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GIS Analysis for Abu Dhabi Schools

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United Arab Emirates University
Deanship of Graduate Studies

GIS Analysis for Abu Dhabi Schools

By

Shaima Hassan Hammadi

A Thesis submitted to the
Deanship of Graduate Studies
UAE University
in partial fulfilment of the Requirements for the Degree of
Master of Science in Remote Sensing and GIS

December 2007

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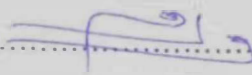**Master of Science in Remote Sensing and GIS**

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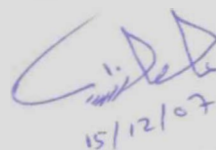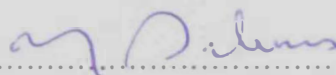Abu Dhabi Water and Electricity Authority

December 2007

The Thesis of Shaima H. Hammadi for the Degree of Master of Science in Remote Sensing and GIS is approved.

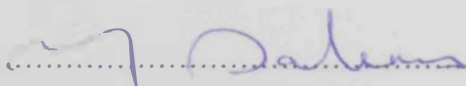..

Examining Committee Member, Dr. Mohamed Yagoub

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United Arab Emirates University
2007/2008

Dedication

To the memory of my father

To my Lovely Mother

To my Husband: Saeed

To my young Son: Abdullah

Acknowledgment

GIS Analysis for Abu Dhabi Schools

Abstract

Geographic Information Systems (GIS) have become an indispensable tool in many fields of study and research. GIS is useful for choosing sites, targeting market segments, planning infrastructure facilities and responding to emergencies. GIS is internationally used for the educational sector in different aspects such as planning schools allocation and managing educational resources. This thesis investigated the spatial distribution of schools in Abu Dhabi with respect to population density and service areas, generated prospective locations for constructing new schools based on the current and future demand using multi-criteria decision rules, developed a road network system that helps in finding shortest and best routes between schools and houses of students and Teachers and developed a user friendly-Interactive GIS based School Finder Tool. In the course of this research a comprehensive GIS database was also developed for all the 71 schools of the Abu Dhabi Island. Entire GIS analysis and tools development were executed using ESRI's ArcGIS 9.2 software. In addition this research has given good insight into the role of geographic information systems (GIS) in the school's education program, planning and Management as teachers may also have opportunities to learn about GIS and apply it to their instruction. The thesis observed that the GIS activities at Abu Dhabi schools are small scale, however GIS industry initiatives, UAE government and higher education institutions outreach, and emerging national standards are signaling an increasing adoption of GIS activities by the schools and there is also a need for specific GIS software designed for teaching and educational purposes.

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Chapter 1

Introduction

Chapter 1

Introduction

1.1   **Background**

Before the discovery of oil, there was very little development in the Arabian
Peninsula, and certainly no proper educational system. In 1962, when oil production
started in Abu Dhabi, the country had just 20 schools for less than 4,000 students,
now the number of schools has increased to 1500 and the total student number has
been increased to 650, 000 (Al Abed et al., 2007).

The discovery of oil provided the necessary finances to improve the education
system. This was a high priority for His Highness Sheikh Zayed bin Sultan Al Nahyan,
the UAE former President, who declared: "Youth is the real wealth of the nation." His
aim was to use the oil revenue to develop academically and technically qualified
citizens.

The UAE provides a comprehensive education system for boys and girls, with free
education for nationals in governmental schools, colleges and universities. The major
concern of Ministry of Education and Youth is to ensure the development of methods
and programs that adhere to the latest international standards, with particular focus
on introducing the latest IT resources at all levels (http://
www.sheikhmohammed.co.ae/english/history/history_edu.asp).
Abu Dhabi is the capital of UAE and Abu Dhabi emirate is the largest of the seven
emirates of the United Arab Emirates. The city lies on a T-shaped island jutting into
the Persian Gulf from the central western coast. An estimated 1.8 million people

lived there in 2006, with about an 80% expatriate population

(http://en.wikipedia.org/wiki/Abu_Dhabi). Abu Dhabi city is located at 24.4667° N

54.3667° E. (Figure 1.1) At the head of Abu Dhabi and across from the Corniche is

Lulu Island, a semi-natural landmass that is arguably the most strategic and valuable

piece of property in the Emirate. Its area is 6,700km².

