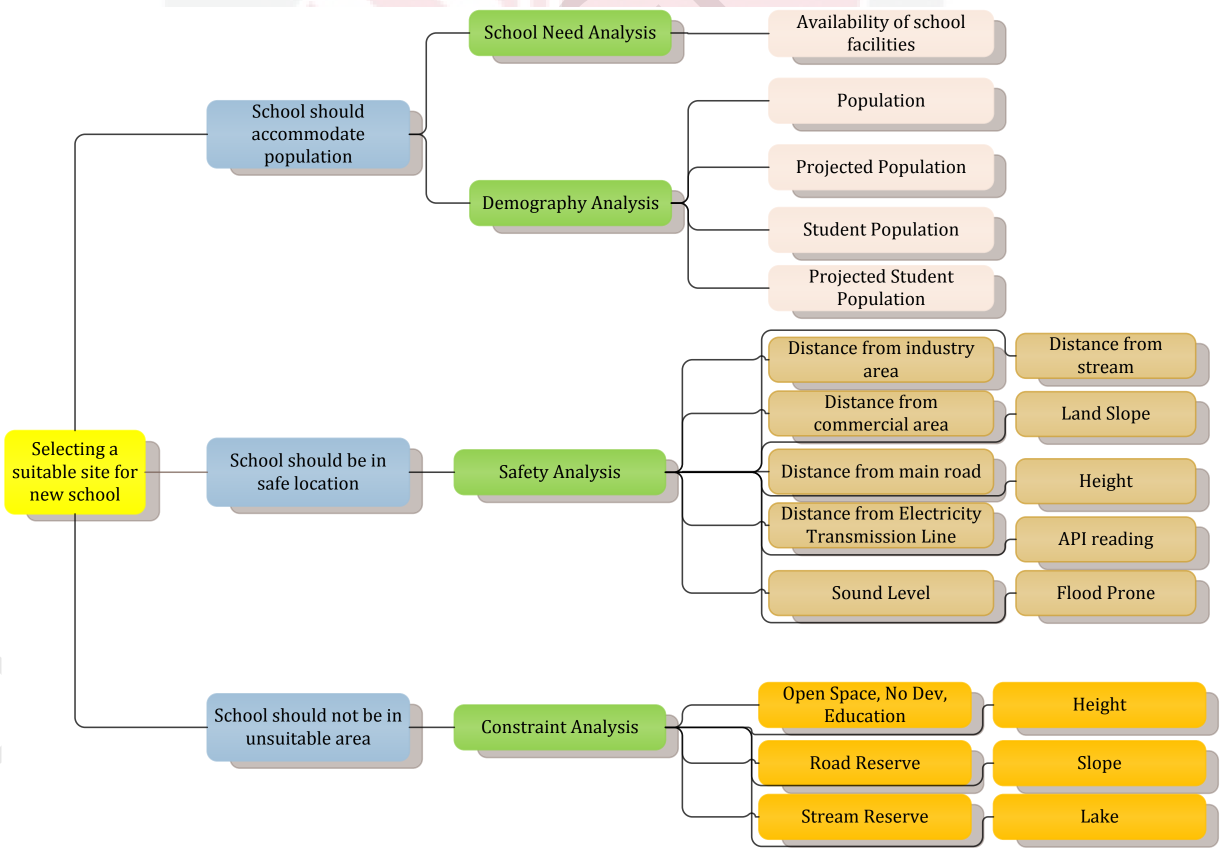


Figure 3.2. The Criteria Tree of the Study

3.2.2 Identifying and Selection of Criteria

The degree of satisfaction of the objectives was measured through the following criteria which will define as School Need Analysis criteria and Suitability Analysis criteria.

3.2.3 School Need Analysis Criteria

The school need analysis is the early analysis to carry out. The analysis can calculate whether a new school is needed in the area. There are two approaches to carry out the analysis. The first method is using the population approach which is given in the JPBD guidelines and procedures prepared by the MOE. This method is based on the number of residents in a neighborhood. According to the guidelines, the need for a primary school in an area depends on the education age group of a settlement or at least one primary school for every neighborhoods unit consisting of between 3,000 to 7,500 residents.

The second method is the student enrolment approach. Planners at EPRD used this method to calculate the number of schools needed in a state or district (Aziz, 2004). The approach will calculate the total number of student enrolment and compare with the ideal numbers or student in the study area and divide them by the multiplication of ideal number of students per class and the number of classroom available using Equation 3.1. Figure 3.3 explained the process in graphical view.

$$N = ER - (CR \times I) \qquad (3.1)$$

Where;
N   number of new school
ER total student population of the study area
CR the number of classroom available in the area
I   the ideal number of students per class.

If N >= 900, then a new school is required. This is based on the ideal number of student population for a school which is the maximum number of classroom for a new school which is 30 and the ideal number of student per classroom recommended by the Ministry which is 30. According to the Vermont Department of Education (2005) the enrolment projection needs to be highly considered to make sure the new school will accommodate the enrolment growth. It must show that the existing facilities are overcrowded and these conditions are not likely to be relieved by a decline in enrolment for the projected future.

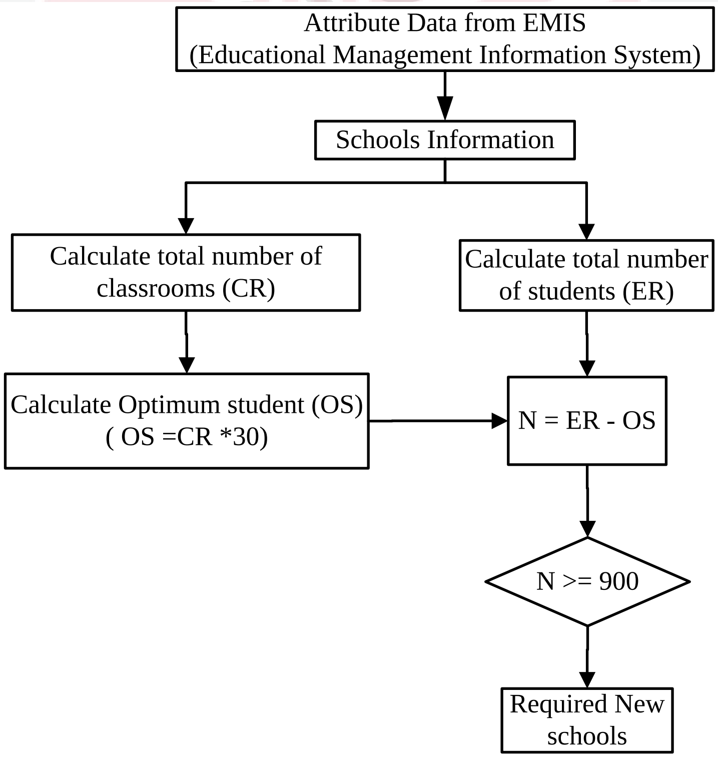


Figure 3.3. Student Enrolment Approach Flowchart

3.3 School Suitability Analysis Criteria

There are two analyses to be conducted under the school suitability analysis criteria. The analyses are demography and the safety analysis.

3.3.1 Demography Analysis Criteria

The aim of this analysis is to determine a suitable location that can accommodate the enrolment and population growth. According to the Vermont Department of Education (2005), in order to build new schools, the school district should submit demographic data, enrolment projections, and a space utilization schedule. Four parameters have been identified for this purpose. There are:

i. Population

This factor is important because it reflects the needs of schools. The higher the population, the higher a school needs. According to the JPBD guidelines, new school should be built if certain numbers of population qualify for the new school. The population count is not suitable because the housing area units vary. The low density scenario can be seen in a single housing area while the high density scenario can be seen in apartment housing area. Thus, the use of population density is more relevant (Aziz, 2004).

ii. Projected population

Well-planned school should accommodate both current and future schools needs. This is to avoid growth or decline in population problems that will contribute to unbalanced school capacity and facility. Thus, a ten year projection data based on population is suitable according to California Department Of Education (2004).

iii. Student Population

The student population is more accurate and appropriate to reflect the needs of the school. In contrast to the population criterion that takes total sum of population, this criterion considers population age. In this study, the minimum ages of 0-14 years were used to represent the number of pupils in primary schools in the area. Similar to population criteria, density of student in the area has been used.

iv. Projected Student Population

Preparing school for future is a challenge that needs to be addressed by the government. Therefore, the number of projected pupils should be highly taken into consideration when planning a school site. The development of schools always involves high capitals, thus schools should be put in a suitable place that can accommodate both current and future student needs. A ten years projection data based on students population is suitable according to California Department Of Education (2004). The projected student density has been used to represent more accurate data.

3.3.2 School Safety Analysis Criteria

The aim of this analysis is to determine a school location in safety and healthy environment. Ten parameters have been identified for this purpose. The choice of parameters is based on the JPBD guidelines, education guidelines, literature and other selected country education guidelines.

The criteria that are found to be applicable to this country are selected based on the availability of data for those parameters here. They are:

i. Distance from industry area

Schools must be located away from industrial areas because of the safety risk caused by the heavy traffic of the route. There is also the possibility of noise and air pollution depending on the nature of industry in the area. Georgia Department of Education (2003) and California Department Of Education (2004) states school site should not be located in areas zone for commercial or industrial development. Risk/hazard analysis should be done if proposed development area is within 3 miles (5 km) radius from the heavy industry. The industry area for this study is categorized as the medium and light industry (Kuala Lumpur City Hall, DBKL). Based on the previous studies, the distance from the industry area to schools were suggested at least 500 m. (Abdullah, 2008; Aziz, 2004). For this study, the acceptable distance from industry areas to school site was at least 1 km.

ii. Distance from commercial area

Schools should be located far from the commercial area because of the heavy traffic that contributes to air and noise pollution. This is also to avoid school children to waste their time playing in the arcade section. For this study, the acceptable distance from the commercial area to schools was at least 1 km.

iii. Proximity to main road

Transportation on roads produces polluted substances which have negative effects for human health (Salvesen et al., 2008). Several studies have found that living or studying in schools near major roads raising risk of heart and lung problems but the risk declined markedly after 150 m (Green et al., 2004). Buffer size from 150 m to 450 m was assigned to the study area. Major roads for this study are defined as those primary roads that are classified as highways and main roads. Roads under street categories were omitted, as these tend to be smaller, two-lane roads with relatively low traffic volumes.

iv. API reading

API is used for measuring air quality. The Department of Environment Malaysia (DOE) is responsible to monitor ambient air quality throughout Malaysia. Malaysia has 51 locations to detect any significant change in the air quality. These monitoring stations are strategically located in residential areas, schools, industrial areas and areas with high traffic volume (Department of Environment Malaysia, 2007).

The API reading for this study was obtained from seven air quality monitoring stations which cover approximately the area of Mukim Batu, Kuala Lumpur namely; Country Heights, Kajang, Pelabuhan Klang, Selangor, Petaling Jaya, Selangor, Shah Alam, Selangor, SMK Seri Permaisuri, Cheras and SK Batu Muda, Batu Muda. The records for the API reading were obtained since January 2009 to April 2009 daily.

v. Noise level reading

Activities such as industrial, development projects and traffic generate excessive noise. Noise pollution has an impact on health and reduces productivity (Department of Environment Malaysia, 2007). School is categorized under Noise Sensitive Area. Noise compliances were based on the limits recommended in the 'Planning Guideline for Environmental: Noise Limits and Controls'. In 2007, noise levels at several areas with a high traffic volume in Kuala Lumpur were measured. The levels ranged from 59.3 to 62.7 dBA . Meanwhile, noise levels for several industrial areas were ranged from 49.3 to 57.5 dBA. According to DOE, in day time, noise level for school should be from 0 to 50 dBA and at night, noise level should be from 0 to 40 dBA (Department of Environment, 2004).

vi. Land slope

Several studies have found that 45% on the slope failures occurred in the gentle slope region (5°-15º), 35% of them occurred in moderate slope regions (15º- 35º) (Yong et al., 2008). It is recommended that for the development on the areas where slope angles generally exceed 10º, a proposed development should be subjected to a geotechnical investigation of surface (City of Ryde, 2007). Based on the Ministry of Education (MOE) and Department of Town and Country Planning (JPBD) guidelines, schools should not be built on the slope that is more than 10^0. Buffer size from 10 to 20 was assigned to the study area.

vii. Height (Elevation)

Based on the MOE and JPBD guidelines, schools should not be built on the area that is above 60 meter. The high land is very fragile and it subjects to excessive erosion and land sliding.

viii. Flood prone

Schools should be located outside a flood zone due to the possible for personal injury, loss of life and major property damages. A 100-year floodplains data are the most suitable data for school safety analysis (Georgia Department of Education, 2003). Since there is no available data for 100-year floodplains of the study area, the analysis was limited to those areas for the year 2000, 2001 and 2003 floodplains.

ix. Distance from stream

Schools should be located far from streams to ensure schools are safe from natural disaster such as flash flood, mud flood and erosion problems which stem from their closeness to river. Indiana State Board of Education (2002) clearly states no school can be built within 500 feet (152.4 meter) of a stream. For this study, the acceptable distance from the school site to the nearest stream was at least 300 m.

x. Distance from electrical transmission line

Schools should be located far from electrical transmission line to ensure students and schools staffs are protected from the high voltage electrical effect (Center for Health Environment and Justice (CHEJ), 2002). The buffer size of 150 m has been used based on California Department of Education guidelines (California Department Of Education, 2004).

3.3.3 Constraint Definition

It is necessary to define the constraints for school building. Constraint is a criterion that determines which areas should be excluded from or included in suitability analysis.

i. School should be built in areas with a particular classification such as open space, no development area and education allocation in the city's master plan. The other land used has to be excluded.

ii. Schools should not be built in the stream reserve area and road reserve area.

iii. Schools should not be built in the area above 60 m height and the slope angle cannot exceed 10^0.

iv. Schools should not be built near lake.

3.3.4 Database Design

A well designed and developed database can help users to accurately generate analysis for further used. The database design also can help programmers or system designers for better integration between systems either it will be single user or multi user, or either it will be off line or on line system. This study is hoped to have a proper design database to carry out the identified analysis process that can help decision makers to speed up decision making process. The data requirement should be justified in the database design before the data collection. Thus, in the next section, detail concept of database will be described. Figure 3.4 shows that database design can be categories to conceptual, logical and physical design.

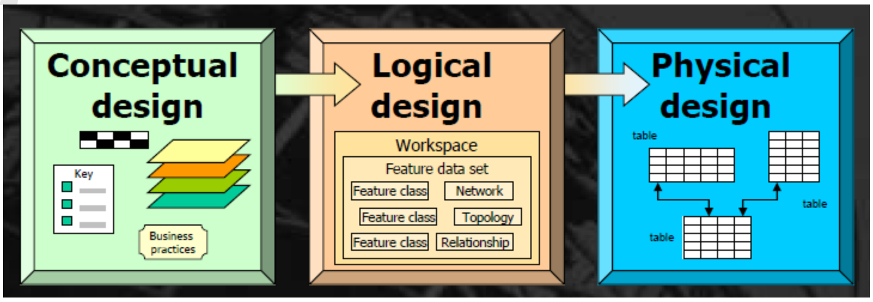


Figure 3.4. Database Design
Source: Lo and Yeung (2006)

3.3.4.1 Conceptual design

Careful design of spatial database via conceptual data modeling will determine the successful development of any GIS system project (Raja, 2006). A conceptual data model plays a fundamental role in spatial databases, and controls the view of the world which the user ultimately receives (Goodchild, 1992). Using graphical tool to draw the model help users to understand and describe the contents of the database and for the developers it helps to improve the processes of programming and system maintenance (Raja, 2006). There are many tools to support the conceptual database modeling. The technique that is widely accepted and will be used in this study for representing the conceptual design is ERD technique developed by Chen (1976).

Figure 3.5 shows the conceptual representation of a school site selection database consists of entities and relationships. The entities are Area, Contour, Facility, Flood, Land Use, Monitoring Station, Mukim, Road, School, Stream, Demography and Electrical Transmission Line. The figure also shows there are 15 relationships in the database. The Mukim Boundary is the main entity in this study. Table 3.2 shows the cardinality of relationship and relationship type.

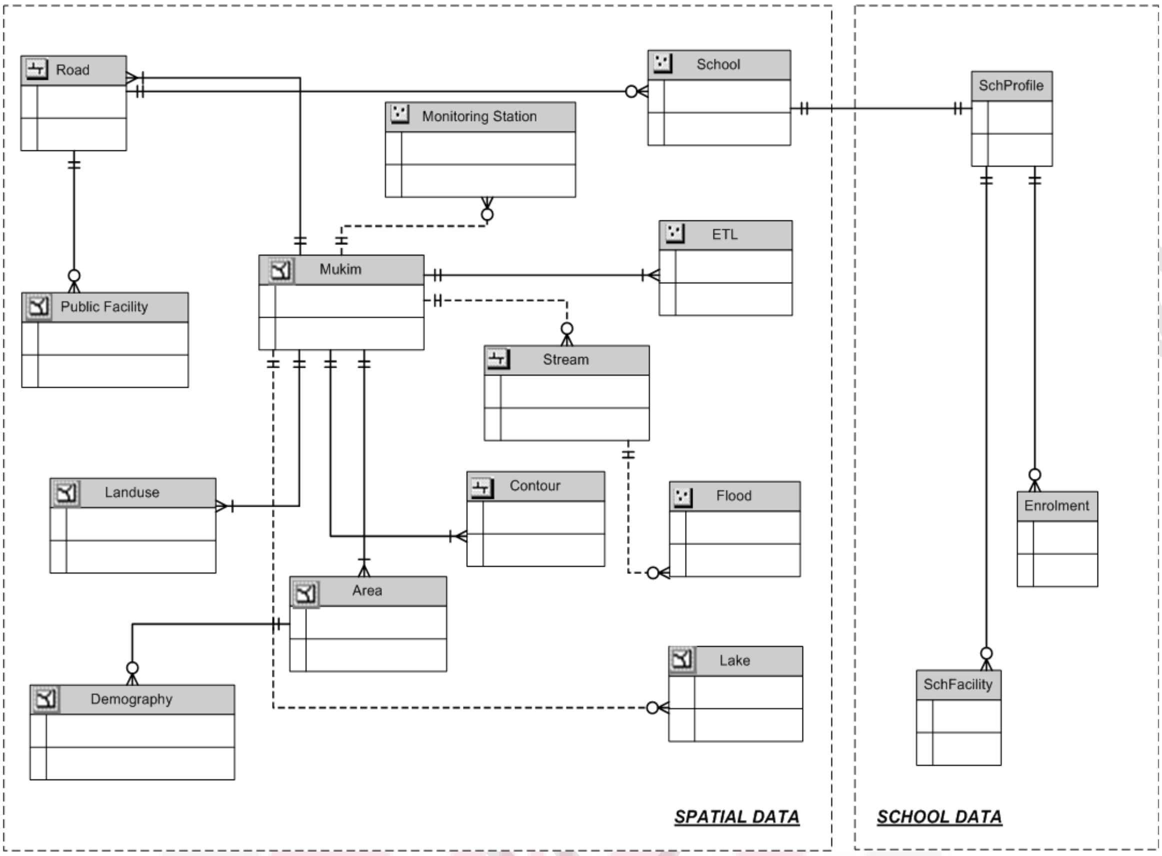


Figure 3.5. Conceptual Model

Table 3.2. Cardinalities of Relationship

Num	Parent	Child	Cardinality	Relationship Type	Explanation
1	Mukim	Road	1 : 1 or more	Identifying	Mukim has many roads, road segment located in one mukim boundary.
2	Mukim	Land Use	1 : 1 or more	Identifying	Mukim Boundary has many land use type, land use allocated to one mukim boundary.
3	Mukim	Area	1 : 1 or more	Identifying	Mukim Boundary has many areas, area located in one mukim boundary.
4	Mukim	Contour	1 : 1 or more	Identifying	Mukim Boundary has many contour, contour located in one mukim boundary.
5	Mukim	Stream	N:M	Non Identifying	Mukim Boundary has many streams, stream segment may located in more than one mukim.
6	Mukim	Utility	1 : 1 or more	Identifying	Mukim Boundary has many utility, utility located in one mukim boundary.
7	Mukim	Monitoring Station	1 : 0 or more	Non Identifying	Mukim may have many monitoring system, monitoring system located in one mukim.
8	Road	School	1 : 0 or more	Identifying	Along the road has many schools, schools located in one road.
9	Road	Public Facility	1 : 0 or more	Identifying	Mukim Boundary has many public facility, public facility located in one mukim boundary.
10	Area	Demography	1 : 0 or more	Identifying	Area has many people, people stay in one area.
11	Stream	Flood Area	N:M	Non Identifying	Overflow of stream may cause flood, flood can be cause by overflow of more than 1 stream.
12	Mukim	Lake	N:M	Non Identifying	Mukim Boundary has many lake, lake may located in more than one mukim.
13	School	SchProfile	1:1	Identifying	School has 1 profile, profile of school belong

					to particular school.
14	SchProfile	Enrolment	1 : 1 or more	Identifying	School has many students, student study in one school.
15	SchProfile	SchFacility	1 : 1 or more	Identifying	School has many facilities, facility belong to one school.

3.3.4.2 Logical Design

Logical data modeling implements conceptual data model and represents the business requirement of an organization (Lo and Yeung, 2006). It is a comprehensive process by which the conceptual data model is consolidated and refined. The database is reviewed in its entirety in order to identify potential problems such as irrelevant data, omitted or missing data, inappropriate representation of entities and lack of integration between various parts of the database (Lo and Yeung, 2006).

Generally, logical data modeling transform conceptual data model to be adjusted in a data base management system (DBMS) format for a database development. The process includes mapping the conceptual design to the logical design, identifying keys and foreign keys, and normalizing the attribute tables. Logical model that commonly used are relational, network and hierarchical. This study used a relational database model. In the relational database model, the relationships between entities can be identified by means of an attribute called key.

In this logical model, the attribute of the entity will be detailed and the definition of the primary key of entity. Logical design for school site selection database is in Figure 3.6 shows the logical design for school site selection database. Detailed attribute in logical design can be seen in Appendix 2.

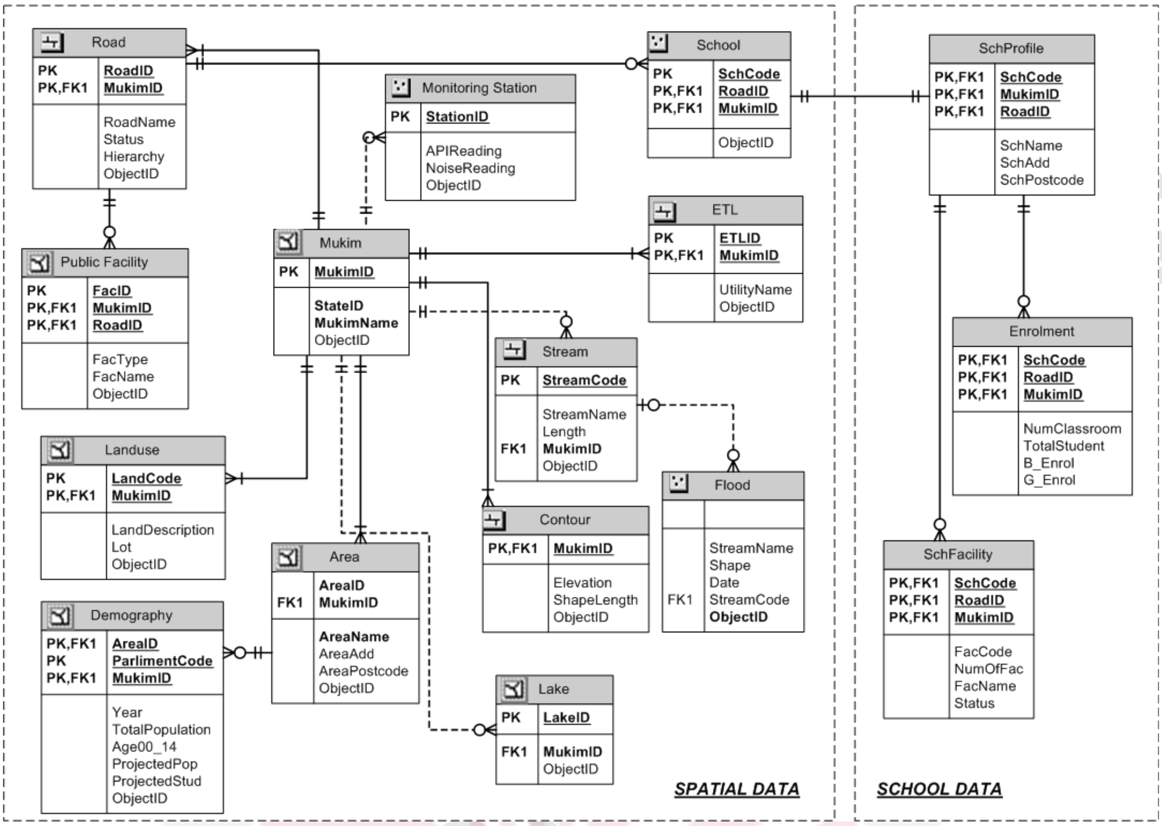


Figure 3.6. Logical Design

3.3.4.3 Physical design

Physical data design is a low-level implementation modeling which storages structure definitions and access path to database is concerned (Lo and Yeung, 2006). It specifies how data are stored and how data flow between processes. To achieve this purpose, software and operating system specification to support the system needs to be carefully designed and chosen. It will depend on a storage capacity, one or multi user, on-line or off-line transaction and data networking

Logical schema from previous stage is used as input to physical design. The output is a physical schema that is data dictionary, characteristics of items, and physical database design specification. Figure 3.7 shows the physical design in ERD. Detailed attribute in physical design can be seen in Appendix 3.

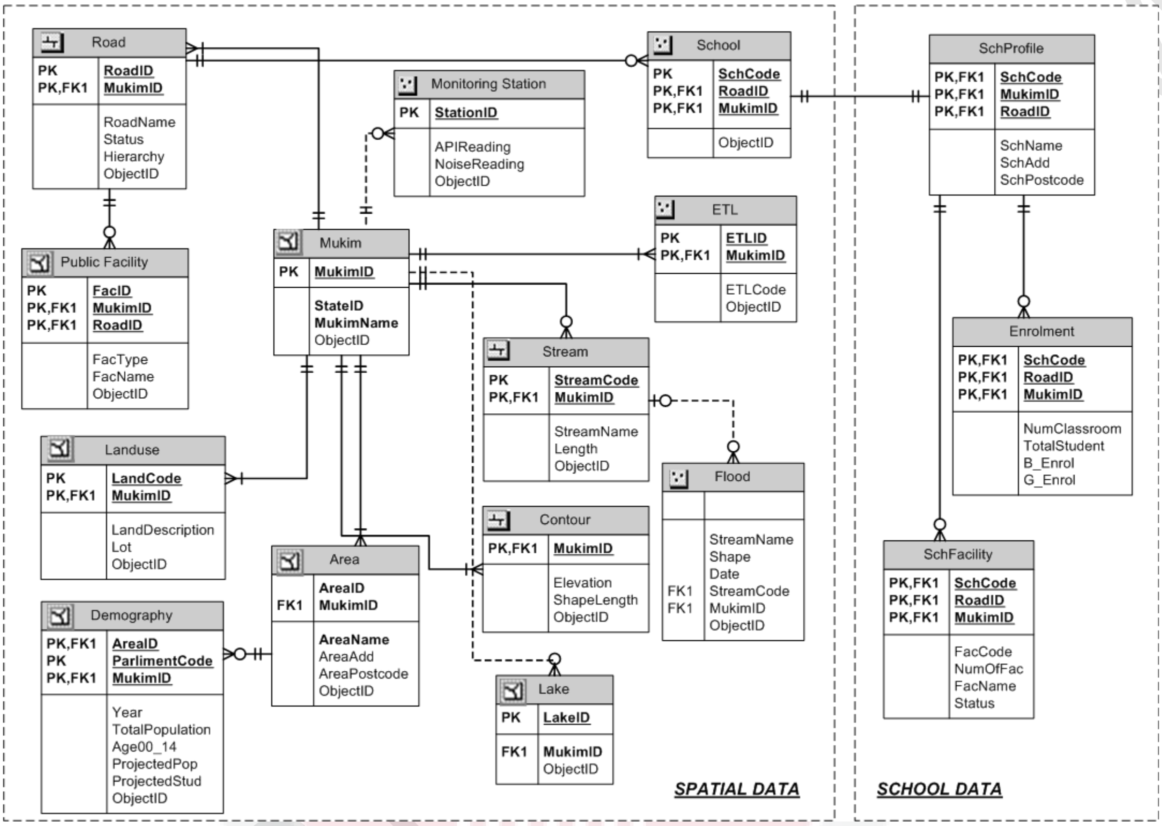


Figure 3.7. Physical Design

3.3.5 Database Development

The database development includes the spatial data collection and data input, data editing, topology development and data format change.

3.3.5.1 Data Collection and Data Input

The data are categorized to spatial data and attribute data. The spatial data includes contour, flood, land use, public facility, road network, schools location, stream, lake, utility and demography; attribute data includes API reading, noise reading and school information. The spatial data sources which were obtained in the form of paper map and digital image was digitized with ArcGIS 9.2 and projected to Selangor_Cassini format, while the spatial data which were obtained from different format of file such as map info file (*.tab) were converted to ArcGIS software (*shapefile*) and were projected to Selangor_Cassini. Table 3.3 shows the data type and sources.

The locations of schools were obtained from DBKL and field survey using GPS Garmin tool (GPSMAP 60Cx). The schools coordinate were input to the database using MapSource software and their attributes were obtained from EMIS system. Currently 48 public schools exist in the study area, which 33 of them are primary schools and the rest are secondary schools. Seven air quality monitoring stations which cover approximately the area of Mukim Batu, Kuala Lumpur namely; Country Heights (Kajang), Pelabuhan Klang, Petaling Jaya, Shah Alam, SMK Seri Permaisuri (Cheras) and SK Batu Muda (Batu Muda) were plotted from Google Earth. The daily API readings from January 2009 to April 2009 were obtained from DOE website (http://www.doe.gov.my). The records of most frequently API reading had been used to represent the overall air quality for selected API stations. Noise readings for the study area were not available. Surrogate data were used for representing the noise level reading in the study area which is ranged from 49.3 to 62.7 dBA, after considering the noise level of the area of Pelabuhan Klang, Petaling Jaya, Shah Alam , Kuala Selangor and Kajang. For this study, the API stations as stated previously would be used as surrogate noise stations. The population data in Enumeration Block (EB) were obtained from DBKL and DOS. The topography map scale is 1:25000. It is a standard scale for topography map.

Table 3.3. Data Requirement

Spatial Data		Attribute Data	
Data Type	**Data Source**	**Data Type**	**Data Source**
Contour map	JUPEM, 2009	API Reading	DOE Website, 2009
Flood map	MyGDI, 2003	Monitoring Station	DOE Website, 2009
Land use map	DBKL, 2007	Schools Information	EMIS, 2009
Orthophoto	JUPEM, 2009		
Public facility	DBKL, 2009		
Road network	JUPEM, 2009		
Schools location	Field survey, DBKL 2009.		
Stream, Lake	JUPEM, 2009		
Topography map	JUPEM, 2009		
Utility map	DBKL, 2009		
Population	DBKL, 2000 DOS, 2000		

3.3.5.2 Data Editing and Topology

Data editing and topology is an important process since it will be used for data cleaning and data preparation for analysis used. Topology is a process to ensure that the associated data forms a consistent and clean topological fabric. Topology is also a collection of rules and relationships that coupled with a set of editing tools and techniques which enable the geodatabase to be more accurate and maintain its referential integrity between objects in the geodatabase.

Figure 3.8 shows the topology rules for road network for this study are road must not overlap, road must not have dangles and road must not intersect.

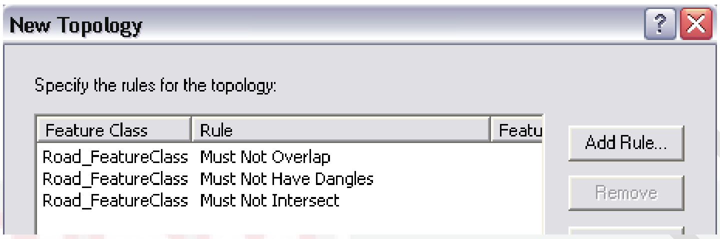


Figure 3.8. Topology Rules for Road Network in the Study Area

3.3.5.3 Geodatabase

Geodatabase is a collection of data sets and acts as a container for data. In this study, one geodatabase was built for easy maintenance, organizing and migrating. The edited and clean spatial data were exported to this Geodatabase, namely EducationGIS (Figure 3.9). There are 4 steps to build the Personal Geodatabase. The 4 steps are Feature Dataset, Feature Class, Table and Relationship Class. Figure 3.9 shows the EducationGIS which consist of 11 Feature Data Set and 13 Feature Class. Details about Feature Data Set and Feature Class can be seen in Table 3.4.

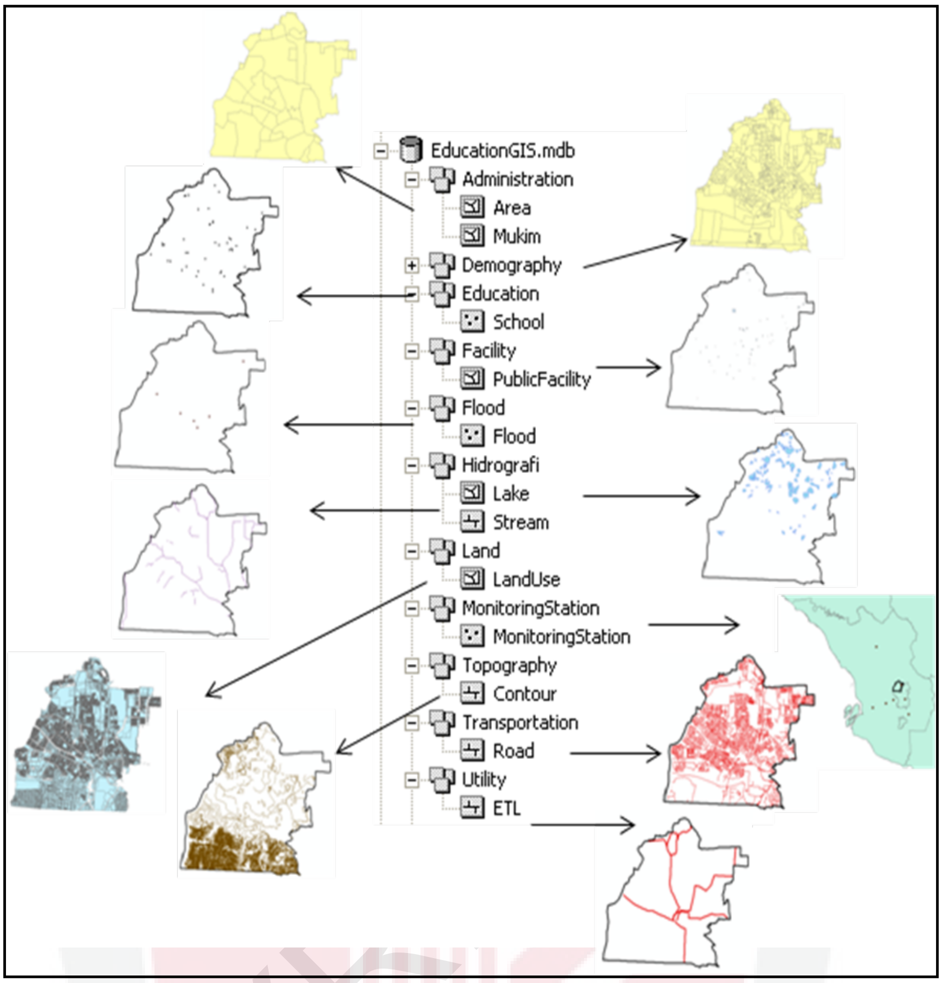


Figure 3.9. Geodatabase - EducationGIS

Table 3.4. Feature Dataset and Feature Class

Feature Dataset	Feature Class
Administration	Mukim, Area
Demography	Demography
Education	School
Facility	PublicFacility
Flood	Flood
Hidrography	Stream, Lake
Land	Land Use
Monitoring Station	MonitoringStation
Topography	Contour
Transportation	Road
Utility	ElectricityTransmissionLine (ETL)

3.3.6 Development of Suitability Map

Suitability map enables to obtain a suitability value for every location on the map. To develop the suitability map, the identified data layers need to be classified and weighted according to their importance. One of the most common technique in multi criteria evaluation is weighted linear combination (WLC) suggested by Eastman (1995).

3.3.7 Formation of Suitability Index

This study used WLC method technique for school suitability index. It was based on the formula:

$$s_{ij} = \sum_{m=1}^{M} (x_{ij}\, w_m)\, c_m \qquad (3.2)$$

Where

S_{ij} suitability score of *i,j* location
x_{ij} criterion score for *m* factor of i,j location
w_m weightage of relative importance for *m* factor
c_m boolean value of constraint factor of *i,j* location
m consideration criterion or factors

i. Establishing the criteria score (X_{ij})

Data need to be standardized in order to create a proper analysis which depends on the type of parameters attributes. Standardizing the scores depends on the attributes that a parameter has. Classification and scores of the categorical attributes have been used which were set from the Planning Guidelines JPBD 19/97, Ministry Of Education, comparison between state guidelines and previous research. The criterion score is standardized from a highly suitable location to not a suitable location score which can be transferred numerically from 1 to 4, which is the highest value represents the highly suitable location (see table 3.5).

ii. Establishing criterion weight (W_m)

For each criterion weightage (W_m), relative importance were set out through discussions and interviewed with a group of expertise using AHP and pair wise comparison. Figure 3.10 shows the role and the experience of the expertise and a questionnaire survey can be seen in Appendix 4. Table 3.5 shows the site suitability criteria which consist of criterion score(X_{ij}) and weight(W_m).

Num	Role / Position	Experience in related field
1.	Head of school planning, EPRD	10 years
2.	School Planning Officer, WPKL	10 years
3.	Planning Officer, DBKL	6 years

Figure 3.10. Role and Experience of Interviewed Expertise

Table 3.5. Site Suitability Evaluation Criteria

Description of score: 1-Not Suitable; 2-Marginally Suitable; 3-Moderately Suitable; 4-Highly Suitable

Analysis	**Criteria**	**Classification**	**Standardzation of Score (X_{ij})**	**Weight (W_m)**
School Demography Analysis (0.5)	**Population Density**	3500 - 7000 7000 - 10500 10500 - 14000 > 14000	1 2 3 4	0.25
	Projected Population Density	3500 - 7000 7000 - 10500 10500 - 14000 > 14000	1 2 3 4	0.25
	Student Density	420 - 1000 1000 - 2000 2000 - 3000 > 3000	1 2 3 4	0.25
	Projected Student Density	420 - 1000 1000 - 2000 2000 - 3000 > 3000	1 2 3 4	0.25
Total Weight				**1.0**
School Safety Analysis (0.5)	**Distance from industry area**	0 - 500 m 500 – 1000 m 1000 – 1500 m >1500 m	1 2 3 4	0.206
	Distance from commercial area	0 - 500 m 500 – 1000 m 1000 – 1500 m >1500 m	1 2 3 4	0.023
	Distance from main road	0 – 150 m 150 – 300 m 300 – 450 m > 450 m	1 2 3 4	0.042
	API reading	0 – 50 51 – 100 101 – 200 > 200	4 3 2 1	0.071
	Sound Level (Day Time)	0 - 50 dBA 51 - 55 dBA 56 - 60 dBA > 61 dBA	4 3 2 1	0.044
	Slope (degree)	0 - 10 > 10	4 1	0.224
	Proximity to Flood prone	0 - 500 m 500 – 1000 m 1000 – 1500 m >1500 m	1 2 3 4	0.026

	Distance from stream	0 – 150 m 150 – 300 m 300 – 450 m > 450 m	1 2 3 4	0.021
	Proximity to electrical transmission line	0 – 150 m 150 – 300 m 300 – 450 m > 450 m	1 2 3 4	0.123
	Height	0 - 60 > 60	4 1	0.22
Total Weight				**1.0**

3.3.8 Constraint Map (C_m)

The identified criteria for constraint mapping as mentioned earlier can be seen in Table 3.6 which it lists the constrains, the available source maps used to represent them, and the standardization methods applied to the derived maps or to the source maps.

Table 3.6. Constraint Map and Standardization

Constraint	**Source data**	**Standardization**
• Open space area • No development area • Education area	Land use	The 3 areas are standardized to 1, all others to 0
Road reserve	Road map	Outside road reserve is standardized to 1, all other value are standardized to 0.
Stream reserve	Stream Map	Outside road reserve is standardized to 1, all other value are standardized to 0.
Height	Contour Map	Below 60m, height is standardized to 1, all other are standardized to 0
Slope	Contour Map	Below 10^0 angle of slope is standardized to 1, all other are standardized to 0.
Lake	Topography Map	Distance less than 150 m is standardized to 0, all other are standardized to 1.

3.4 Definition of New Criteria Structure of the Evaluation Phase

The potential sites for the schools were evaluated using different set of criteria. For this last phase, accessibility approach was used to identify the most suitable school. Accessibility refers to how easy is to go to a site. It helps to determine how suitable a site is for a new business. For this study, it concerns the ease with which activities may be reached from schools by students or school staff. How schools student or staff can go for a specific facilities or amenities. The method to conduct this phase can be graphically viewed in Figure 3.11.

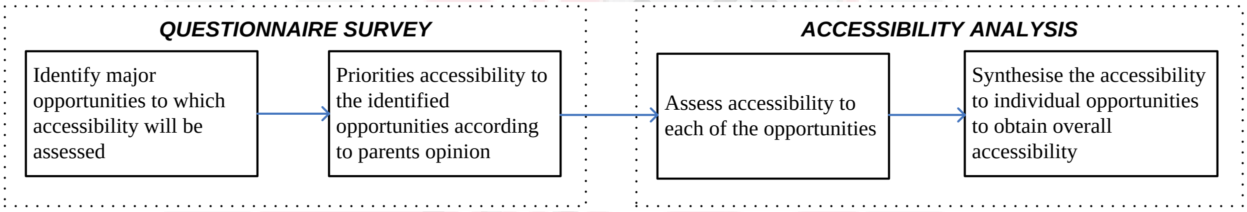


Figure 3.11. A Multi Criteria Framework for Accessibility Analysis
Adopted from Zhu et al. (2005)

Based on the framework, the first step is on identifying facilities and amenities to which will be measured for school development. After that, parents' opinion will be obtained for ranking the school accessibility criteria. These two steps were conducted through questionnaire surveys. Using Statistical Package for the Social Sciences (SPSS) software, these opportunities were ranked based on the survey results. The accessibility evaluation were transformed into GIS data layers and each data layers was assigned a weight derived using a multi criteria analysis technique based on the data from the survey.

These data layers were then synthesized into one data layer by applying WLC equation through map algebra. This will result in the overall accessibility of each potential location for school development.

3.4.1 Identification and Ranking of School Accessibility Criteria

Questionnaire surveys were conducted in four primary schools at Mukim Batu area in January and February 2010 to identify facilities and amenities that are relevant and important to the student parents. It is also to determine the relative importance of accessibility to the identified facilities. The questionnaire survey can be seen in Appendix 6.

3.4.2 Formation of School Accessibility Index

Using the WLC technique, school accessibility index was generated which the criterion score were obtained from community opinions and relative importance were set out through the questionnaire survey and was further analyze using a ranking method namely SMARTER in JavaHP software. The WLC technique used this formula:

$$A_{ij} = \sum_{m=1}^{M} (x_{ij}.w_m) \qquad (3.3)$$

Where:

A_{ij} Accessibility score of *i,j* location

x_{ij} criterion score for *m* factor of i,j location

w_m weightage of relative importance for *m* factor

m consideration criterion or factors

The detailed ranking method and procedure can be seen in section 4.9. Table 3.7 shows the accessibility criteria which consist of criterion score (X_{ij}) and weight(W_m).

Table 3.7. Accessibility Evaluation Criteria

Description of score: 1-Not Suitable; 2-Marginally Suitable; 3-Moderately Suitable; 4-Highly Suitable

Analysis	**Criteria**	**Classification**	**Standardzation of Score (X_{ij})**	**Weight (W_m)**
Accessibility Analysis	**Number of Housing Lot**	0 - 1500 1500 - 3000 3000 - 4500 > 4500	1 2 3 4	0.418
	Number of Roads	< 1 1 2 > 2	1 2 3 4	0.242
	Number of Health Centre	< 1 1 2 > 2	1 2 3 4	0.158
	Number of Safety Centre	< 1 1 2 > 2	1 2 3 4	0.103
	Number of Library	< 1 1 2 > 2	1 2 3 4	0.061
	Number of Community Centre	< 1 1 2 > 2	1 2 3 4	0.028

3.4.3 Model Validation

Model validation is important for data quality control and for testing the model. A comparison between the suitable sites with the proposed school location provided by DBKL was carried out. The proposed school location was obtained from DBKL in digital softcopy and was digitized for further analysis. The both sites location were overlaid to determine how much the proposed school location matched with the model output.