The current developments in Abu Dhabi, like its neighbor Dubai is focused primarily

on large hotel, condominium and office complexes built in modern architectural

styles.

(1)

(2)
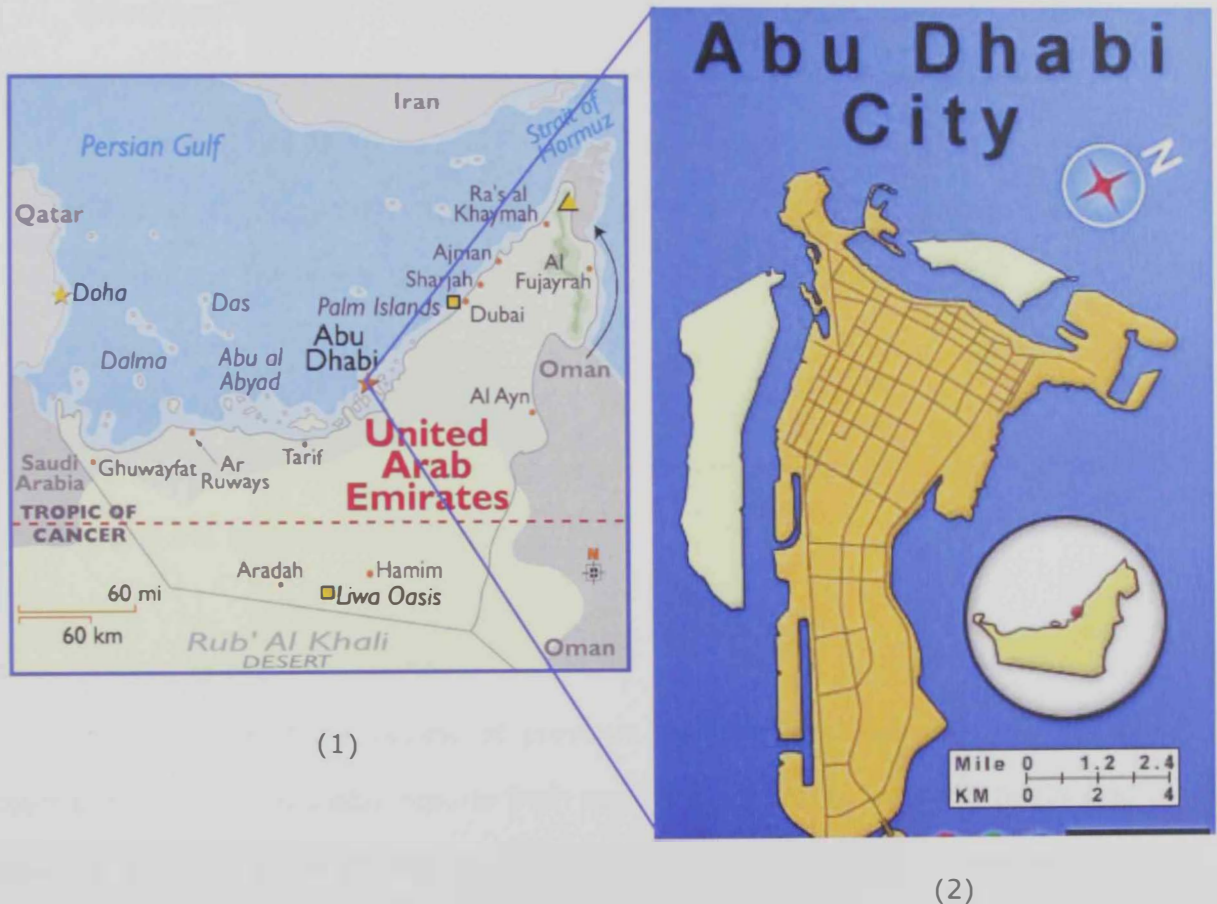
Figure 1.1: Study Area

Source (1): http://worldatlas.com/webimage/countrys/asia/ae.htm

Source (2):http://guide.theemiratesnetwork.com/maps/abu_dhabi_map.php

1.2   Objectives of the study

The specific objective of this study is to investigate the GIS's implementation in schools. This investigation is set to be achieved and illustrated by carrying out the following:

1. Investigate spatial distribution of schools with respect to population density and calculating their service areas in the Abu Dhabi Island.

2. Site new school locations based on the current and future demand using GIS multi-criteria analysis.

3. Find out the hot spot areas for the Schools based on number of students per school and District.

4. Develop a network system that helps in finding shortest route between schools and houses.

5. Develop an Interactive GIS based School Finder Tool for Abu Dhabi Island.

6. Design and Develop a GIS database for Abu Dhabi Schools

1.3   Methodology

The objectives of the study have been achieved through a number of tasks that were conducted and are elaborated hereafter.

Task 1: Review of previous studies

This task encompassed the review of previous studies that were relevant to the subject of this study, available reports from various sites on the Internet, books and magazines and Literature of GIS analysis for school administration from different countries.

Task 2: Identification of datasets and data collection

Data and information were collected from different organizations in Abu Dhabi. Abu Dhabi satellite image (IKONOS-2006) and Districts, Zones, Roads, centerline, location and names of the schools were collected from Abu Dhabi water and electricity authority (ADWEA) as shape files. Information about the schools such as name of the school, grade, gender, number of students, Telephone and Fax numbers were collected from Abu Dhabi Educational Zone. Population data of Abu Dhabi Island were collected from Department of Economy and Planning.

Task 3: Visiting Abu Dhabi Education Zone, Abu Dhabi