3.5 Summary

The school site selection process has been elaborated in this chapter which consist of 3 phase; Intelligence, Design and Choice. A set of criteria for school need analysis and school safety analysis have been identified and ready to be used in the next chapter. A geodatabase has been developed to conduct further analysis in a systematic way. The next chapter expounds the simulation of the model and discusses the results.

CHAPTER 4

RESULTS AND DISCUSSION

4.0 Introduction

This chapter reports and analyzes the results obtained from the implementation of the proposed methodology. This chapter starts with observation the schools in the study area. It is then followed by an elaboration on geoprocessing process and technique for a school site selection. Finally, results from each stage is interpreted and discussed.

4.1 Schools in the Study Area

There are 33 primary public schools in Mukim Batu. The primary schools consist of 22 national primary schools (SK) and 11 national-type schools (SJKC and SJKT). Table 4.1 shows the schools in the study area. This study focuses on primary schools only. The table shows 25 primary schools operated in the morning session, while 3 other schools operated in the afternoon session. There are also 5 schools operated in a double session and 4 schools that share buildings with others.

Schools that are operated in a double session show that the available classrooms are not enough to accommodate student enrolment. Meanwhile, the sharing school building scenario shows that there are serious needs for new schools development.

Table 4.1. Schools in the study area

Type of Schools	Number of Schools	Number of schools in single session		Number of schools in double session	Building status		Enrolment	Number of Classroom
		Morning	Afternoon		Own Building	Share with other building		
SK	22	17	2	3	20	2	13467	551
SJKC	9	6	1	2	7	2	13603	286
SJKT	2	2			2		602	20
TOTAL	33	25	3	5	29	4	27672	857

Source : Educational Planning and Research Division (2009)

4.2 School Need Analysis

The first analysis to be done is to determine the ideal number of the schools needed in the area. The first population approach was based on JPBD guidelines which stated that new school should be developed for a neighborhood consists of 3500 to 7000 residents. By using the highest residents in the JPBD guidelines (7000) and estimated population of the Mukim Batu (250000), the ideal number of primary schools are 36 using Equation 4.1

$$S = \frac{p}{n} \tag{4.1}$$

Where:

S ideal number of school

p population

n maximum number of residents according to the guidelines

The second enrolment approach was based on MOE guidelines; the optimum number of students per classroom should be 30. The total numbers of classroom in the study area are

857, and the existing enrolments are 27672 (see table 4.1). By using the equation 3.1 the numbers of needed schools are $\frac{27672-(857*30)}{900}=2.18$. The values indicate that, 2 new schools are needed in the study area.

Both approaches (population and enrolment approach) seem to be logical because the required numbers of new schools are not much different. The first approach identifies that, there should be 3 more schools required in the area (36 - 33). While the second approach identifies another 2 schools need to be built in the area.

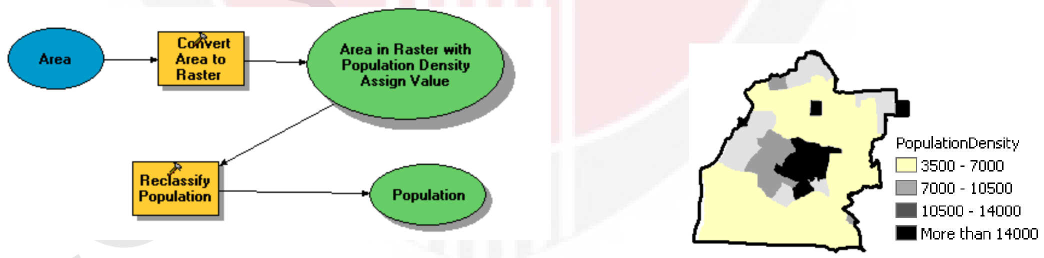
For further analysis in locating the potential site selection, suitability analysis has been carried out. In this analysis the area with suitability criteria can be identified. Further on, it can determine the number of schools that fell within classified zone (1-Not Suitable; 2-Marginally Suitable; 3-Moderately Suitable; 4-Highly Suitable). The suitability analysis consists of **Demography Analysis** and **Safety Analysis**.

4.3 Demography Analysis

Thematic layers involve in this analysis were Mukim Batu, Area, Demography and School. The subsequent sections detail the geoprocessing for every factor.

4.3.1 Accommodating Population

Schools should be built to accommodate population. The higher population; the more schools need to be developed. As stated in JPBD guidelines, there should be 1 primary school for every 3000 to 7500 residence. Population count is not appropriate because the housing type varies. Therefore, the use of population density is more appropriate. Density is calculated as the number of population in a region divided by the region's area. By using intersect function, both areas and demography thematic layers were combined and intersect. From the intersect function, the population in particular areas can be determined. Figure 4.1(a) shows the geoprocessing workflow for preparing the population density criterion map. Firstly, in order for quick perform the quantitative analysis and mathematical modeling, the area layer was converted to raster format. The population density field was used to assign values to the output raster. A reclassification process was executed according to the classification and scores as in Table 3.5.



(a) Geoprocessing workflow to generate the population density criterion map

(b) Population density criterion map

Figure 4.1. Geoprocessing Workflow and Population Density Criterion Map

Table 4.2 shows the area of population density which was represented by pixel value of 10x10 meter square. The pixel value of 10x10 meter square was chosen for more accurate analysis. There are 3404.29 ha representing the population area with less than 7000

(76.7%) residents. Majority of the area located on the south and north part of the study area (Figure 4.1 (b). The highest population density with more than 14000 residents located in the central part of the study area which represent 11.2% (497.24 ha). In the population density criterion map (Figure 4.1 (b)) the highest population is represented by the darker hues.

Table 4.2. Population Density Criterion Map Analysis

Value	Population Density	Count	Area in m^2	Area in Hectare	%
1	3500-7000	340429	34042900	3404.29	76.7
2	7000-10500	79959	7995900	899.59	18.0
3	10500-14000	43658	4365800	436.58	9.8
4	More than 14000	49724	4972400	497.24	11.2

4.3.2 Accommodating Projected Population

Figure 4.2(a) shows the geoprocessing workflow for preparing the projected population density criterion map. Starting by converting the area layer to raster format by using the projected population density field assign value, reclassification process was executed according to the classification and scores as in Table 3.5.

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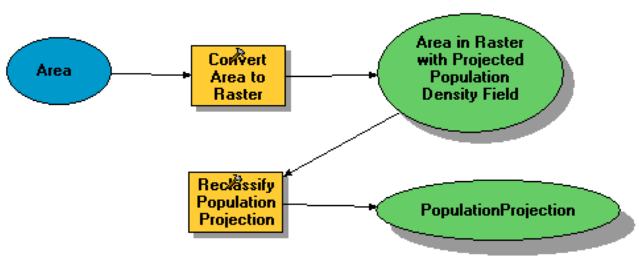
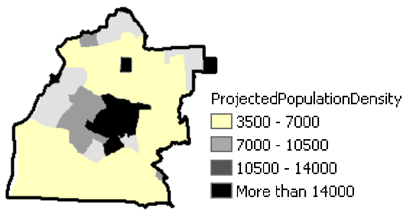


(a) Geoprocessing workflow to generate the projected population density map



(b) Projected population density criterion map

Figure 4.2. Geoprocessing Workflow and Projected Population Density Criterion Map

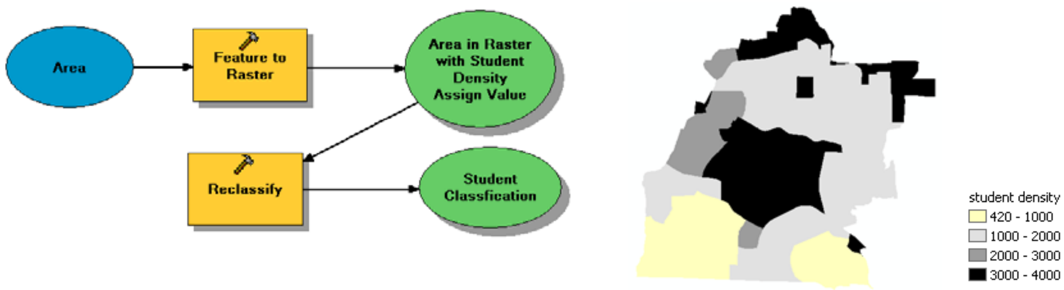
Table 4.3 shows 2550.29 ha represent the population which is less than 7000 (49.7%) which is located on the South and North part of the study area. Comparing with the population criterion map, there will be slightly increased in hectare which shows that there will be a slight declining in population projection for the next 10 years. The area with a high projected population density also has been noticed located on the central part of the study area (Figure 4.2 (b)).

Table 4.3. Projected Population Density Analysis

Value	Projected Population Density	Count	Area in m^2	Area in Hectare	%
1	3500-7000	255029	25502900	2550.29	49.7
2	7000-10500	121892	12189200	1218.92	23.8
3	10500-14000	50172	5017200	501.72	9.8
4	More than 14000	86002	8600200	860.02	16.8

4.3.3 Accommodating Students

School should be distributed geographically to accommodate students' needs. Different with population analysis, this analysis focused into a small group of people age between 0 to 14 years old. Start with calculating the student density in vector format; it will then being converted to raster with student density field assign value and reclassified according to the classification and scores as in Table 3.5. Figure 4.3(a) shows the geoprocessing workflow for preparing the student density criterion map.



(a) Geoprocessing Workflow to Generate the Students Density Criterion Map
(b) Student Density Criterion Map

Figure 4.3. Geoprocessing Workflow and Criterion Map for Student Density

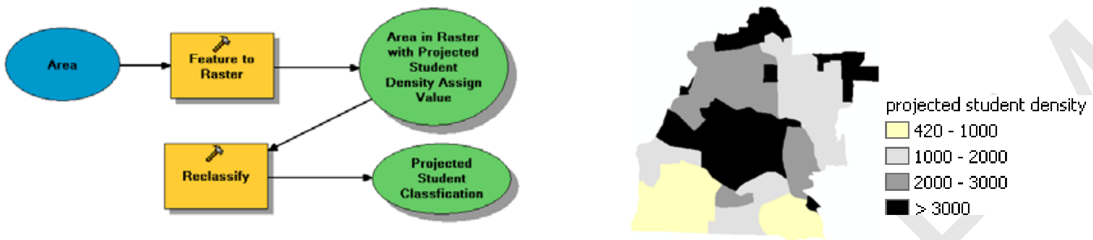
Table 4.4 shows 1391.98 ha (26.2%) represent the area with more than 3000 school children with age from 0 to 14 years old, 2734.08 ha (51.4%) represent the area between 1000 to 3000 school children, and 1011.64 ha (19%) represent the area with less than 1000 school children. The student density criterion map shows the darker hues is the most dense school children which located on the centre of the study area (Figure 4.3 (b)).

Table 4.4. Student Density Criterion Map Analysis

Value	Student Density	Count	Area in m^2	Area in Hectare	%
1	420-1000	101164	10116400	1011.64	19
2	1000-2000	227996	22799600	2279.96	42.9
3	2000-3000	45412	4541200	454.12	8.5
4	More than 3000	139198	13919800	1391.98	26.2

4.3.4 Accommodating Projected Students

To accommodate future students need, surrogate data has been used for representing projected students since there is no available data. It is estimated that the population for Kuala Lumpur for the year 2020 is 2.2 million (Kuala Lumpur City Hall, 2009), means that the population is estimated to 2.2% increasing, therefore, the students' population is also estimated to increase 2.2%. Figure 4.4(a) shows the geoprocessing workflow for preparing the projected student density criterion map.



(a) Geoprocessing Workflow to Generate Projected Students Density Criterion Map

(b) Projected Student Density Criterion Map

Figure 4.4. Geoprocessing Workflow and Criterion Map for Projected Student Density

Table 4.5 shows 1509 ha (29.4%) represents the area with more than 3000 school children with age from 0 to 14 years old (score 4), 2610.21 ha (50.9%) represents the area between 1000 to 3000 school children (score 2 to 3), and 1011.64 ha (19%) represents the area with less than 1000 school children (score 1). The student density criterion map shows the darker hues is the most dense school children which located in the centre of the study area (Figure 4.4(b)).

Table 4.5. Projected Student Density Criterion Map Analysis

Value	Projected Student Density	Count	Area in m^2	Area in Hectare	%
1	420-1000	101164	10116400	1011.64	19.7
2	1000-2000	145571	14557100	1455.71	28.4
3	2000-3000	115450	11545000	1154.50	22.5
4	More than 3000	150910	15091000	1509.10	29.4

4.3.5 Results of Demography Analysis

The 4 criterion maps need to combine in order to get the final result of the demography analysis. The Map Algebra function has been used to enter the formula for combining all criterion maps. The formula used WLC technique which has been defined in previous section (Equation 3.2). The workflow for carrying the process can be seen in Figure 4.5 and the map output in Figure 4.6.

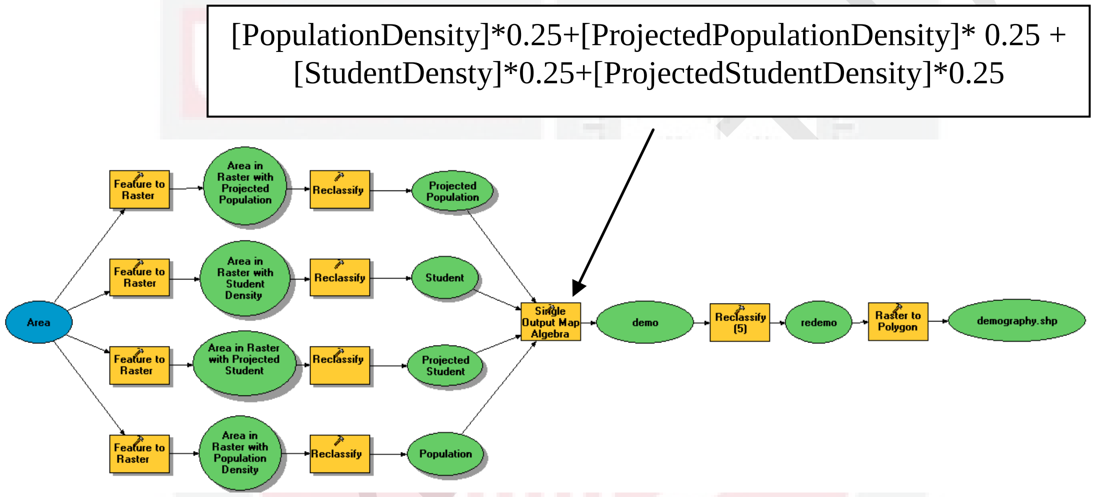


Figure 4.5. Geoprocessing Workflow to Generate Demography Analysis

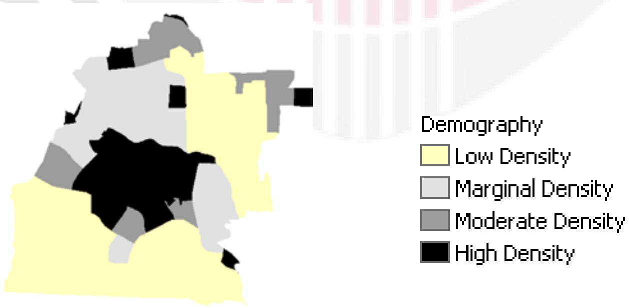


Figure 4.6. Demography Analysis Map

Table 4.6 shows the highly density area (score 4) represent 927.07 ha (18.1%) which located on the central part of Mukim Batu, while 2500 ha (48.7%) represent for low density area (score 1). In the Demography Analysis map (Figure 4.6), darker hues represent the highly density location and lighter hues represent the low density location.

Table 4.6. Demography Analysis

Value	Demography	Count	Area in m^2	Area in Hectare	%
1	Low Density	250075	25007500	2500.75	48.7
2	Marginal Denstiy	112110	11211000	1121.10	21.8
3	Moderate Density	58203	5820300	582.03	11.3
4	High Density	92707	9270700	927.07	18.1

Figure 4.7 shows a pie chart representing the Demography Analysis. Approximately 29% of the Mukim Batu area is in the densest area, while 49% represent the lowest dense area. Figure 4.8 shows the high density area which are Jinjang Selatan, Kepong Baru, Kepong Baru Tambahan, Taman Sri Bintang, Taman Cuepacs, Taman Sri Segambut and Jinjang Selatan Tambahan.

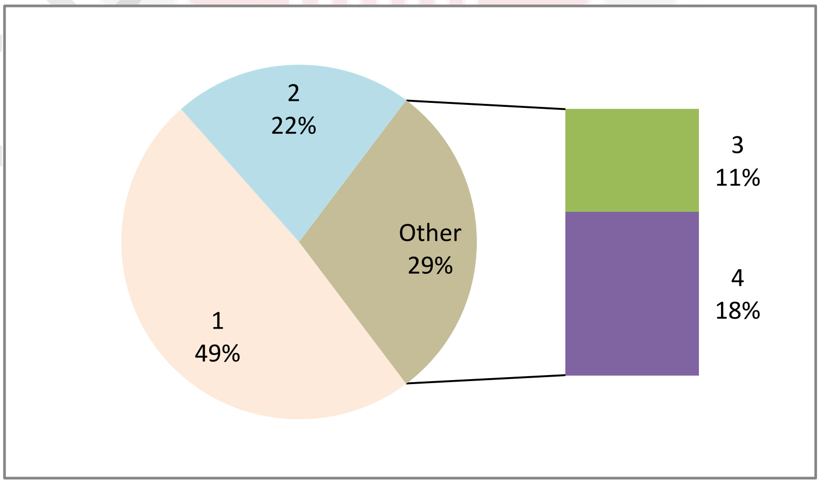


Figure 4.7. Demography Analysis Result in Pie Chart

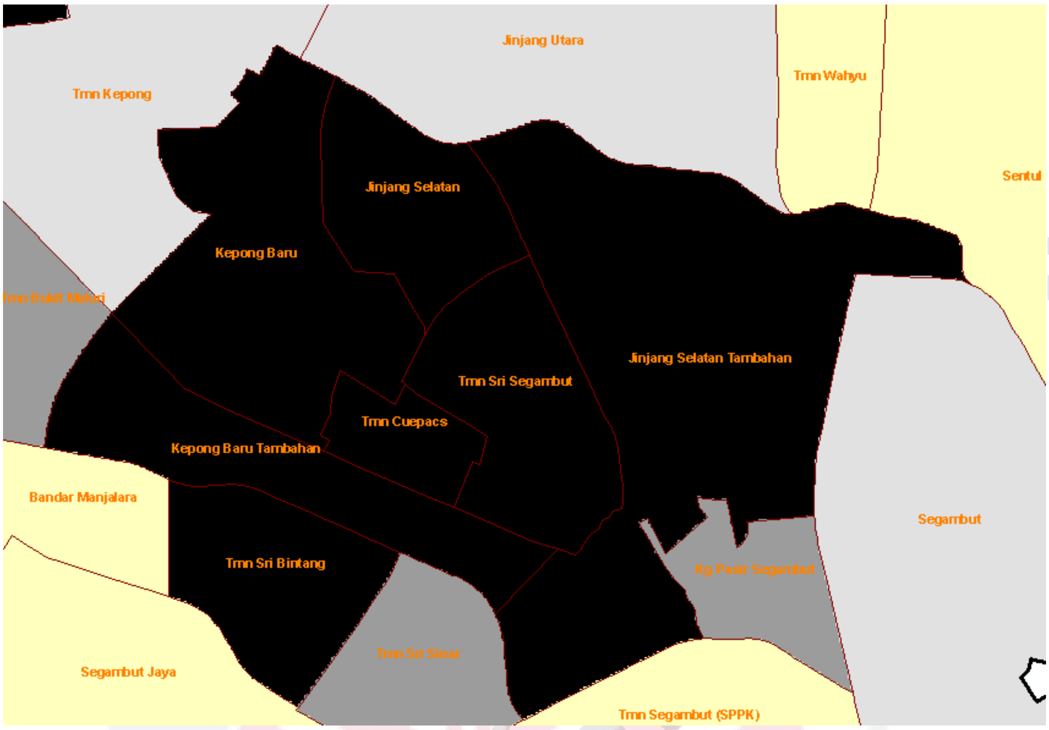


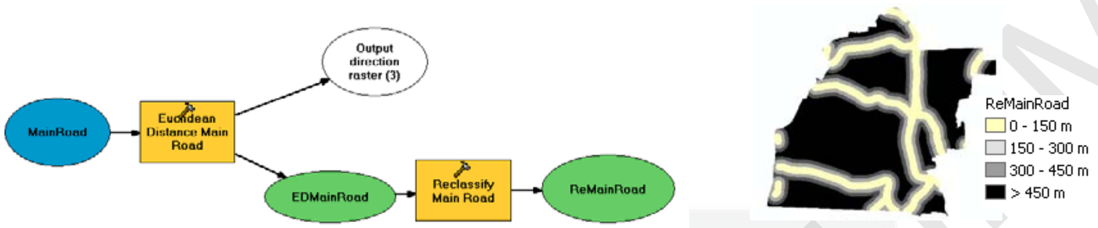
Figure 4.8. The High Density Area in Darker Hues

4.4 Safety Analysis

There are 6 Feature Dataset involved in this analysis which consists of Transportation, Environment, Utility, Physical, Land use and Topography. The subsequent sections detail the geoprocessing for every factor.

4.4.1 Proximity to Main Road

To measure the distance to the main road, **Euclidean Distance** function has been used. Firstly, main road category needs to be identified. There are 12 main roads in the study area namely Kuching Road, Karak Highway, Duta-Sg Buloh Highway, Kepong Road, Selayang-Kepong Highway, Damansara-Puchong Highway, Sentul Road, Batu Caves Road, Sprint Highway, Duta Road, MRR2 Highway and Ipoh Road (Kuala Lumpur City Hall, 2010). A reclassification process was executed according to the classification and scores as in Table 3.5.



(a) Geoprocessing workflow for proximity to main road

(b) Proximity to Main Road criterion map

Figure 4.9. Geoprocessing Workflow and Criterion Map for Proximity to Main Road

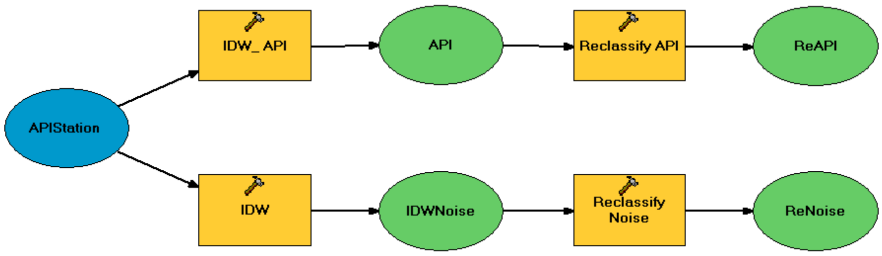
Table 4.7 shows 51.4% (score 4) of the study area represents the highest suitable location from main road which located more than 450 m from the main road. But, there was 17.9% of the study area located very near to main road (< 150m).

Table 4.7. Output Analysis of Proximity to Road Criterion Map

Value	Proximity to Main Road	Count	Area in m^2	Area in Hectare	%
1	0 - 150 m	94610	9461000	946.1	17.9
2	150 - 300 m	84551	8455100	845.51	16.0
3	300 - 450 m	78208	7820800	782.08	14.8
4	More than 450 m	272207	27220700	2722.07	51.4

4.4.2 Noise and API

For both noise and API factors, **Inverse Distance Weighted** (IDW) technique was used to interpolate surface from noise and API station points. As mentioned in the previous section surrogate data has been used to represent the overall noise near Mukim Batu, while API reading has been obtained from 7 air quality monitoring station since January 2009 to April 2009 daily (Refer 3.3.2). By using IDW function, cell values can be determined using a linearly weighted combination from a set of sample points obtained from the monitoring station. Figure 4.10 (a) shows the geoprocessing workflow to obtained API and noise reading for Mukim Batu area.



(a) Geoprocessing workflow for API and noise level reading

(b) Criterion Map for API

(c) Criterion Map for Noise level

Figure 4.10. Geoprocessing Workflow and Criterion Map for API and Noise Reading

Table 4.8 and Table 4.9 shows output analysis of API and noise criterion map. Based on DOE classification, API level for Mukim Batu was considered good. The noise level for Mukim Batu was accepted to range between 49.3 to 62.7dBA and it felt in scales 3 and 4 (Table 4.9).

Table 4.8. Output Analysis of API Criterion Map

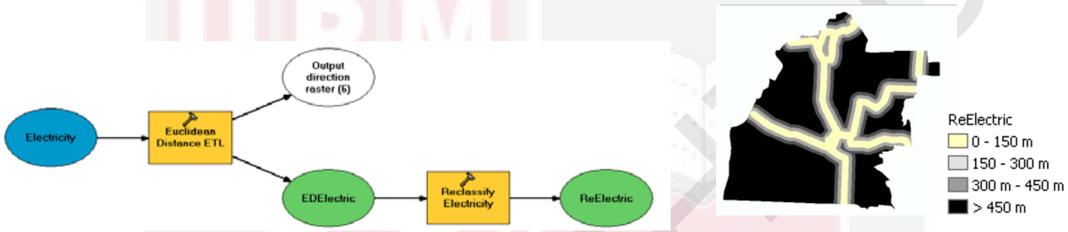
Value	Count	Area in m^2	Area in Hectare	Percentage
4	529576	52957600	5295.76	100

Table 4.9. Output Analysis of Noise Level Criterion Map

Value	Count	Area in m^2	Area in Hectare	Percentage
3	337177	33717700	3371.77	63.7
4	192399	199239900	1923.99	36.3

4.4.3 Proximity to Electricity Transmission Line (ETL)

Figure 4.11 used the same Euclidean Distance Function to proximately measure the distance from ETL to neighborhood.



(a) Geoprocessing workflow for proximity to ETL (b) Proximity to ETL Criterion Map

Figure 4.11. Geoprocessing Workflow and Criterion Map for Proximity to ETL

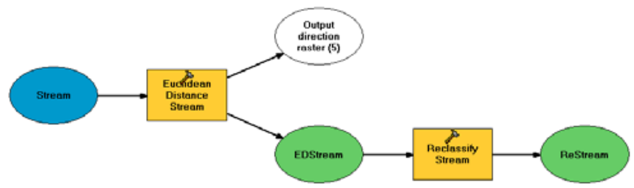
Table 4.10 shows 60.23% of the study area located more than 450 m from ETL, but there are still 15.4% located in not suitable area (less than 150 m from the ETL). The ETL cruising Mukim Batu in 4 corner, North, West, East and South. There should be no school building within 150 m from ETL.

Table 4.10. Output Analysis of Proximity to ETL

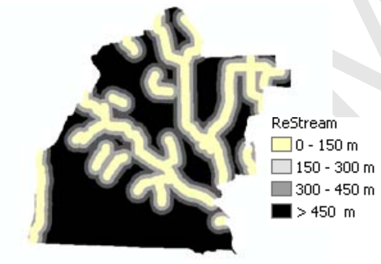
Value	Proximity to ETL	Count	Area in m^2	Area in Hectare	%
1	0 - 150 m	81699	8169900	816.99	15.4
2	150 - 300 m	69572	6957200	695.7	13.1
3	300 - 450 m	59338	5933800	593.38	11.2
4	More than 450 m	318966	31896600	3189.68	60.23

4.4.4 Proximity to Stream

Euclidean Function is used to measure proximity to stream which the flow can be seen in Figure 4.12(a) and the output can be seen in Figure 4.12(b).



(a) Geoprocessing workflow for proximity to stream



(b) Proximity to Stream Criterion Map

Figure 4.12. Geoprocessing Workflow and Criterion Map for Proximity to Stream

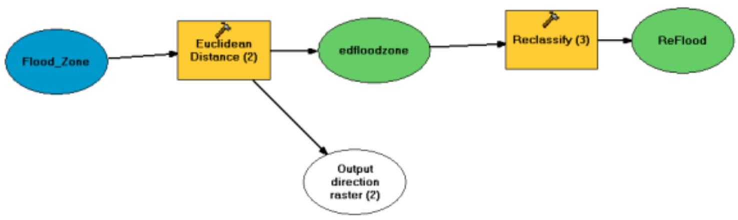
Table 4.11 shows there are 60.23% of the study area located more than 450 m from the stream which is the highly suitable area for school development (represent in darker hues in Figure 4.12(b)). But, there are 15.4% are not suitable for school development which located very near to stream (less than 150 m).

Table 4.11. Output Analysis of Proximity to Stream

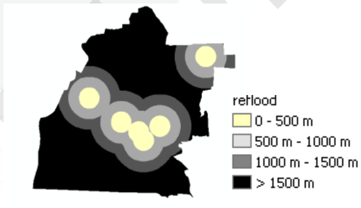
Value	Proximity to Stream	Count	Area in m^2	Area in Hectare	%
1	0 - 150 m	81699	8169900	816.99	15.4
2	150 - 300 m	69572	6957200	695.7	13.1
3	300 - 450 m	59338	5933800	593.38	11.2
4	More than 450 m	318966	31896600	3189.68	60.23

4.4.5 Proximity to Flood

Flood flash in Mukim Batu located near Sg Keroh, Sg Batu and Sg Kemursing. There have been tremendous flash floods near Sg Batu and Sg Keroh lately (Refer paper cutting in Appendix 10).



(a) Geoprocessing workflow for proximity to flood zone



(b) Proximity to Flood Criterion Map

Figure 4.13. Geoprocessing Workflow and Criterion Map for Proximity to Flood

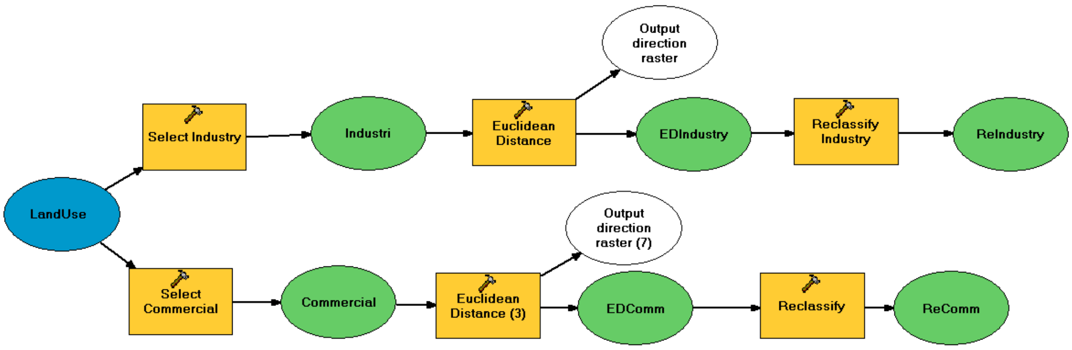
Table 4.12 shows there are approximately 1300 ha (25%) located very near to the flood zone (less than 1000 m), meanwhile there are approximately 3000 ha area located more than 1.5 km from the flood zone. The safe area from flood zone will be the area which is represented in darker hues in Figure 4.13(b).

Table 4.12. Output Analysis of Proximity to Flood

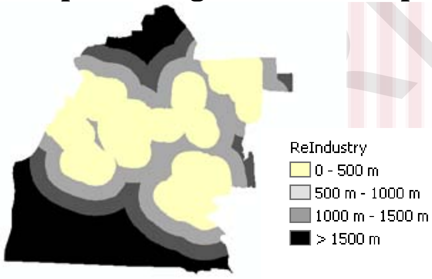
Value	Proximity to Flood	Count	Area in m^2	Area in Hectare	%
1	0 - 500 m	43574	43574	435.74	8.2
2	500 - 1000 m	89339	89339	893.40	16.9
3	1000 - 1500 m	95237	95237	952.37	18.0
4	More than 1500 m	301426	301426	3014.26	57.0

4.4.6 Proximity to Industry and Commercial

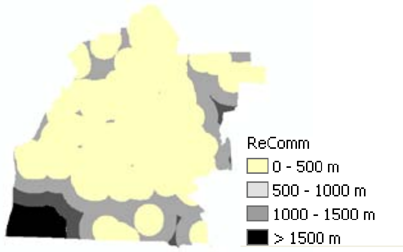
Geoprocessing workflow for preparing industry and commercial criterion map can be seen in Figure 4.14(a). The two types of activities were extracted from the land use thematic layer. Using **Euclidean Distance** function, proximity to existing industry and commercial can be measure.



(a) Geoprocessing workflow for proximity to industry and commercial area



(b) Proximity to Industry Criterion Map



(c) Proximity to Commercial Criterion Map

Figure 4.14. Geoprocessing Workflow and Criterion Map for Proximity to Industry and Commercial

Figure 4.14 (b) shows the proximity to industry criterion map with the darker areas represent higher distance from industry areas, while the lighter areas indicate the distance closer to the industry area. Table 4.13 shows there are approximately 2000 ha (39%) located very near to industry area (less than 500 m), and approximately 1300 ha (25%) located more than 1.5 km from industry.

Table 4.13. Output Analysis of Proximity to Industry Area

Value	Proximity to Industry	Count	Area in m^2	Area in Hectare	%
1	0 - 500 m	205024	205024	2050.24	38.7
2	500 - 1000 m	119991	119991	1199.91	22.7
3	1000 - 1500 m	74024	74024	740.24	14.0
4	More than 1500 m	130537	130537	1305.37	24.6

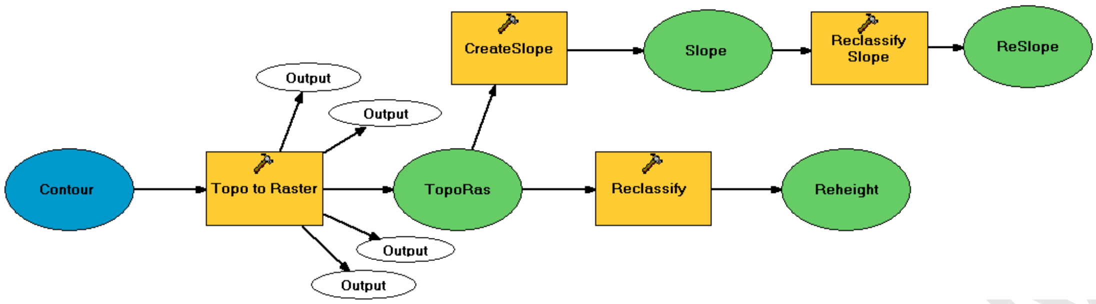
Figure 4.14 (c) shows the proximity to commercial criterion map. It is obvious to see lighter areas in the map compare to the darker areas. Table 4.14 proof there are almost 72% (3825 ha) that located in the lighter areas (less than 500 m) and only 4.4 % located far from commercial area (more than 1.5 km). This shows Mukim Batu is one of the extensively development areas.

Table 4.14. Output Analysis of Proximity to Commercial Area

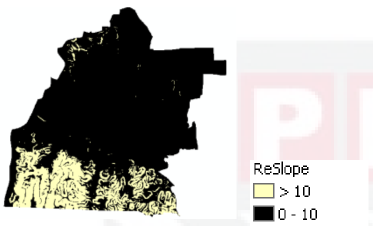
Value	Proximity to Commercial Area	Count	Area in m^2	Area in Hectare	%
1	0 - 500 m	382514	382514	3825.14	72.2
2	500 - 1000 m	102034	102034	1020.34	19.3
3	1000 - 1500 m	21671	21671	216.71	4.1
4	More than 1500 m	23304	23304	233.04	4.4

4.4.7 Slope and Height

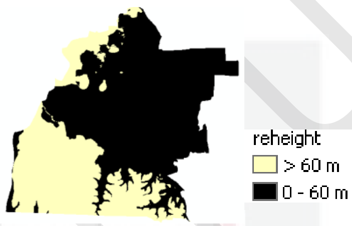
The workflow to create slope can be seen in Figure 4.15(a). Both slope and height were created and generated from contour map. A reclassification process was executed according to the classification and scores as in Table 3.5.



(a) Geoprocessing workflow to create slope and height



(b) Slope Criterion Map



(c) Height Criterion Map

Figure 4.15. Geoprocessing Workflow to Create Slope and Height and the Criterion Map

Table 4.15 shows analysis table of the slope criterion map. There is approximately 83% located less than 10^0 of slope while 17% located on more than 10^0 of slope. The steep slope mostly located on south part of the study area.

Table 4.15. Output Analysis of Slope Criterion Map

Value	Slope	Count	Area in m^2	Area in Hectare	%
1	More than 10^0	90736	90736	9073.6	17.1
4	0 - 10^0	438840	438840	43884.0	82.9

Table 4.16 shows the table analysis of height criterion map. There is approximately 36% of the area located above 60 m height meanwhile 64% of the Mukim Batu area located below 60 m height. The higher land (More than 60 m) located mostly on the south part and some located on northwest of the study area.

Table 4.16. Output Analysis of Height Criterion Map

Value	Height	Count	Area in m^2	Area in Hectare	%
1	More than 60 m	192268	192268	1922.68	36.3
4	0 - 60 m	337308	337308	3373.08	63.7

4.4.8 Results of Safety Analysis

The 10 criterion maps need to combine in order to get the final result of the safety analysis. The Map Algebra function has been used to enter the formula for combining the 10 criterion map. The formula used WLC technique which has been defined in previous section (3.2). The workflow for carrying the process can be seen in Figure 4.16 and the map output in Figure 4.17.

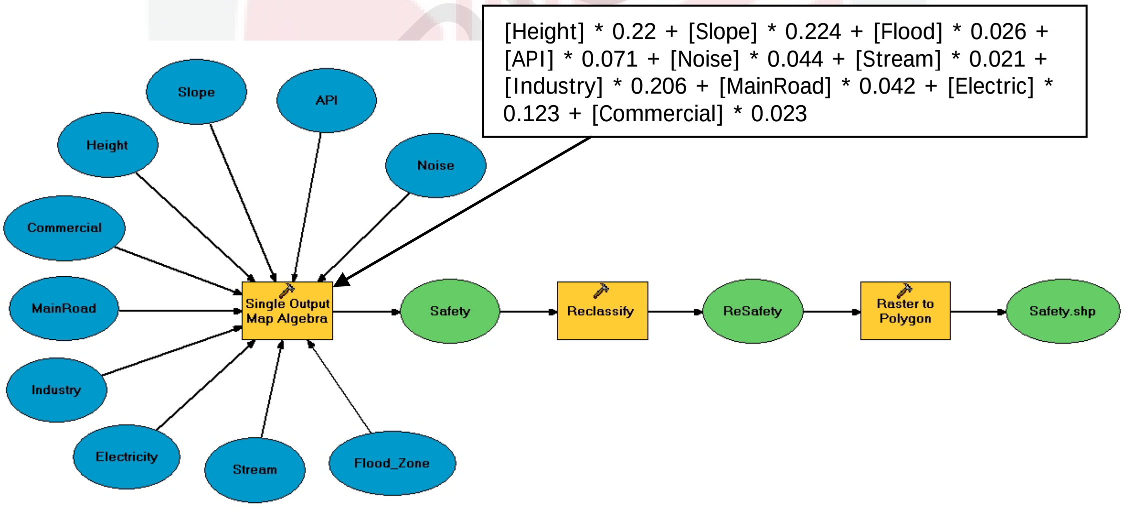


Figure 4.16. Geoprocessing Workflow to Generate the Safety Analysis Map

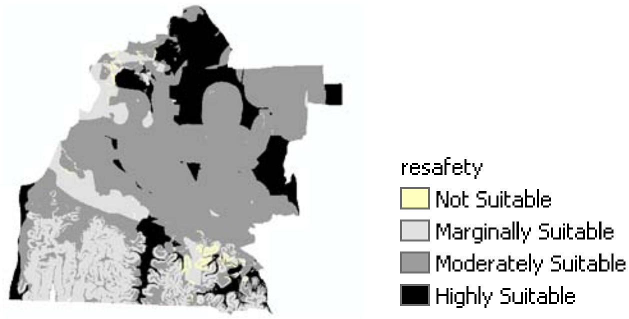


Figure 4.17. Safety Analysis Map

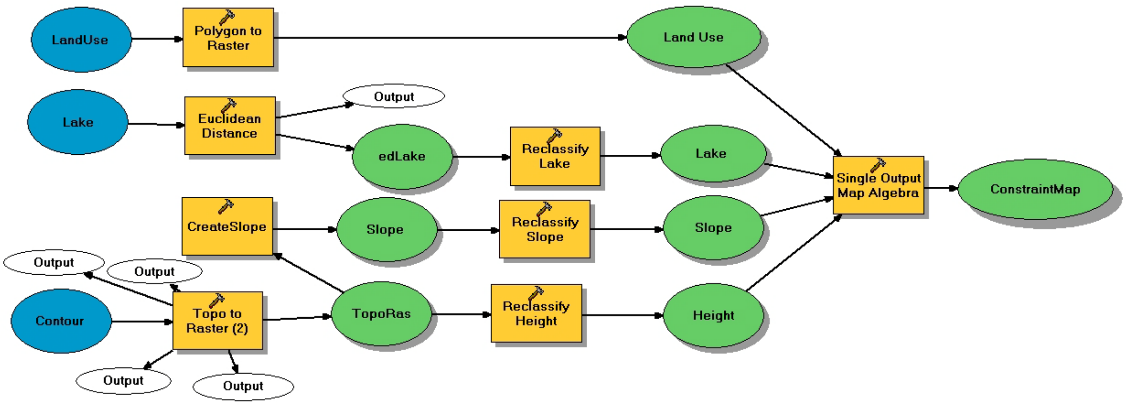
Table 4.17 shows there was only 17.3% of Mukim Batu located in highly safety suitable location (score 4) which represent approximately 900 ha. There was approximately 59% that located in moderately suitable location and 23% located in marginally suitable. The smallest value (score 1) only represent 1.1% (55 ha) of the Mukim Batu area. The highly safety location can be seen mostly in the north and east part of the study area.

Table 4.17. Output Table of Safety Analysis

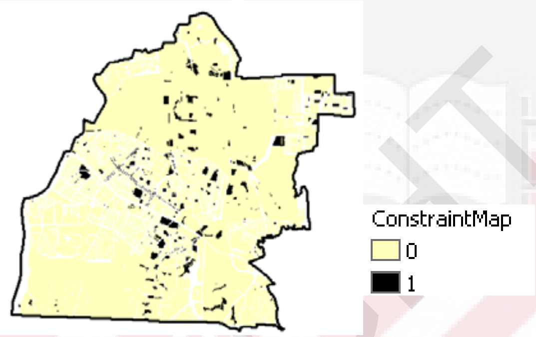
Value	Safe Area	Count	Area in m^2	Area in Hectare	%
1	Not Suitable	5493	549300	54.93	1.1
2	Marginal Suitable	121700	12170000	1217	23.0
3	Moderate Suitable	310230	31023000	3102.3	58.6
4	Most Suitable	91406	9140600	914.06	17.3

4.5 Constraint Map

As mentioned in previous section, land available for school development is the land use that has been allocate for education, no development area and open space. These allocations type of land use have been standardized to 1. The other categories can be seen in Table 3.6.



(a) Geoprocessing Workflow to Create Constraint Map



(b) Constraint Map

Figure 4.18. Geoprocessing Workflow and Constraint Map

Table 4.18 shows that 95% of the study area is not available for school development. Located near Kuala Lumpur City, Mukim Batu is the one of fastest growing regions. There are a lot of buildings, housing area, commercial centre etc. These contribute to 5% for land available for school development.

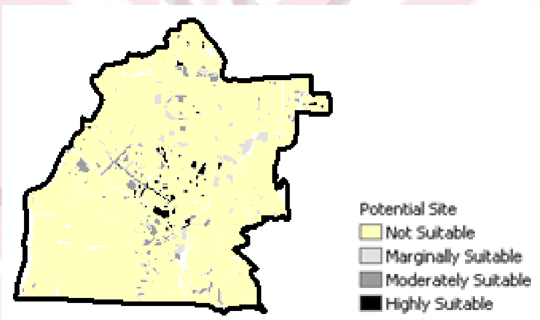
Table 4.18. Attribute table of Constraint Map

Value	Count	Area in m2	Area_Ha	%
0	400506	40050600	4005.06	95
1	20036	2003600	200.36	5

4.6 Developing School Suitability Map

Two analyses presented in previous section need to combined (overlay) in order to generate school suitability map. Using map algebra and WLC technique, both constraint and criterion map are overlaid to get the suitability area for potential school site. The suitability map was design and tested using a model builder shown in Figure 4.19(a) and Figure 4.19(b) shows the suitability map.

(a) Geoprocessing Workflow to Create Suitability Map



(b) Suitability Map

Figure 4.19 Geoprocessing Workflow and Suitability Map

Table 4.19 shows approximately 200 hectare of the Mukim Batu area was identified as potential area for school location (score 2 to score 4). Approximately 72 ha (2%) of the potential area are identified as score 4 (highly suitable area), and this area was located on centre of the region (Figure 4.19 (b)). There was 2% (100 ha) of the potential area identifies as moderately suitable area (score 3) and 1 % (38 ha) for marginally suitable area (score 2). 95% of the study area contributes for not suitable area (score 1) which mostly fell in the south area.