Visited Abu Dhabi Education Zone and got the courses associated with geography from grade four to ten. Got the information of all schools in Abu Dhabi Island such as: Name of the school, grade, gender, no. of students, Telephone and Fax numbers as an excel sheet.

Task 4: Visiting Schools of grade 10

Visited the governmental and private schools in Abu Dhabi Island and distribute questionnaire; Interviewed different Geography teachers to know their background in Computer and GIS technology; Conducted meetings with School Administration to understand their knowledge in using GIS for Schools, network analysis and finding shortest bus routes.

Task 5: Data processing and design of goedatabase

All the data and layers gathered from different departments were in different formats and on different projection systems. All these data sets were converted to ESRI Shape file format and brought into a common Projection System (UTM_WGS84_ZONE40N) then relevant attribute data were added to each layer.

Task 6: Data Analysis

Using the Processed data GIS analyses were conducted to understand School distribution with respect to Demographic patterns. Calculated the service areas of different schools; generated prospective locations for constructing new schools in the future. Developed an Interactive GIS based School Finder Tool and a Network system for finding shortest and best routes for Students and Teachers. Collected UAE Geography text books from grades 4 to 10 were reviewed and analysed for their geographical concepts related to GIS, GPS and Remote Sensing technologies. Computer and GIS skills of Geography Teachers were analysed using the Questionnaire reports

Task 7: Thesis Preparation

Upon completion of the above 6 tasks, Final Maps, satellite images, Figures, reports and Tables were prepared in the final format. Reported all the findings and results; Conclusion was made based on the results of the study and recommendations were proposed for future studies.

1.4   Organization of the thesis

This thesis is composed of five chapters. Chapter one covers the objectives and the methodology used to achieve these objectives, chapter two is devoted to the GIS technology and its importance for schools.