Table 4.19. Potential Site Analysis

Value	Count	Area in m^2	Area in Hectare	%
1	398215	39821500	3982.15	95.0
2	3789	378900	37.89	1.0
3	9842	984200	98.42	2.3
4	7221	722100	72.21	1.7

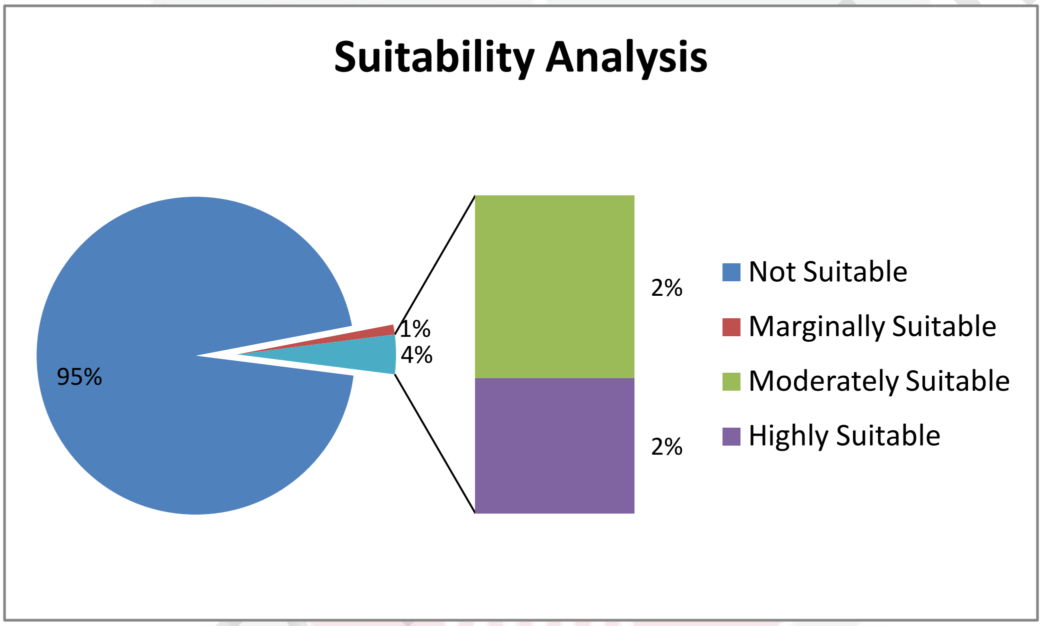


Figure 4.20. Pie Chart Representing the Area (ha) in Percentage of the Suitability Analysis Zone

4.7 Design of Alternative Sites for the School

The suitability map was overlaid with the existing schools location. Using **Spatial Join Function**, the areas which intersect with the existing schools location will be filtered. Table 4.20 shows 26 out of 47 existing schools (including secondary schools) have high suitability index of 2, 3 and 4 which represent 55.3%. Later, the suitability map of 2 and

4 score has been chosen as the alternative site. For further selection, JPBD guidelines for selecting a suitable size for school area have been used. It is stated that, a suitable area for primary school should be more than 2.4 hectare. The area with less than 2.4 hectare has been filtered leaving 13 potential sites (Figure 4.21).

Table 4.20. Existing List of Schools with the Suitability Index

Num	Suitability Index	School Code	School Name
1	1	WEB0224	SMK ST MARY (M)
2	1	WBA0086	SK INTAN BAIDURI
3	1	WBB0085	SK ST MARY
4	1	WBA0056	SK TAMAN KOPERASI POLIS
5	1	WEA0234	SMK BATU MUDA
6	1	WRA0004	SMK AGAMA KUALA LUMPUR
7	1	WEA0227	SMK MENJALARA
8	1	WBA0064	SK MENJALARA
9	1	WBA0079	SK SERI KEPONG
10	1	WEA0236	SMK SINAR BINTANG
11	1	WBC0123	SJK(C) KHAI CHEE
12	1	WBB0097	SK BATU 4 (1) JLN IPOH
13	1	WBC0168	SJK(C) JINJANG TENGAH 2
14	1	WBC0146	SJK(C) JINJANG TENGAH 1
15	1	WBA0020	SK KG SELAYANG
16	1	WBA0072	SK SERI MURNI
17	1	WBC0149	SJK(C) KEPONG 1
18	1	WBC0150	SJK(C) KEPONG 2
19	1	WBA0091	SK SEGAMBUT MAKMUR
20	1	WBA0089	SK KIARAMAS
21	1	WEA0220	SMK SRI HARTAMAS
22	2	WBA0095	SK BATU MUDA
23	2	WBC0154	SJK(C) MUN CHOONG
24	2	WEA0231	SMK DATO' IBRAHIM YAACOB
25	2	WBC0127	SJK(C) LAI CHEE
26	3	WBC0147	SJK(C) JINJANG UTARA
27	3	WEB0249	SMK JINJANG
28	3	WBA0077	SK SERI NILAM
29	3	WBB0217	SK LA SALLE JINJANG 2 (M)
30	3	WBB0103	SK LA SALLE JINJANG 1 (M)
31	3	WBD0184	SJK(T) LDG EDINBURGH
32	3	WEA0194	SMK TAMAN BUKIT MALURI
33	3	WBA0014	SK TAMAN BUKIT MALURI

34	3	WEA0202	SMK RAJA ALI
35	3	WBB0215	SK BATU 4 (2) JLN IPOH
36	3	WBA0065	SK TAMAN SERI SINAR
37	3	WEB0228	SMK PEREMPUAN JALAN IPOH
38	3	WEA0243	SMK SEGAMBUT
39	3	WBA0022	SK SEGAMBUT
40	4	WBB0113	SK KEPONG BARU
41	4	WBC0148	SJK(C) JINJANG SELATAN
42	4	WBB0098	SK SERI DELIMA
43	4	WEB0248	SMK RAJA ABDULLAH
44	4	WEA0208	SMK KEPONG BARU
45	4	WBA0059	SK TAMAN KEPONG
46	4	WBD0192	SJK(T) SEGAMBUT
47	4	WEA0228	SMK SEGAMBUT JAYA

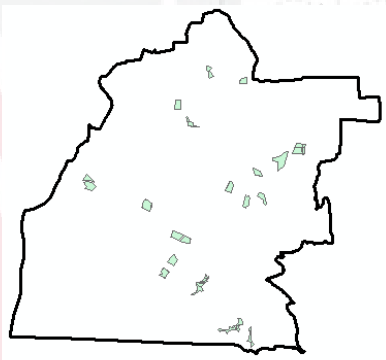


Figure 4.21 The Potential Area with Size More than 2.4 hectare and have Suitability Score of 2,3 and 4

The remaining site has been exported to **KML** format to be viewed in Google Maps for better choosing. The flow for selecting the alternative site can be viewed in Figure 4.22.

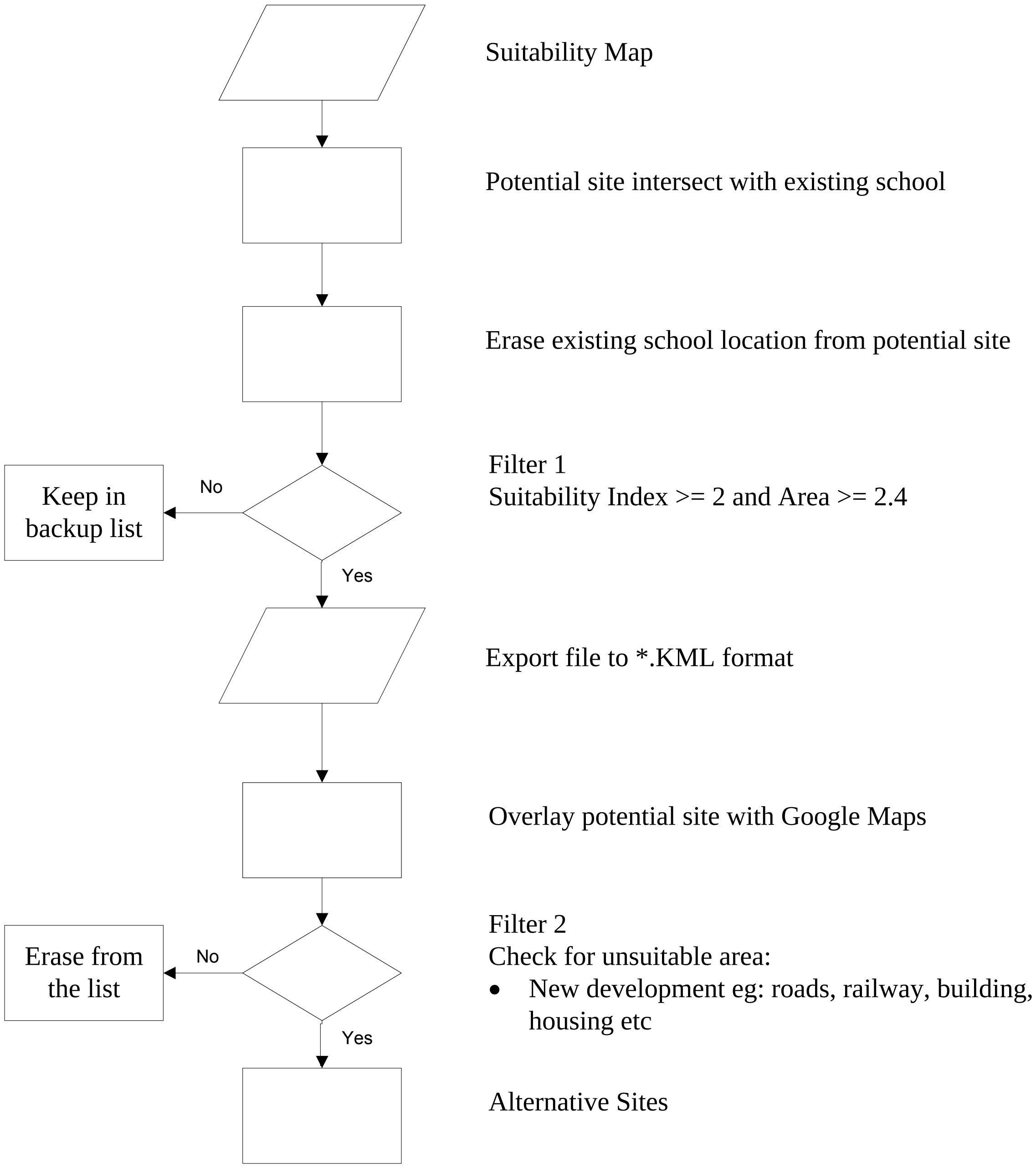


Figure 4.22. Flow Chart for Choosing Alternative Sites

Table 4.21. List of Potential Site after Filter 1

Shape *	ID	GRIDCODE	Area_Ha	Site_ID
Polygon	720	2	9.038858	A1
Polygon	183	4	4.862945	A10
Polygon	187	4	3.403417	A11
Polygon	892	3	2.68301	A12
Polygon	237	2	3.331591	A13
Polygon	141	3	4.009933	A2
Polygon	93	3	3.033831	A3
Polygon	110	3	2.719308	A4
Polygon	234	4	2.903629	A5
Polygon	237	3	2.421471	A6
Polygon	243	3	5.594403	A7
Polygon	244	3	2.579147	A8
Polygon	299	3	3.170413	A9

4.8 Design of Alternative Sites after Filter 2

Out of 13 filtered potential areas, 6 sites have been selected. The other 7 areas namely A4, A6, A8, A10, A11, A12 and A13 were not selected because they were located near to railway and have rapid development in the area. The locations of the potential site were taken from Google Earth image and also from the field work. Figure 4.23 to Figure 4.26 show the image taken from Goggle Earth and Appendix 9 show pictures of the location taken from the field work.

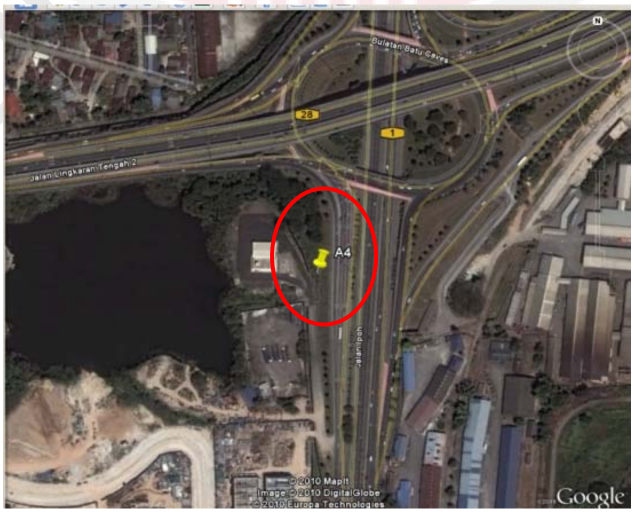


Figure 4.23. Alternative Sites of A4
Located very near to new commercial building

Figure 4.24. Alternative Site of of A6 and A13
A6 is found to be located on new building and A13 on new road

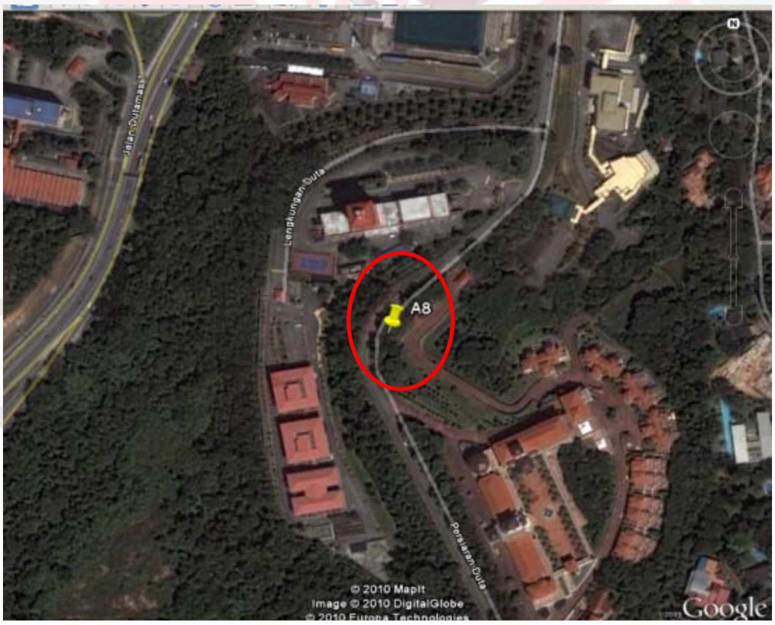


Figure 4.25. Alternative Site of A8
Located very near to new road

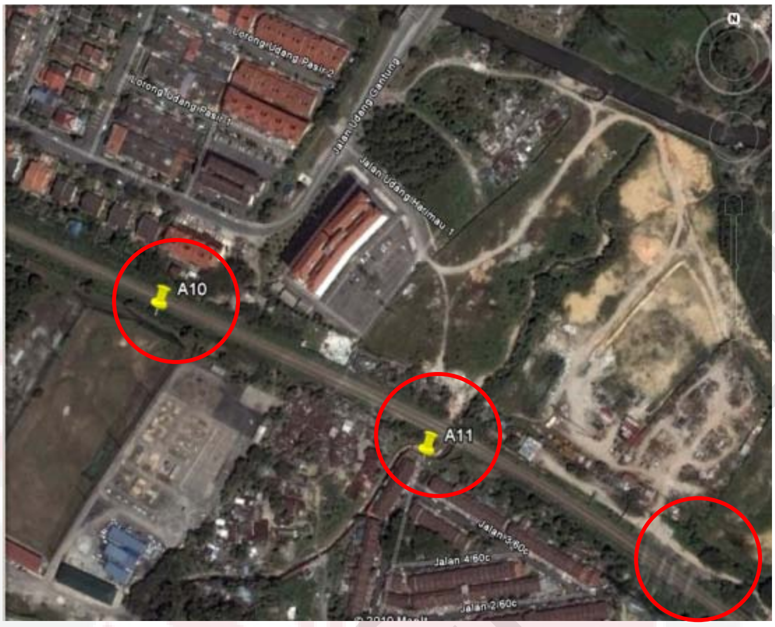


Figure 4.26 Alternative Site of A10, A11 and A12
Located very near to railway

The 6 alternative sites can briefly described as follows:

Figure 4.27. Alternative Site for A1

Alternative 1 (A1) is located at 3°12'N and 101°40'E with extensively settlement area in Taman Batu Permai, Taman Metropolitan Batu and Taman Mastiara. It represents approximately 9 ha and has score value of 2 (***marginally suitable zone***). It is located on a flat land with slope less than 10^0 and height less than 60 m. There is 1 secondary school nearby, WEA0231) and 1 national-type primary school, WBC0154 located on the south of the site. There is also 1 primary school, WBA0095 separated by Sg Batu River on the north. The main problem of this site is some of the area is located very near to Electrical Transmission Line (Less than 150 m)

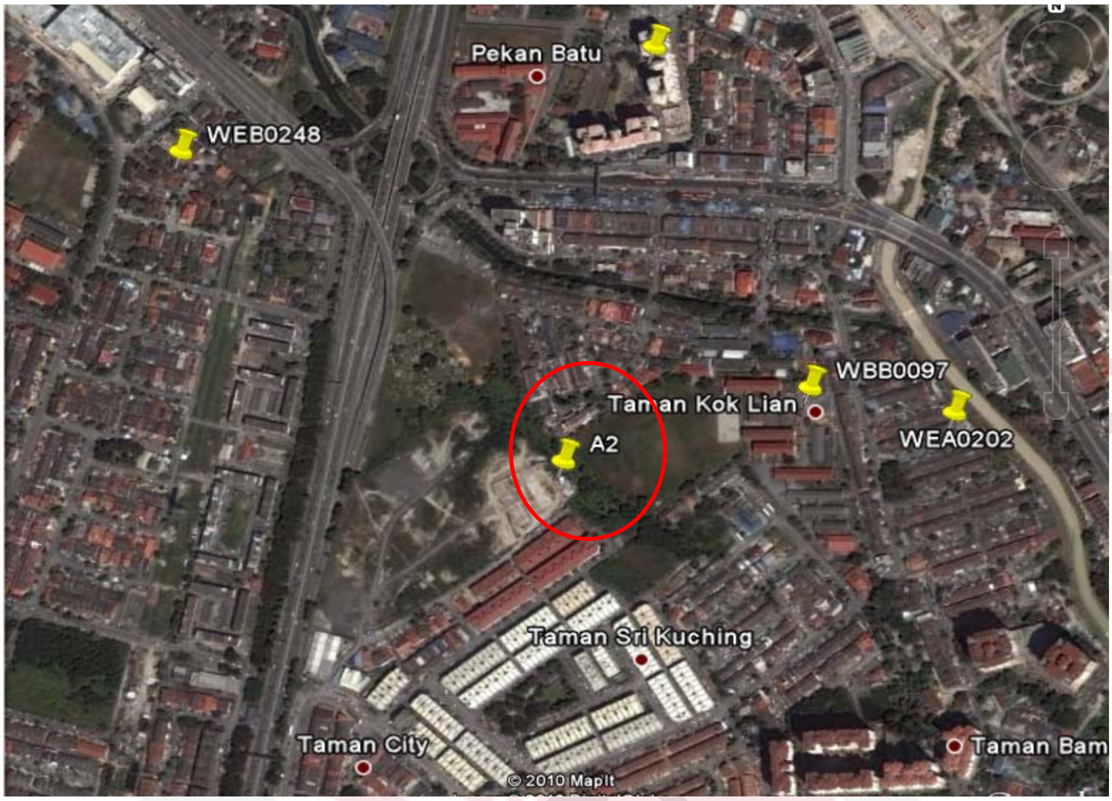


Figure 4.28. Alternative Site of A2

A2 is located at 3°11'N and 101°40'E which surrounded with 5 housing area namely Taman Kok Lian, Taman Sri Kuching, Taman City, Taman Segambut Indah and Taman Bamboo. It represents 4 ha and located in ***marginally suitable zone*** (score value of 2). There are 2 primary schools (SK Batu 4(1) and SK Batu 4(2)) and 1 secondary school (SMK Raja Ali) near the site. SK Batu 4(2) is sharing same building with SK Batu 4(1). Both school operated in same building. The SK Batu 4(1) students will come in the morning, while SK Batu 4(2) students will come in the afternoon session.

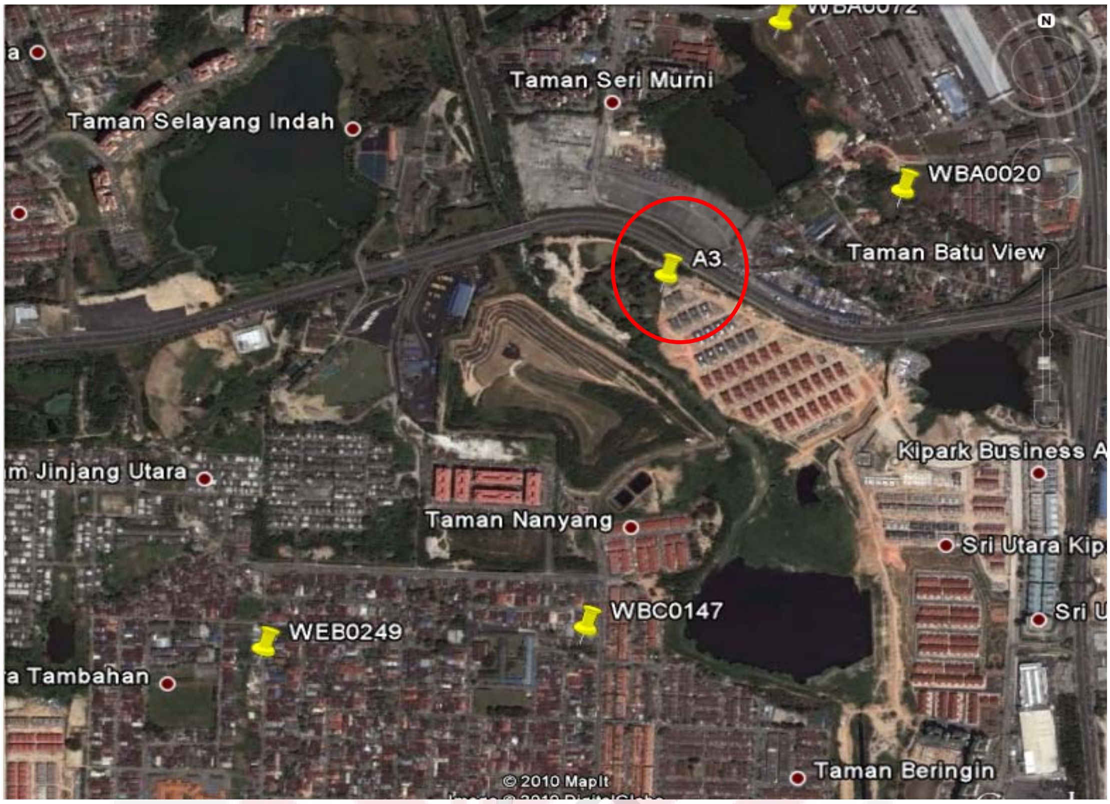


Figure 4.29. Alternative Site of A3

A3 is located at 3°13'N and 101°39'E near Taman Nanyang, Taman Perumahan Jinjang Utara, Taman Beringin, Sri Utara Kipark and Kipark Business Centre. Surrounding with extensively settlement area, it represents approximately 3 ha with score value of 3. There are 1 secondary school (WEB0249) and 1 primary school. (WBC0147). The major problem with this site it is some of the area is located very near (Less than 150) to the main road (MRR2 highway.).

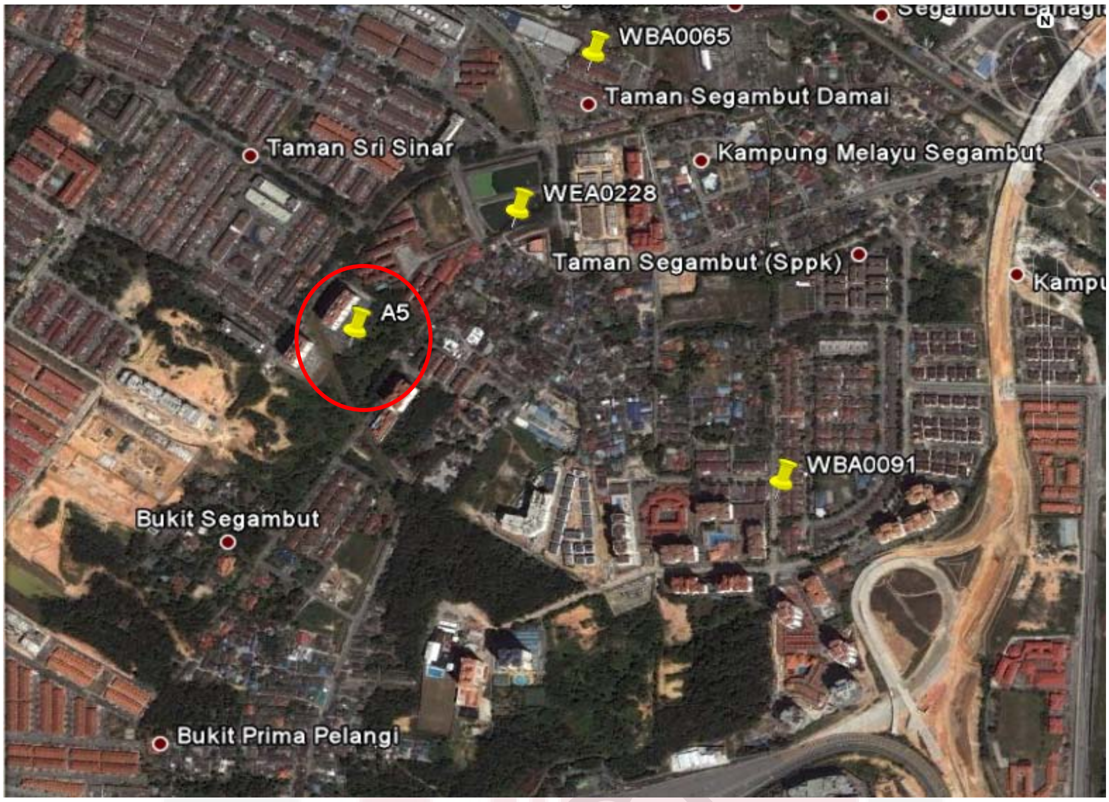


Figure 4.30. Alternative Site of A5

A5 is located at 3°11'N and 101°39'E with extensively settlement area such as Taman Sri Sinar, Taman Segambut Damai, Kampung Melayu Segambut, Taman Segambut(SPPK), Bukit Segambut and Bukit Prima Pelangi. It represents approximately 3 ha with 2 schools nearby which is WEA0228 (secondary school) and WBA0065 (primary school) and located at a ***moderately suitable zone*** (score 3).

Figure 4.31. Alternative Site of A7

A7 is located at 3°10'N and 101°40'E which surrounded by rapid development housing area in Hartamas Heights, Duta Nusantara and Taman Tunku. It represents approximately 5.6 ha with score value of 3 (***moderately suitable location zone***). There is 1 primary school (WBA0089) and 1 secondary school (WEA0220) near the site.

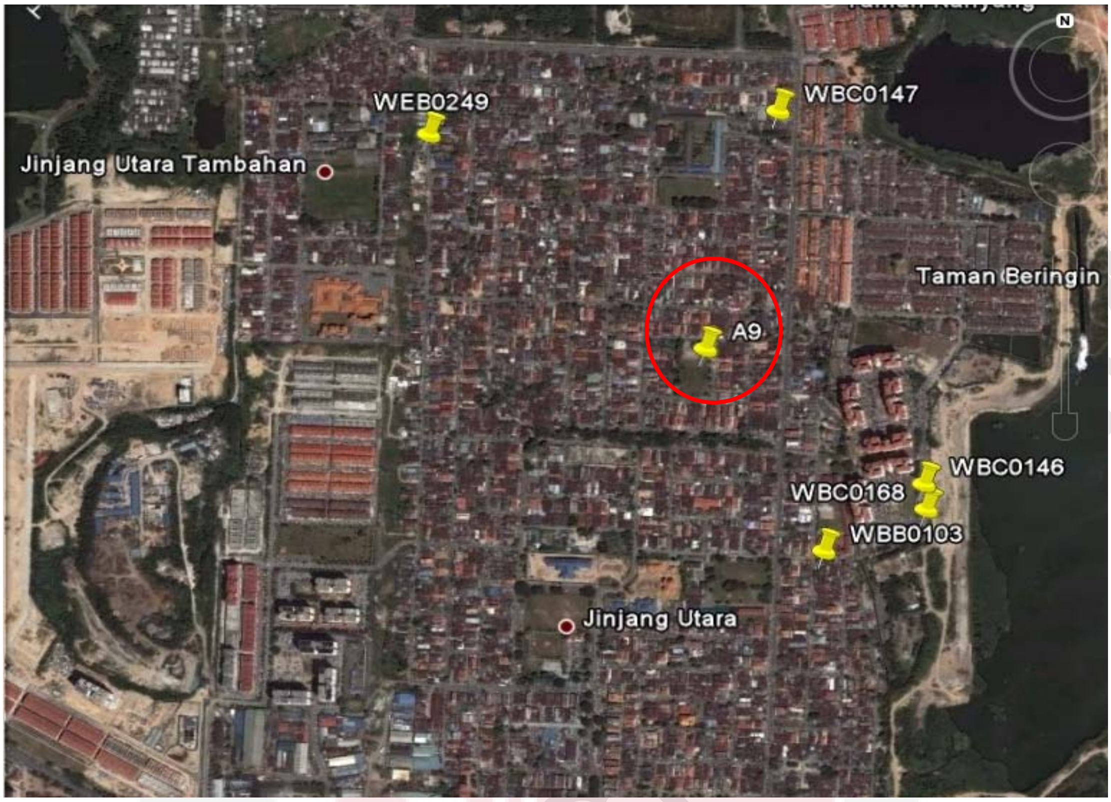


Figure 4.32. Alternative Site of A9

A9 is located at 3°13'N and 101°39'E with score value of 2 (***marginally suitable zone***). It represents approximately of 2.5 ha with big extensively housing area such as Taman Beringin, Jinjang Utara Tambahan and Jinjang Utara. There are 4 primary schools (WBB0103, WBB0217, WBC0168, WBC0146 and WBC0147) and 1 secondary school (WEB0249). WBB0217 is sharing same building with WBB0103. The problem of this site is there are already many primary schools near the site.

4.9 Evaluation and ranking of alternative sites

4.9.1 Definition of New Criteria

The last phase of decision making is the evaluation and choice of alternative options. The 6 alternative sites for the school were evaluated using a different criteria structure. In this last phase the accessibility from the alternative site to the public facility will be analyzed. Opinion and needs from community was introduced in this last phase.

4.9.2 Identification and Ranking of School Accessibility Criteria

Questionnaire surveys were conducted in Mukim Batu area in January and February 2010 to identify appropriate and important opportunities to the public to establish the relative importance of accessibility to these identified alternatives. 200 questionnaires forms were given to respondents and a total of 127 forms were replied. The responses were then summarized using SPSS software which identified 6 opportunities that the respondents are most concerned. Table 4.22 shows the summary. Using a 5 point scale, accessibility to each opportunity was rated which 1 represents the lowest important and 5 represents the most important based on their opinion when considering a school location. Table 4.22 lists the average scores. These scores determine the rank order of the school accessibility criteria.

Table 4.22. Rank Order of the School Accessibility Criteria

Criteria	Mean Score	Ranking
Proximity to housing area	4.8	1
Proximity to roads	4.3	2
Proximity to health centre	3.9	3
Proximity to safety centre	3.8	4
Proximity to library	3.9	5
Proximity to community centre	3.0	6

Multi criteria analysis tool, JavaAHP has been used to develop a hierarchy model which is shown in Figure 4.33. As mentioned in previous section this tool can be used using internet connection at http://www.hipre.hut.fi. To derive the priorities of accessibility to each identified opportunity, SMARTER weighting method in JavaAHP has been used, which is shown in Figure 4.34.

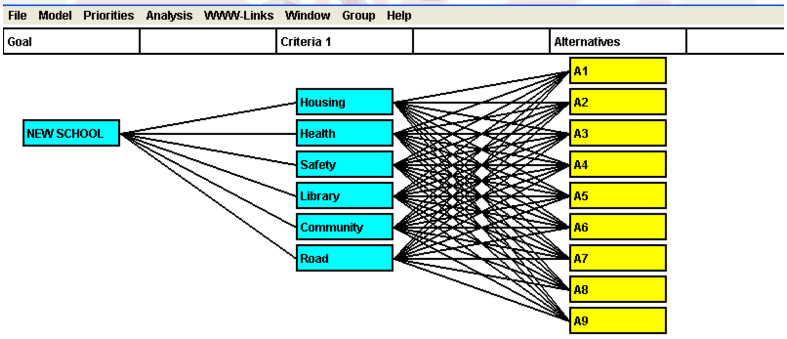


Figure 4.33. Hierarchy Model for Deriving Weights of the School Accessibility Criteria

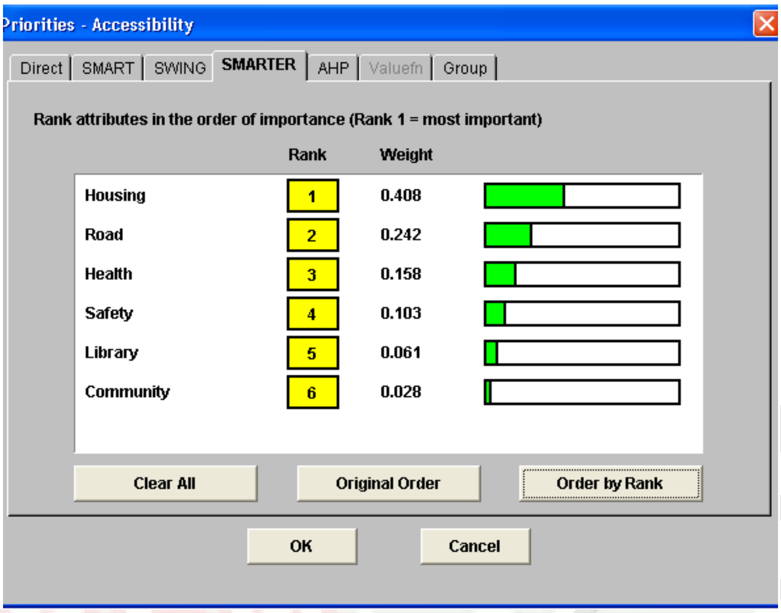
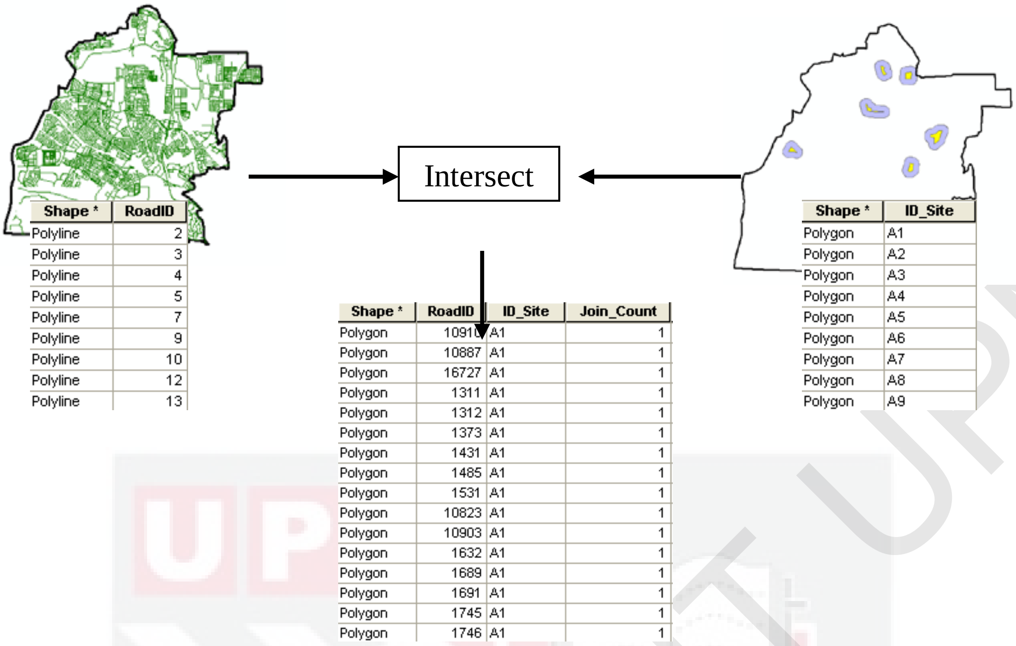


Figure 4.34. SMARTER Weighting Method to Derived Weights of the School Accessibility Criteria

4.9.3 Coverage Evaluation of Potential Sites over Facility Sites

To analyze whether the opportunity can cover by the identified alternatives, the **Spatial Join** function was used. This function analyzed whether the facility sites fall within the catchment area from the alternatives sites. In this case, a 200 m buffer was used for catchment area over road; a 800 m buffer was used for catchment area over housing area, library, health centre, safety centre and community centre. Intersect option was selected as the spatial query. Figure 4.35 shows the example of the spatial join function between opportunity and alternative sites. A pivot table in MS Excel has been used to summarize the results and shown in Appendix 7.



Shape *	RoadID
Polyline	2
Polyline	3
Polyline	4
Polyline	5
Polyline	7
Polyline	9
Polyline	10
Polyline	12
Polyline	13

Shape *	ID_Site
Polygon	A1
Polygon	A2
Polygon	A3
Polygon	A4
Polygon	A5
Polygon	A6
Polygon	A7
Polygon	A8
Polygon	A9

Shape *	RoadID	ID_Site	Join_Count
Polygon	10910	A1	1
Polygon	10887	A1	1
Polygon	16727	A1	1
Polygon	1311	A1	1
Polygon	1312	A1	1
Polygon	1373	A1	1
Polygon	1431	A1	1
Polygon	1485	A1	1
Polygon	1531	A1	1
Polygon	10823	A1	1
Polygon	10903	A1	1
Polygon	1632	A1	1
Polygon	1689	A1	1
Polygon	1691	A1	1
Polygon	1745	A1	1
Polygon	1746	A1	1

Figure 4.35. Implementation of Geospatial Joining Technique to Measure Catchment Area from Alternative Point.

4.9.4 Calculating for Alternatives Accessibility Index

In order to obtain accessibility index, WLC technique was used. Using Equation 3.3, X_{ij}, is the criterion score for m opportunity and W_m, is the weight of the opportunity derived from JavaAHP (Figure 4.34). The criterion score is according to the classification and scores as in Table 3.7. Table 4.23 shows the combined criterion score for accessibility parameters, while Table 4.24 shows the overall accessibility value (S_{ij}) or Alternatives Accessibility Index after multiplication of criterion score with the weight.

Table 4.23. Criterion Score for Alternatives Accessibility Parameters

Alternatives Sites	Housing Area	Road	Health Centre	Safety Centre	Library	Community Centre
A1	4	4	3	1	2	4
A2	4	4	3	2	2	4
A3	4	3	1	1	1	1
A5	4	4	3	1	1	2
A7	1	4	1	1	1	2
A9	4	4	2	2	1	2

The criterion score of the accessibility parameters which has been calculated in Table 4.23 is then multiplied with the criterion weight which has been derived from SMARTER weighting method in Figure 4.34.

Table 4.24. Alternatives Accessibility Index

Alternative Sites	Housing Area	Road	Health Centre	Safety Centre	Library	Community Centre	Total Accessibility Score (A_{ij})
Weight	**40.8**	**24.2**	**15.8**	**10.3**	**6.1**	**2.8**	**100**
A1	163.2	96.8	47.4	10.3	12.2	11.2	341.1
A2	163.2	96.8	47.4	20.6	12.2	11.2	351.4
A3	163.2	72.6	15.8	10.3	6.1	2.8	270.8
A5	163.2	96.8	47.4	10.3	6.1	5.6	329.4
A7	40.8	96.8	15.8	10.3	6.1	5.6	175.4
A9	163.2	96.8	31.6	20.6	6.1	5.6	323.9

Table 4.25. Alternative Sites in Ranking Order

Alternative Sites	Accessibility Score	Rank
A2	351.4	1
A1	341.1	2
A5	329.4	3
A9	323.9	4
A3	270.8	5
A7	175.4	6

Table 4.25 shows the result after the combination which shows that A2 has the highest total accessibility score (351.4) and A7 has the lowest total accessibility score (175.4).

4.9.5 Output Model Validation

Validation was done by comparing the location of suggested school location by DBKL and the alternatives sites obtained from the previous section. Figure 4.36 shows both layer, potential site overlay with DBKL proposed site. It can be seen that only item no 2 and 3 from 19 DBKL proposed site overlay nicely with alternative site, A1. It shows the model represent 10.5% match with DBKL proposed site.

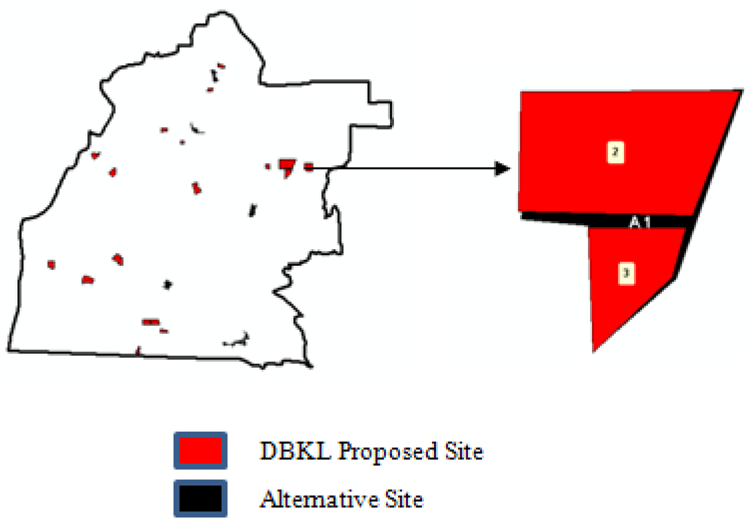


Figure 4.36. Alternatives Sites Overlay with DBKL Proposed Site.

Land use types that were chosen for suitable school location consists of 3 categories. They were education, areas without development and a vacant land. Table 4.25 shows that there were 11(57.9%) unmatched land use type between DBKL proposed site and the output from the study. The unmatched land use were Industry (ID Num 10 and 11), Road (ID Num 7), Housing (ID Num 1, 5, 6, 8, 9, 12, 15) and Commercial (ID Num 4). But there were 8 sites (42.1%) matched with land available for this study. The sites were identified as ID Num 2, 3, 13, 14, 16, 17, 18 and 19. As mentioned in previous paragraph only item no 2 and 3 are overlay nicely with the output from the study.

The main reason to support inequality results is the proposed sites by DBKL are located on not suitable area such as on the highlands (more than 60 m). Figure 4.37 shows the DBKL proposed site (red colour) overlay with constraint map. Both situations (unmatched land used type and unsuitable land for development) explained the unmatched school location between the DBKL proposed site and the study output.

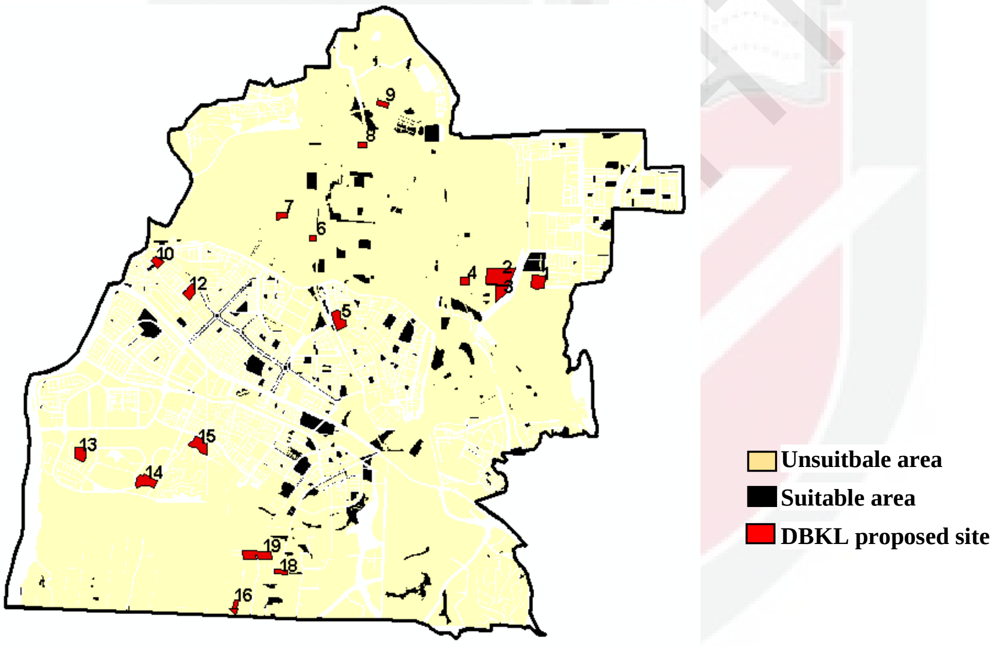


Figure 4.37. DBKL Proposed Site Overlay with Constraint Map

Table 4.25. Land Use Type of DBKL Proposed Site

DBKL Site	Not Suitable Land use Type					Suitable Land use Type			
	*1	*2	*3	*4	Total	*5	*6	*7	Total
1			1		1				0
2					0	1			1
3					0	1			1
4				1	1				0
5			1		1				0
6			1		1				0
7		1			1				0
8			1		1				0
9			1		1				0
10	1				1				0
11	1				1				0
12			1		1				0
13					0		1		1
14					0			1	1
15			1		1				0
16					0			1	1
17					0			1	1
18					0			1	1
19					0			1	1
Total	2	1	7	1	11	2	1	5	8

*

1	Industry	5	Education
2	Road	6	Vacant land
3	Housing	7	No development area
4	Commercial		

4.10 Discussion

Having performed school need analysis, the required number of schools is obtained. Using two approaches, the number is estimated to 2 new schools. By looking to the rapid development in the area and KL estimated population for the year 2020 (2.2 million), the new development area for school development should be well planned and prepared.