The third chapter presents GIS Education in UAE universities and colleges in general and Schools in particular. In addition, it includes review and analysis of geography text books from grade 4 to 10, analysis of Geography Teacher's skills using Questionnaire and about the GIS applications in different organizations in UAE.

The fourth Chapter presents fully the GIS database creation and GIS analysis, such as Correlation analysis between students, population and schools, service area

analysis of schools, Spatial distribution analysis of schools, hot spot analysis of student numbers, site selection analysis of schools and also presents the development of an Interactive School Finder Tool and route Network system for Students and Teachers.

The final chapter highlights thesis summary, conclusion, and recommendations.

Chapter 2

GIS Technology for schools

Chapter 2

GIS Technology for schools

2.1   Introduction

Geographic Information System (GIS):

GIS is a collection of computer hardware, software, and geographic data for capturing, managing, analyzing, and displaying all forms of geographically referenced information (Audet and Ludwig, 2000; Longley et al; 2001; http://www.gis.com/whatisgis/index.html).

It is also a tool to answer questions about a location; it can combine layers of information stored in a database that may include addresses, aerial photographs, satellite images, dates, and other numerical values. A GIS does more than tell "where," but can also answer questions like "why" and "what if?" With a GIS, it is possible to explore relationships, trends, and conduct analyses that can be represented as maps. GIS can be applied to a variety of topics in the physical and social sciences, as well as mathematics and art/design, providing a great foundation for interdisciplinary projects. Working with GIS helps students develop computer literacy, analytical approaches to problem solving, and communication and presentation skills (Lo and Albert, 2002; http://www.esri.com/industries/k-12/education/what_is.html).

The components of GIS are:

Hardware

Hardware is the computer on which a GIS operates. Today, GIS runs on a wide range of hardware types, from centralized computer servers to desktop computers used in stand-alone or networked configurations.

Software

GIS software provides the functions and tools needed to store, analyze, and display geographic information.

Data

Maybe the most important component of a GIS is the data. Geographic data and related tabular data can be collected in-house or bought from a commercial data provider. Most GISs employ a DBMS to create and maintain a database to help organize and manage data.

People

GIS technology is of limited value without the people who manage the system and develop plans for applying it. GIS users range from technical specialists who design and maintain the system to those who use it to help them do their everyday work.

Methods

a successful GIS operates according to a well-designed plan and business rules, which are the models and operating practices unique to each organization (Heywood et al, 1998; http://www.sfu.ca/rdl/GIS/tour/comp_gis.html).

What can we do with GIS?

Various analysis can be done with GIS, this include:

Map Where Things Are

Mapping where things are lets you find places that have the features you're looking for, and to see where to take action.

Map Quantities

People map quantities, like where the most and least are, to find places that meet their criteria and take action, or to see the relationships between places. This gives an additional level of information beyond simply mapping the locations of features.

Map Densities

A density map lets you measure the number of features using a uniform areal unit, such as acres or square miles, so you can clearly see the distribution.

Find What's Inside

Use GIS to monitor what's happening and to take specific action by mapping what's inside a specific area. For example, a district attorney would monitor drug-related arrests to find out if an arrest is within 1,000 feet of a school--if so, stiffer penalties apply.

Find What's Nearby

Find out what's occurring within a set distance of a feature by mapping what's nearby.

Map Change

Map the change in an area to anticipate future conditions, decide on a course of action, or to evaluate the results of an action or policy (Mitchell, 1999; http://www.gis.com/whatisgis/dowithgis.html)

2.2   Importance of GIS for schools

GIS can help learners of all ages understand the world around them. GIS helps students and teachers engage in studies that promote critical thinking, integrated learning, and multiple intelligences, at any grade level (http://edcommunity.esri.com/im/).

GIS in school administration improves planning and decision making in areas including enrollment model for public schools, facility management, finding shortest route, spatial distribution of schools, site selection for schools, school finder system and hot spot analysis.