The Demography Analysis has generated 4 zone of areas with the high density area (score 3 and 4) which produces 29% of the area, followed by 21.8% (score 2) of the marginally dense area and 48.7% (score 1) represents the lowest dense area. This analysis is suitable to view the appropriate distribution of current and future residents to ensure the schools can accommodate population and students. Failure to this analysis will cause the schools to be built outside the population and students catchment area. From the analysis, it shows less population in the southern part of the study area because it consists of high ground in excess of 60 m, which is not suitable for housing development and education. Area with high population density is located in the middle of study area. The result from demography analysis indicates that the population approach by using demography standards for school planning criteria is enough for this country and can be enhanced with the enrolment approach by MOE.

The safety analysis generated 4 zone of area with the high safety area produce 17.3% (915 ha with score 4), 59% in score 3 and 23% in score 2. It shows only 1.1% of the study area located in not safety area. The healthy environment mostly located far beyond the central part of the study. Both analyses were layered with a constraint map to ensure the land availability. The constraint factors like land use type and development standard set by JPDB and MOE guidelines has been input to the constraint map (see Table 3.6). It shows that only 5% (200 ha) of the study area is available for school development.

Both analysis are combined with the constraint map, resulted 5% of the study area with score 2 to 4 (200 ha). Some of the existing schools located on the suitable area (see table 4.20), while the others located at areas which are not suitable. The results from suitability analysis indicate that the distance from ETL, distance from major road and distance from commercial factors are most challenging for a big city like KL. The current study shows that, A1 has minimum score of 2 with some of the area is within 150 m from ETL, meanwhile A2 and A3 (score 2) is located within 300 m from major road.

The finding of alternatives sites were carried by overlaying with the google earth image and the result shows there are 6 potential sites to be selected as new school building. It was also supported by field worked and found to be reliable (Appendix 8). Unfortunately, the results **did not show any site with the highest score value of 4** except the 3 locations which are found near to railway. This is because the area of Mukim Batu is one of the development cities which located very near to Kuala Lumpur City.

Alternatives sites have been further ranked according to community needs. This is a new method in which the community opinion applies to a public school site selection which result 6 potential sites in rank order. According to DBKL officer in charge, it is found that one of the site (A1) is identified reliable although it has only score 2. She suggested one of the DBKL proposed site which the score is 1 (ID 19). This site is given by the housing developer in the area of Mount Kiara. Further study needs to be done in order to accept this site selection because the site is located at a higher hill.

A relational geodatabase which has been developed in this study provides easy implementation and safe a lot of times for repetitive process which the working directory only focuses in one personal geodatabase. It is interesting to note that all 3 analyses (demography, safety and constraint) of this study were carried out by 3 different sets of graphical model which used a model builder in ArcGis 9.2 environment. During the analysis, many repetitive processes have been done, and the graphical model has helped a lot for accurately doing repetitive and testing processes. The model has helped users to further understanding the systematic process and for further enhance the analysis process.

Generally, due to tremendous development in the study area and lack of land availability have affected the potential school locations. The most interesting finding was that there are only 5% (200 ha) of the study area are suitable (score 2, 3 and 4) for school development after taking demography and safety factor into consideration. MOE and DBKL should discuss about this matter seriously because the population of students will be increasing in the year of 2020. It is estimated that the KL population will be 2.2 million in 2020 (Kuala Lumpur City Hall, 2009). This study has managed to bring ideal situations which combine the decision maker opinion and community needs.

4.11 Conclusion

The school site selection model proposed in this study has successfully identified the best potential school site. Firstly, by using two approaches in school need analysis number of schools needed in the study area can be identified. The criterion and suitability map has been successfully developed by using a model builder and can be implemented for repeating and updating process in current and future situation. The Demography analysis has been identified that there are 18.1% (score 4) of the study area is in rapid growth meanwhile safety analysis identify 17.3% (score 4) of the area is in safety zone. The main problem of this study area is the land availability whereby there is only 5% of the area is available for a school development. Using the sequence and systematic flow, 6 potential sites has been identified. A spatial accessibility has been used to rank the 6 potential sites which have been validated with DBKL proposed site and development school officers and find that one of the potential site to be reliable. The other potential site needs to be further analyzed. This study has brought new approaches which combine the decision makers and community needs in a school site selection decision making process.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

The previous chapter has explained in detailed the process, analysis and the results gained upon running the model. This chapter summarized several important findings from the study and draws conclusion based on those findings. Recommendations for future studies are also provided.

5.1 Summary and Conclusion

This research had managed to improve several aspects on the school siting issues. In order to find the best solution for school siting, a school planning data model has been successfully developed which is the important contribution to educational planning. The development of data model and geodatabase has brought a new approach and technique for school site selection especially for planners and decision makers in MOE because it can help planners to focus on what data is required and how it should be organized and it also help decision makers for speed up the decision making process. The data model and the geodatabase can be further implemented to a system such as a decision support system or web based decision support system. It can be used directly as a system prototype because it has been tested in the study. This can help to minimize time and cost for preparing and testing the entire process.

Specific criteria in JPBD guidelines have been used to determine the most suitable site for school siting. However, there were problems to translate the school planning guidelines to school planning criteria and parameters, since there were lacks of standards in the guidelines. This study has managed to translate the school planning guidelines into planning criteria and parameters by selecting appropriate criteria, standards and classification (see Table 3.5). A set of demography criteria and safety criteria has been identified and developed using comparison between local guidelines and other selected country education guidelines such as California, Utah, Vermont, Georgia and Alaska. The comparison table can be seen in Appendix 1. Some of the guidelines have standards that can be used and implemented in the school planning guidelines. The review from previous researches also had lead to identification of suitable standards such as proximity to major road, commercial area and industry area. The demography and safety criteria can be modified and adapted to local school planning guidelines for better school siting process. This study managed to improve current guideline by adding planning criteria and parameters which is not done by previous study and therefore had managed to accomplish the second objective of this study.

A group of decision makers and planners were interviewed to rank the importance of demography and safety criteria. AHP weighing method has been used to derive the priorities of identified criteria using a multi criteria analysis tool, JavaAHP. Later, the averages for every criterion in the demography and safety group were calculated to represent the criterion weight. The result can be seen in Appendix 5. The MCDA and AHP have successful integrating the decision makers and planners opinion.

Through the use of GIS software, this study has been able to develop a demography model and a safety model using ArcGis 9.2 model builder. The *validate entire model* function in the model builder has helped to verify the data elements and parameters value. Finally the WLC Technique is applied to produce a list of potential primary school siting with the suitability index to fulfill the third objective of the study. This is done by analysing the output of demography model and the output of safety model

This study has also managed to develop another set of school planning criteria. By using community needs, a set of accessibility criteria was developed. 200 survey forms were distributed among parents who represent the community and a number of 127 forms had been collected. The responses from the community were then summarized using SPSS software which identified 6 opportunities that respondents are most concerned. The opportunities were accessibility to a housing area, accessibility to roads, accessibility to health centre, accessibility to safety centre, accessibility to library and accessibility to community centre. By using the same multi criteria analysis tool, JavaAHP, a hierarchy model was developed and to derive the priorities of accessibility to each identified opportunity, ranking method using SMARTER weighting in JavaAHP has been used. This is a new approach for school planning which combine decision makers' opinion and community needs.

The demography and safety model which have been developed in this study can be used repetitively to analyze the school siting process whenever there is changing in policy or data input. For example, if the decision makers or planners want to put another constraint such as distance from railway in school site selection process. They can add the railway layer to the constraint map tool and run the suitability analysis again without the need to redo the entire process. This can help to save significant amount of time for preparing and testing the new constraint. In case of updating land use data input, users just need to refer to the new land use and all the processes can be executed again without extra time needed. This is a very important situation because data will be always changed and updated are always complicated and a time consuming. The geoprocessing in graphical flow can help users especially the decision makers and planners to easily understand the particular activities. This can help a better planning and decision making process for current and future situation. The what-if scenario also can be generated by using the geoprocessing graphical model.

5.2 Suggestion for Future Research

From this study, there are many aspects which can be further developed by other researchers. The following aspects are recommended:

i. *Data Completeness.* This study has used population and projected population for population analysis using census data from Department of Statistics. Further studies are suggested to combine various sources of population data from other agencies such as National Registration Department or Housing Property for better school planning. A field study to collect API reading and noise level using particular devices also should be carry out. This is to ensure the potential site selection is safe from noise and air pollution.

ii. *Data model transformation*. This study applies the data model to geodatabase using offline environment. Future studies are suggested to transfer the site selection data model to web base or open source database such as ORACLE or MySQL. This can help to obtain the maximum of data storage.

iii. *Decision Support System*. The site selection process can be further implemented to a system such as a decision support system or web based decision support system. It can be used directly as a system prototype because it has been tested in the study. This can help to minimize time and cost for preparing and testing the entire process.

iv. *Areas of Application*. For the purpose of extending the study, locating potential site such as safety facility or emergency facility can also used the same technique and process. The data model and the geoprocessing flow in this study can help a better understanding and integrating to other site selection activities. The overlay technique using combination of criterion map and constraint map can directly be applied for other activities with some minor constraint modification such as travel time distance.

v. *Artificial Intelligence methods*. This study used Spatial Multi Criteria Analysis (SMCA) for carrying out the land suitability analysis using map Boolean overlay and weighted linear combination (WLC). Therefore it may be appropriate to further investigate the school site selection using another land suitability analysis technique such as Artificial Intelligence (AI) method which covers a number of methods such as evolutionary algorithms (EAs), genetic programming, artificial neural networks, cellular automata (CA) and fuzzy systems.

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APPENDICES

Appendix 1. Comparison of Selected States' School Siting Policies

CATEGORY	GUIDELINE	STATE	SOURCE
Demographic	Located in the optimum distance from population catchment's area; Convenient and readily accessible to present and/or future school populations to be served, and to the public for community use educationally or recreationally. Located in appropriate for student population.	Local Guidelines	(Town and Country Planning Department of Peninsular Malaysia, 1997)
	Site must consider school projections and potential growth scenario which the data source can be from department of education, regional county, municipal and community master plans, real estate agency population and land value histories and projections.	Utah	(Utah State Office of Education, 2007)
	To accommodate enrolment growth, it must be shown that the existing facilities are overcrowded or inadequate to support programs required by state or federal rules. It must also be shown that these conditions are not likely to be relieved by a decline in enrolment for the foreseeable future. The educational specifications must be based on reasonable projections of enrolments for the school over the next five to ten years so that the design of the facility can accommodate such projections.	Vermont	(Vermont Department of Education, 2005)
	Appropriately located with respect to other schools and the population to be served.	Geogia	(Georgia Department of Education, 2003)
	Ideally, all students served by the school would be in convenient, safe walking distance to the site.	Alaska	(Alaska Department of Education, 1997)

Environmental	Located far from noise, air pollution and other disturbing elements; The routes to and from the school site should not expose children to hazardous environmental materials or safety hazards	Local Guidelines	(Town and Country Planning Department Peninsular Malaysia, 1997)
	Risk/hazard analysis required is proposed site is within 3 miles radius of electrical transmission lines rated at 115 KV or higher; oil or petroleum products transmission lines and storage facilities; hazardous chemical pipelines; etc	Georgia	(Georgia Department of Education, 2003)
	Site must be at least the following distances from electric power line easements: 100 ft. from edge of easement for 50-133 kv line, 150 ft. from 220-230 kv line and 350 ft. from 500-550 kv line	California	(California Department Of Education, 2004)
	Risk assessment must be performed if site is within 1500 ft of an above ground or underground pipeline, if risk posed, must abandon	California	(California Department Of Education, 2004)
	Must consult w/air quality management agencies if hazardous air emissions within 1/4 mile of site; must make written finding to acquire site presently zoned for agricultural production; if site within 2,000 ft of significant disposal of hazardous waste site school district must contact Department of Toxic Substances Control for determination of regulatory status	California	(California Department Of Education, 2004)
	Ideally, the site would have no susceptibility to damage (facilities, utilities, etc.) from natural disasters. These would include earthquakes, avalanches/landslides, volcanic activity as well as health and safety hazards such as bluffs/steep cliffs, bodies of water and sewage/garbage disposal areas.	Alaska	(Alaska Department of Education, 1997)
	Incompatible noise such as from air traffic, vehicle traffic, industrial uses, etc. is detrimental to educational delivery, sound decibel level is below 65db sustained and 75db peak Wetlands should be avoided due to the adverse impact on cost and schedule	Alaska	(Alaska Department of Education, 1997)

Physical/ Geological	Not be located on the sensitive area such as swamp, hilly, flood or land slide area;	Local Guidelines	(Town and Country Planning Department, 1997)
	Risk/hazard analysis required is proposed site is within 3 miles radius of lakes rivers, dams, reservoirs, or other bodies of water; within 100 year flood plain or dam breach zone	Georgia	(Georgia Department of Education, 2003)
	Flooding potential from adjacent bodies of water should be considered. Ideally, the site would not be located within a flood plain of flood-prone area.	Alaska	(Alaska Department of Education, 1997)
	Sites which border on eroding river banks and eroding sea spits should be evaluated on how much and how often erosion takes place to determine if a facility would be endangered. Slopes which have been cleared of vegetation can also erode due to heavy rain	Alaska	(Alaska Department of Education, 1997)
Transportation	Located in the conducive for teaching and learning, far from the industrial and highways; Not located on arterial or major collector roads; Not be placed on site which involves journeying through quiet or remote lanes; Avoid high-volume traffic flow near elementary school entrances and exist. Be situated centrally to a neighborhood, abutting and having access to a collector street.	Local Guidelines	(Town and Country Planning Department, 1997)
	No site within 500 ft. of the edge of the closest traffic land of a freeway or busy traffic corridor; identify sources of air pollution within 1/4 mile of the site that emit hazardous air emissions (including industrial, traffic corridors, agricultural operations and rail yards)	California	(California Department Of Education, 2004)
	Setback of 2,500 ft for roads where explosive loads are carried and 1,500 ft for roads where gasoline, diesel, propane, chlorine, and other combustible or poisonous gases are transported	California	(California Department Of Education, 2004)
Utility / Facility	Located near the other facility such as bus transportation;	Local Guidelines	(Town and Country Planning Department, 1997)

	Electricity and telephone services, Public water and sewage service - highly needed, Convenient accessibility, be supportive to an efficient	Georgia	(Georgia Department of Education, 2003)
	1. Far from Oil Wells, Gas Wells, Mines & Quarries, Sink Holes, High Pressure or Oil Line, Fiber Opitc Lines 3. Far from airport - can cost substantial cost increase inconstruction 2. High Voltage Electrical Lines - Present several hazards for the school site. Electric and Magnetic fields produced by the high voltage can decreased school student health 4. Far from Radio & Communication Tower - Potential for wind/lighting	Alaska	(Alaska Department of Education, 1997)
	In some instances, a district/community can identify an existing facility (e.g. swimming pool, food service, etc.) which is shared between multiple schools and to which close proximity is essential or desired.	Alaska	(Alaska Department of Education, 1997)
	Sites with good drainage are easier to develop and maintain. Good drainage reduces the chance of water or ice collecting around a facility which could cause undermining, decay and/or frost heave leading to structural damage. It could also make general use and occupancy of the site difficult.	Alaska	(Alaska Department of Education, 1997)
	Connection into an existing, reliable water supply system with adequate capacity is preferred. Sites closest to the existing system would be rated highest. When considering adequacy, don't forget fire suppression system requirements. If a new water system is required for the site, then sites should be rated as to their potential to support/provide the system. For new systems, proximity to wells, lakes or rivers may be a factor.	Alaska	(Alaska Department of Education, 1997)
	Connection into an existing, reliable waste/sewer system with adequate capacity is preferred.	Alaska	(Alaska Department of Education, 1997)

	Site should not be located in areas zoned for commercial or industrial development; risk/hazard analysis if site within 3 mile radius of industrial/manuf.	Georgia	(Georgia Department of Education, 2003)
Land Use	Located in the conducive for teaching and learning, far from the industrial and highways;	Local Guidelines	(Town and Country Planning Department, 1997)
	Current and projected zoning and land use should be compatible with the use of the site for a school. If local regulations do not currently permit educational facilities, it could be a lengthy process to obtain a change in zoning or a conditional use permit.	Alaska	(Alaska Department of Education, 1997)
	Land status availability is one of the most fundamental criteria for locating capital improvements. The title to the site should be free of legal encumbrances, platted and surveyed with an accurate legal description and have a single owner	Alaska	(Alaska Department of Education, 1997)
	The site should be free of evidence of past use by industrial functions, unregulated storage of items containing hazardous materials or know disposals of hazards. A site assessment may be required.	Alaska	(Alaska Department of Education, 1997)
Size	Primary school - 2.4 ha for flat area, 3.2 ha for hilly area; Secondary school 3.6 ha for flat area, 4.5 ha for hilly area	Local Guidelines	(Town and Country Planning Department, 1997)
	K-6 School 10 acres plus one acre for each 100 students; Middle School 20 acres plus one acre for each 100 students; Junior High School 20 acres plus one acre for each 100 students Senior High School 30 acres plus one acre for each 100 students Combined 7-12 High School 30 acres plus one acre for each 100 students	Utah	(Utah State Office of Education, 2007)

Appendix 2. Attribute in Logical Design

	Entity Name	Attribute	Explanation
1	Area	AreaID MukimID AreaName AreaAdd AreaPostcode ObjectID Shape ShapeLength Shape_Area	PK FK
2	Contour	MukimID Elevation Shape ShapeLength ObjectID	FK
3	Demography	ParlimentCode MukimID AreaID Year TotalPopulation Age00_14 ProjectedPop ProjedtedStud ObjectID Shape ShapeLength ShapeArea	PK FK FK
4	Flood	StreamName Date ObjectID Shape SteamCode MukimID	 FK FK
5	Land use	LandCode MukimID LandDescription Lot ObjectID Shape Shape_Length Shape_Area	PK FK
6	Monitoring Station	StationID StateID API reading Noise reading	PK FK

		ObjectID Shape	
7	Mukim Boundary	MukimID StateID MukimName ObjectID Shape Shape_Length Shape_Area	PK FK
8	Public Facility	FacID MukimID RoadID FacName FacType ObjectID Shape Shape_Length Shape_Area	PK FK FK
9	Road	RoadID MukimID RoadName Status Hierarchy ObjectID Shape Shape_Length Shape_Area	PK FK
10	School	SchCode MukimID RoadID ObjectID Shape	PK FK FK
11	Stream	StreamCode MukimID StreamName ObjectID Shape Shape_Length	PK FK
12	ETL (Electrical Transmission Line)	ETLID MukimID ETLCode ObjectID Shape Shape_Length	PK FK
13	Lake	LakeID MukimID ObjectID Shape Shape_Length Shape_Area	PK FK

14	SchProfile	SchCode SchName SchAdd SchPostcode Telephone	PK
15	Enrolment	SchCode Classroom TotalStudent B_Enrol G_Enrol	PK
16	SchFacility	SchCode FacCode FacilityName NumOfFac Status	PK

Appendix 3. Attribute in Physical Design

	Entity Name	Attribute	Data Type	Allow Nulls	Default Value	Precision	Scale	Length	Explanation
1	Area	AreaID	Text	No				2	PK
		MukimID	Text	No				2	FK
		AreaName	Text	No				50	
		AreaAdd	Text	Yes				50	
		AreaPostcode	Integer	Yes		0	0	5	
		ObjectID	Double	Yes		0	0		
		Shape	Geometry	Yes					
		ShapeLength	Double	Yes		0	0		
		Shape_Area	Double	Yes		0	0		
2	Contour	MukimID	Text	Yes				2	FK
		Elevation	Double	Yes					
		Shape	Geometry	Yes					
		ShapeLength	Double	Yes		0	0		
		ObjectID	Double	Yes		0	0		
3	Demography	ParlimentCode	Text	No				4	PK
		MukimID	Text	Yes				2	FK
		AreaID	Text	No				2	FK
		Year	Integer	Yes				4	
		TotalPopulation	Double	Yes		0	0		
		Age00_14	Double	Yes		0	0		
		ProjectedPop	Double	Yes		0	0		
		ProjedtedStud	Double	Yes		0	0		
		ObjectID	Double	Yes		0	0		

		Shape ShapeLength ShapeArea	Geometry Double Double	Yes Yes Yes		0 0 0	0 0 0		
4	Flood	StreamName Date ObjectID Shape SteamCode MukimID	Text Date Double Geometry Text Text	Yes Yes Yes Yes Yes Yes		 0 	 0 	50 6 2 2	 FK FK
5	Land use	LandCode MukimID LandDescription Lot ObjectID Shape Shape_Length Shape_Area	Text Text Text Text Double Geometry Double Double	Yes Yes Yes Yes Yes Yes Yes Yes		 0 0 0	 0 0 0	2 2 50 4	PK FK
6	Monitoring Station	StationID StateID API reading Noise reading ObjectID Shape	Text Text Double Double Double Geometry	Yes Yes Yes Yes Yes Yes		 0 0 0	 0 0 0	2 2	PK FK
7	Mukim Boundary	MukimID StateID MukimName ObjectID Shape Shape_Length Shape_Area	Text Text Text Double Geometry Double Double	Yes Yes Yes Yes Yes Yes Yes		 0 0 0	 0 0 0	2 3 50	PK FK
8	Public	FacID	Text	Yes				2	PK

	Facility	MukimID	Text	Yes				2	FK
		RoadID	Text	Yes				4	FK
		FacName	Text	Yes				50	
		FacType	Text	Yes				2	
		ObjectID	Double	Yes		0	0		
		Shape	Geometry	Yes					
		Shape_Length	Double	Yes		0	0		
		Shape_Area	Double	Yes		0	0		
9	Road	RoadID	Text	Yes				4	PK
		MukimID	Text	Yes				2	FK
		RoadName	Text	Yes				50	
		Status	Text	Yes				50	
		Hierarchy	Integer	Yes				4	
		ObjectID	Double	Yes		0	0		
		Shape	Geometry	Yes					
		Shape_Length	Double	Yes		0	0		
		Shape_Area	Double	Yes		0	0		
10	School	SchCode	Text	Yes				7	PK
		MukimID	Text	Yes				2	FK
		RoadID	Text	Yes				4	FK
		ObjectID	Double	Yes		0	0		
		Shape	Geometry	Yes					
11	Stream	StreamCode	Text	Yes				4	PK
		MukimID	Text	Yes				2	FK
		StreamName	Text	Yes				50	
		ObjectID	Double	Yes		0	0		
		Shape	Geometry	Yes					
		Shape_Length	Double	Yes		0	0		
12	ETL	ETLID	Text	Yes				2	PK
		MukimID	Text	Yes				2	FK
		ETLCode	Text	Yes				2	

		ObjectID	Double	Yes		0	0		
		Shape	Geometry	Yes					
13	Lake	LakeID	Text	Yes				4	PK
		MukimID	Text	Yes				2	FK
		ObjectID	Double	Yes		0	0		
		Shape	Geometry	Yes					
		Shape_Length	Double	Yes		0	0		
		Shape_Area	Double	Yes		0	0		
14	SchProfile	SchCode	Text	Yes				7	PK
		SchName	Text	Yes				50	
		SchAdd	Text	Yes				50	
		SchPostcode	Integer	Yes		0	0	5	
		Telephone	Text	Yes				10	
15	Enrolment	SchCode	Text	Yes				7	PK
		Classroom	Integer	Yes		0	0	4	
		TotalStudent	Integer	Yes		0	0	5	
		B_Enrol	Integer	Yes		0	0	5	
		G_Enrol	Integer	Yes		0	0	5	
16	SchFacility	SchCode	Text	Yes				7	PK
		FacCode	Text	Yes				4	
		FacilityName	Text	Yes				50	
		NumOfFac	Integer	Yes		0	0	3	
		Status	Text	Yes				50	

Appendix 4. School Siting Survey Form

Dear Sir/Mdm

As a person in charge of school planning process, you undoubtedly have ways in which you determined the location for new schools. Your response to this survey can greatly enhance my understanding. I am conducting this research to know the ranking of the provided criteria stated by Town and Country Planning Department of Peninsular Malaysia and the Ministry of Education and other selected country guidelines for developing new school. This research is hoped to improve the school planning process in our country. Your participation in this research is, of course, voluntary. Your confidentiality and anonymity are assured. Please understand that use of this data will be limited to this research, as authorized by the University Putra Malaysia, although results may ultimately be presented in formats other that the dissertation, such as journal articles or conference presentations.