2.2.1 Enrolment Model for public schools

Today, Geographical Information Systems is an efficient tool to tackle many issues. The matters based on geographical information like Automatic Student Registration (ASR) not a problem anymore with GIS in education sector and GIS mapping procedures are used widely in ASR process.

For example, a prototype model was developed for Turkey where there are 36,712 and 59,723 students in 74 elementary schools and 25 secondary schools. This model include several graphic data layers as roads, buildings, school locations, administrative boundaries, and non-graphic layers as street numbers, residential addresses and school capacities. As a result, students had an opportunity to enroll in the nearest school via internet using address information (http://www.fig.net/pub/fig2007/papers/ts_4h/ts04h_01_yildirim_aydinoglu_1401.pdf).

The ASR model is based on GIS, relational databases and address information system. The main components of the model allow to capture, store, update, analyze and display all forms of geographic information are hardware, software and spatial data. Also, this model includes updating procedures, data sharing rules, and other related data. ASR model is an important part of school site management. GIS has proven to be an extremely effective and efficient tool to solve ASR problem.

2.2.2   School Facility Management and GIS

Geographic information systems technology can provide a significant analytical tool for planning and delivering educational services.

Student information and service data can be combined with other available commercial demographic or governmental data sets to help in planning, implementation, communication or management projects. It helps in tracking and analyzing data both geographically and temporally, and relates information from different sources. For example, you can analyze development patterns to aid in school sitting or optimize bus runs by analyzing drive times (http://mwvcog.org/gis/downloads/SchoolAdmin_GIS.pdf). For instance, Council of government (COG), Mid Willamette Valley developed and maintains the GIS base mapping that helps support the 60 attendance zones, map books, transportation routing facilities management, and planning activities of the Salem Keizer School District.

2.2.3   Finding the fastest route

Network analysis is defined as a set of geographical locations interconnected in a system by a number of routes. Network refers to a system of lines topologically structured, for example transportation lines and river lines (Kansky, 1963).
In analyzing networks, major concern is how far the locations are from one another whether the routes joining them curve or straights (Haggett and Chorley, 1969)

This project focused on determining the best route between two destinations based on a specific travel expense, travel cost would be based on the length of time required to travel between locations, mileage, operating cost or some other factors. A Geographical Information System (GIS) can determine both the quickest and shortest routes between these locations.
(http://gis.esri.com/library/userconf/proc03/p0320.pdf)
Factors influencing the length of time such as school zones, traffic lights, and rush hour traffic would be considered in the determination of the fastest route. The use of

GIS to determine the quickest route between locations is one of the goals of this project.

2.2.4   Spatial Distribution of schools

Spatial Distribution is the locations of features or measurements observed in geographic space (Fotheringham et al., 1994; http://atlas.library.arizona.edu/glossaryq_s.htm)

- Three general patterns of Spatial Distribution
    - **Random** any point is equally likely to occur at any location and the position of any point is not affected by the position of any other point. There is no apparent ordering of the distribution
    - **Uniform** every point is as far from all of its neighbors as possible
    - **Clustered** many points are concentrated close together, and large areas that contain very few, if any, points (Lo and Al bert, 2002; http://www.css.cornell.edu/courses/620/lecture8.ppt#256,1,Spatial Distribution)

RANDOM   UNIFORM   CLUSTERED
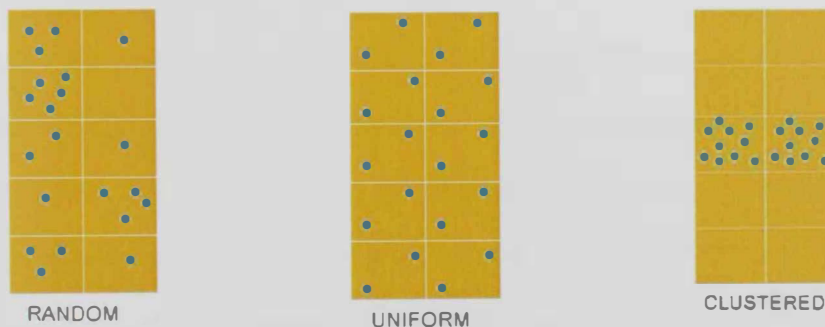
Figure 2.1: Patterns of spatial distribution