I greatly appreciate your participation in this research. Thank you for your interest and participation in this study. I genuinely appreciate your time.

Sincerely,

Zubaidah binti Bukhari

Please enter your details:

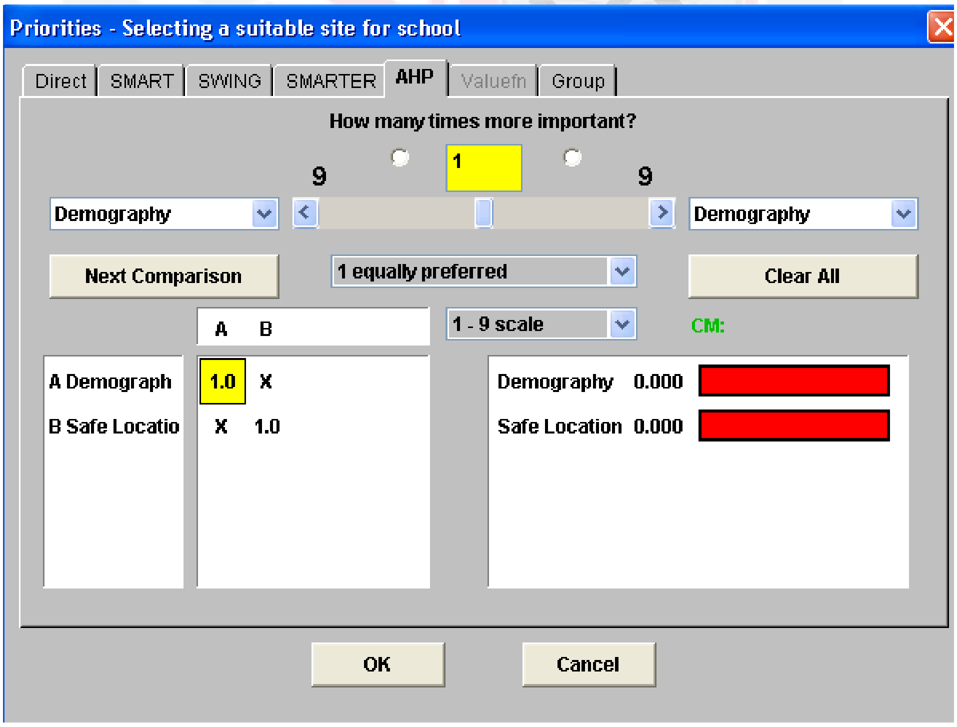
Name	:	
Office/Dept.	:	
Position	:	
Experiences in School Planning	:	

Please give your score based on the criteria below regarding the new school building.

Intensity of importance	Definition
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 strong importance
9	Extremely importance

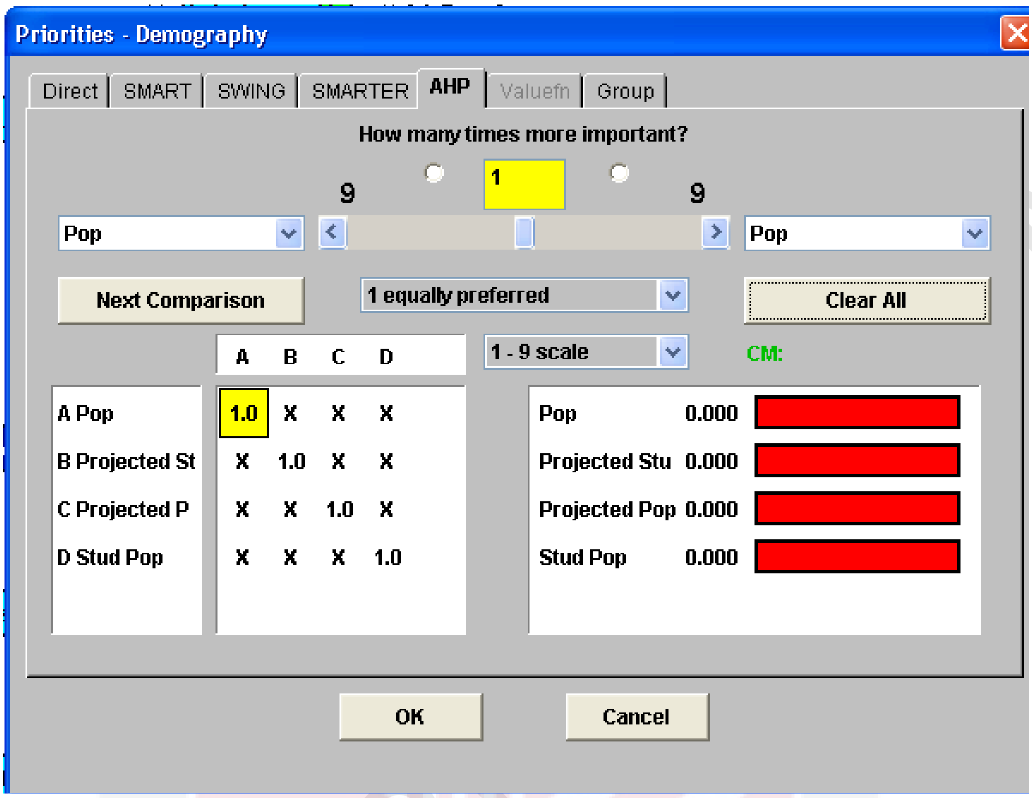
Please enter ranking (1-9) in the blank (X) cell

1. Demography and Safety Criteria



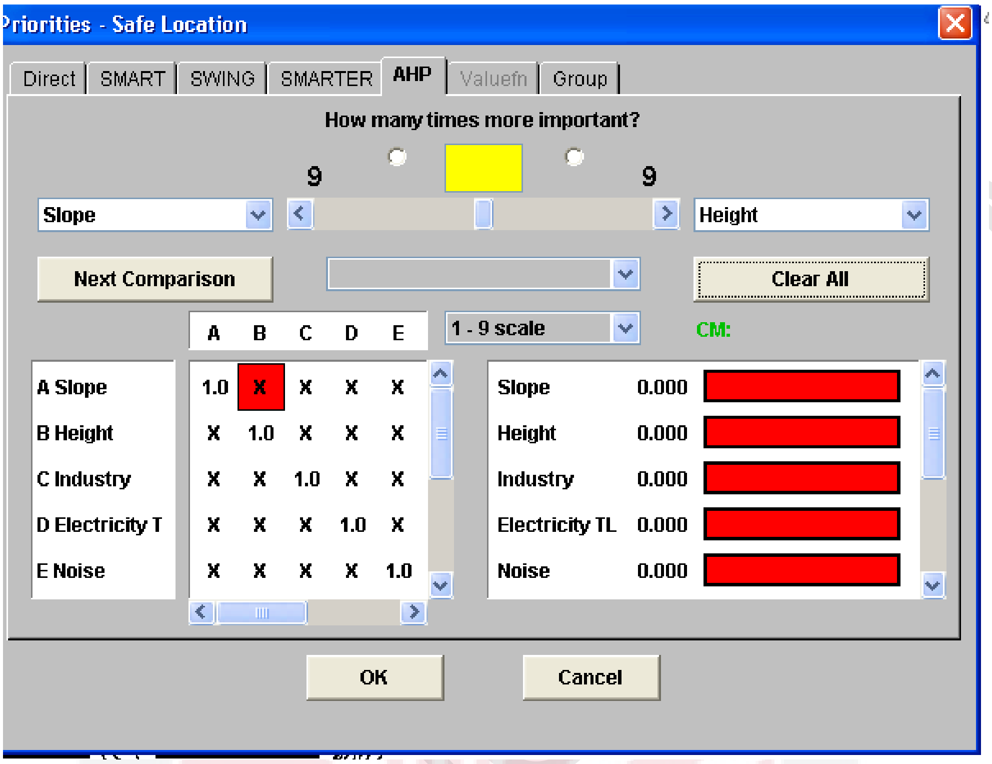
2. Demography Analysis

Please enter ranking (1-9) in the blank (X) cell



3. Safety Analysis

Please enter ranking (1-9) in the blank (X) cell



Appendix 5. Criterion Weight Result

1. Demography and Safety Analysis

	EPRD	WPKL	DBKL	Average
Demography	0.333	0.5	0.75	0.5300
Safety	0.667	0.25	0.47	0.4700

2. Demography Analysis

	EPRD	WPKL	DBKL	Average
Population	0.3193	0.333	0.375	0.250
Projected Population	0.1807	0.167	0.125	0.250
Student Population	0.2360	0.333	0.125	0.250
Projected Student Population	0.2640	0.167	0.375	0.250

3. Safety Analysis

Criteria	EPRD	WPKL	DBKL	Average
Slope	0.224	0.233	0.233	0.224
Height	0.227	0.240	0.230	0.220
Industry	0.193	0.167	0.19	0.206
ETL	0.121	0.117	0.12	0.123
Noise	0.040	0.082	0.06	0.044
Main Road	0.030	0.057	0.04	0.042
Flood	0.040	0.041	0.04	0.026
Stream	0.210	0.029	0.15	0.210
Commercial	0.230	0.020	0.16	0.230
API	0.071	0.015	0.05	0.071

Appendix 6. Questionnaire Survey for Accessibility Analysis

1.. **Position**

Government Staff	
Private Staff	
Housewife / Not working	
Others (state)	

____

2.. **Children's Education**

Kindergarten	
Primary School	
Secondary School	

3.. **In your opinion, schools should be developed in area that:**

Marks (Please circle according to the priority, num 1 indicate the lowest important factors, num 5 indicate the most important factors)

	Strongly not important	Not important	Less Important	Important	Most important
Near to housing areas	1	2	3	4	5
Near to health centres (hospital/clinic)	1	2	3	4	5
Near to safety centres (police/fire brigade)	1	2	3	4	5
Near to roads that have low volume of traffics	1	2	3	4	5
Near to community halls	1	2	3	4	5
Near to libraries	1	2	3	4	5

4.. **From your point of view, how do you judge your children's school's location?**

Strongly not suitable	Not suitable	Less suitable	Suitable	Most suitable
1	**2**	**3**	**4**	**5**

5.. **If not suitable, please provide your opinion:**

____

____

____

____

6.. **From your point of view, what other facilities that are important to schools especially to primary school?**

i ______________________________

ii ______________________________

iii ______________________________

iv ______________________________

v ______________________________

Appendix 7. Accessibility Model Output and the Criterion Score

Row Labels	Sum of Join_Count	Criterion Score
A1	21	4
A2	25	4
A3	3	3
A5	23	4
A7	5	4
A9	41	4

Intersection between Road and 200 m buffer from Alternatives Sites and the Criterion Score

Row Labels	Sum of Join_Count	Criterion Score
A1	6417	4
A2	8183	4
A3	4469	4
A5	8930	4
A7	802	1
A9	6128	4

Intersection between Housing area and 800 m buffer from Alternatives Sites and the Criterion Score

Row Labels	Sum of Join_Count	Criterion Score
A1	2	3
A2	2	3
A3	0	1
A5	2	3
A7	0	1
A9	1	2

Intersection between Health Centre and 800 m buffer from Alternatives Sites and the Criterion Score

Row Labels	Sum of Joint Count	Criterion Score
A1	0	1
A2	1	2
A3	0	1
A5	0	1
A7	0	1
A9	1	2

Intersection between Fire Station and 800 m buffer from Alternatives Sites and the Criterion Score

Row Labels	Sum of Join_Count	Criterion Score
A1	1	2
A2	1	2
A3	0	1
A5	0	1
A7	0	1
A9	0	1

Intersection between Library and 800 m buffer from Alternatives Sites and the Criterion Score

Row Labels	Sum of Join_Count	Criterion Score
A1	8	4
A2	4	4
A3	0	1
A5	0	1
A7	1	2
A9	1	2

Intersection between Community Hall and 800 m buffer from Alternatives Sites and the Criterion Score

Appendix 8. Picture of Alternative Sites

(a)

(b)

Alternative site of A1

(a) Picture shows the location of A1 which is close to Jalan 9/18B, 51200 Kuala Lumpur

(b) Picture shows the site of A1 which represents approximately 9 ha and overlays nicely with 2 of DBKL proposed site.

(a)

(b)

Alternative Site of A2

(a) Picture shows the site of A2 which is located close to housing area
(b) Picture shows the site of A2 which can be accessed by existing road

(a)

(b)

Alternative Site of A3
Picture of (a) and (b) show the site of A3 which represents approximately 3 ha.

(a)

(b)

Alternative Site of A5

(a) Picture shows the site of A5 which represents approximately 3 ha.
(b) Picture shows the site of A5 which located close to existing road

(a)

(b)

Alternative Site of A7
Picture of (a) and (b) show the site of A7 which represents approximately 6 ha.

(a)

(b)

Alternative Site of A9

Picture of (a) and (b) show the site of A9 which can be easily accessed by existing road.

Appendix 9. Picture of Unsuitable Sites

(a)

(b)

Alternative Site of A4

Picture of (a) and (b) show the site of A4 which has been developed with commercial buildings.

(a)

(b)

Alternative Site of A6

Picture of (a) and (b) show the site of A6 which has been tremendous developed with condominium and apartment buildings.

(a)

(b)

Alternative Site of A8

Picture of (a) and (b) show the site of A8 which has been tremendous developed with new buildings

(a)

(b)

Alternative Site of A10

Picture of (a) and (b) show the site of A10 which is located close to railway and ETL.

(a)

(b)

Alternative Site of A11

Picture of (a) and (b) show the site of A11 which is located close to railway.

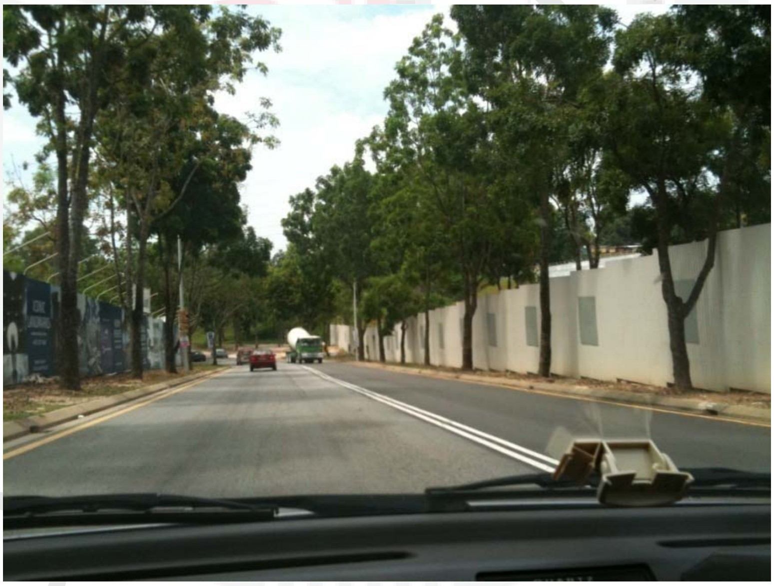
(a)

(b)

Alternative Site of A12

Picture of (a) and (b) show the site of A12 which is located close to railway.

(a)



(b)

Alternative Site of A13

Picture of (a) and (b) show the site of A13 which has been developed with new roads.

Appendix 10. Paper Cutting About Flash Flood in WPKL

Thousands caught unawares as 2m-high flash floods hit KL

By PRIYA MENON

KUALA LUMPUR: Thousands of motorists were stuck in massive traffic jams for more than two hours yesterday evening after a storm caused flash foods in various parts of the city.

Flood waters rose up to 2m at the junction of the Dynasty Hotel on Jalan Ipoh and in the Kampung Baru area.

Residents at Jalan Kolam Air were badly affected as flood waters rose as high as one metre. A resident, Ravi Chandran, 43, said it was not the first time the area had been flooded. The residents live beside Sungai Batu and flash floods have been occurring for years.

Paper Cutting 1

Thursday March 5, 2009

Massive flood causes havoc in Kuala Lumpur

By FAZLEENA AZIZ
Photos by CHUA KOK HWA

Submerged: Tuesday's downpour left parts of the city like this road near Jalan Ipoh inundated.

Thousands of people were left stranded as water as deep as 2m covered the major roads in the city.LRT commuters were also badly hit when the Kelana Jaya LRT service was halted by a power failure during a thunderstorm. Some commuters were stuck in trains and only reached their destinations hours later.StarMetro did a check around Jalan Ipoh and the PWTC areas after the flood water subsided and found that many business operators had closed their shops to clean up the mess."What KL really needs is a revamp of its drainage and irrigation system. Our drains are old, clogged, dirty and in need of major upgrading," she said.Junaidah said that the relevant authorities needed to address the flood situation seriously instead of making empty promises.The KL City Hall (DBKL) said in a statement yesterday that the heavy downpour on Tuesday afternoon measured at 468mm and had caused several low-lying areas in the city to be flooded.It said that heavy rain lasting an hour and 15 minutes caused the Sungai Batu, Sungai Keroh and Sungai Gombak to overflow.

According to the DBKL, several long-term flood prevention projects such as three flood retention ponds in Segambut Bahagia are expected to be completed in April this year.This includes detouring work on Sungai Gombak and a flood mitigation pond in the Batu area.The DBKL had also carried out river widening works at Sungai Keroh and the Jinjang flood control pond expected to be completed in June this year.The projects covering flood mitigation ponds in Jinjang and Batu and river widening works on Sungai Gombak and Sungai Keroh are expected provide flood prevention once they are completed

Paper Cutting 2

BIODATA OF STUDENT

Zubaidah Bukhari was born in Perak, Malaysia on the 26th of January 1970. She attended both primary and secondary schools in Perak. After completing her secondary school in 1986, she obtained her diploma in the University of Technology Mara (UITM) majored in Computer Science before continued her study in the University of Technology Malaysia (UTM). In 1990, she graduated from UTM and was conferred the degree of Computer Science.

Her first working experience was as a Research Assistant in UTM. While working in the researching field, she had been offered two offers, either to be a tutor and further her study in master or to work as a system analyst. She took the challenge to be a system analyst in a well known private company in Ipoh. During her involvement with that career, her enthusiasm in information technology has dragged her to developed several system applications in Ipoh as a junior system analyst.

She seeks for another new experience by joining the education field at UTM, Skudai, Johore to be a teacher. She graduated in 1992 and had been assigned to run the career in Bukit Bintang Boys Secondary School in Petaling Jaya. In 1999, she had been transferred to Seri Serdang Secondary School. In her third year of teaching in the school, she awarded excellence service award. In 2005, she was offered to work as an Assistant Director in EPRD (Educational Planning and Research Development). She has been involved in the development of one of the off line system which was well known as EMIS (Educational Management Information System) and has been awarded excellence service award in 2007.

She is interested in GIS during her job at EPRD which she involved in the school mapping data. With her background in computer science, she has gained more interest in GIS and this will help a lot of decision making processes which will be very useful to MOE (Ministry of Education). With zero background in GIS, she challenged herself to further her study in UPM to do GIS and Geomatic Engineering.

Besides her profound interest in GIS and computer, she is fond with a school planning and a database design. Today, her skill in computer and GIS has been proven very useful in the accomplishment of her master's research.

LIST OF PUBLICATIONS

Bukhari, Z., Mahmud, A. R., Ahmad, N., & Shariff, A. R. M. (2010). Spatial Multi-criteria Decision Analysis for Safe School Site Selection. *International Geoinformatics Research and Development Journal*, *1*(2), 1-14.

Bukhari, Z., Mahmud, A. R., Ahmad, N., & Shariff, A. R. M. (2010). Spatial Multi-Criteria Decision Analysis for School Site Selection. *Jurnal Penyelidikan Pendidikan, 2010*.(Paper accepted to be published)

Bukhari, Z., Mahmud, A. R., Ahmad, N., & Shariff, A. R. M. (2010). *Developing Policy for Safe School Development Using Spatial Multi-Criteria Decision Analysis.* Paper presented at the MRSS 2010, PWTC, Kuala Lumpur.

Bukhari, Z., Mahmud, A. R., Ahmad, N., & Shariff, A. R. M. (2010). *Using Spatial Multi Criteria Decision Analysis for Safe School Site Selection* Conference of World Engineering Conference, Kuching, Sarawak.

Development of School Site Selection Model, Silver Medal at PRPI, UPM, 2010.