For example, In California 173 schools (2.3%) with a total enrolment of 150.323 students were located within 150 m of high traffic roads (primarily in the central cities); 535 schools (7.2%) were within medium traffic roads

(http://www.oehha.ca.gov/public_info/public/kids/pdf/proximity%20of%20schools%20to%20roads.pdf).

In India, the maximum walking distance to schools from children's houses is set to be less than 1 kilometer for lower primary level education and three kilometers for upper primary level.

In Sapporo, Japan, city planning regulations indicates that primary schools should be located within 500 m and 10 minutes walking distance from the residence and for lower secondary schools are within 1,000 m and 15 minutes walking distance from their houses.

In Thailand, there are no specific regulations or requirements for school locations, Only few common rules, such as not near factories, warehouses, landfills etc., are stipulated for school planning. This loose enforcement of school planning regulations has also become one of the factors that triggered the random school distribution regardless of the consideration for demand.

(http://www.gisdevelopment.net/aars/acrs/2002/edu/100.pdf)

2.2.5   Site Selection for new school

The site selection process can be viewed as being composed of two major phases, preliminary and detailed. In the preliminary phase large areas are screened to identify potential sites. After identifying a set of sites, additional factors can be included in the detailed phase. The site selection can be approached through location-allocation models, which involve the determination of the number of new facilities, as well as their locations, and the allocation of item movement between the new and existing facilities. The solution will generally result in the identification of more than one specific site (LaPlaca, 1997).

For example, In Jordan they use GIS to build a data model for school mapping to find a proper site for new school and take into consideration some criteria like:

- Maintain school capacity in terms of the ratio of available class room area per student

- Match the increase in population of the area for the next ten years

- Show the overall distribution of current schools in the area in a map with all related info (http://www.isprs.org/istanbul2004/comm2/papers/135.pdf).

Another example of using GIS for site selection is in Delaware where a school district was chosen for analysis, and existing GIS themes were identified for use in the analysis. Part of the study was also to look at what other data might be needed. GIS data used in the analysis, among others, were land use, parcel line data, sewer network, and resource protection areas. Geo processing techniques such as intersect and buffering were used. Surrogate point data was created to represent students.

The above analysis provided a number of possible locations for school sites. It was obvious that some sites, although identified as suitable, would not be. For example, open space in the interior of existing housing subdivisions could be excluded although it might meet all criteria used (http://gis.esri.com/library/userconf/proc01/professional/papers/pap618/p618.htm).

As a result Geographic Information System holds great potential for use as a tool in school site suitability analysis. With additional brainstorming and further refinement of the model, administrators, working in conjunction with school planners knowledgeable in GIS techniques, could create a model that would prove beneficial in school site planning. Further, with some modifications, this model could be adapted for use in other districts.

There are other criteria taken into consideration in other countries like (http://www.psd150.org/board/SiteSelectionCriteria.pdf):

- Size, the site(s) should be large enough to accommodate the District's, the minimum size 8-15 acres for one story school and 6-12 acres for a two story school.

- Amenities, There are both "desirable" and "undesirable" amenities sought in the areas of a new school building(s).

  ✓ adjacency to parks, libraries, and recreational centers.

  ✓ Not adjacency to commercial enterprises with a high concentration of vehicular traffic.

  ✓ Not adjacency to areas with a high incidence of crime.

- Other Consideration, proximity to student population.

- Accessibility to site by walk, car, bus, public transportation.

- Traffic volume and congestion.

2.2.6   School Finder System

A system is an inter-related set of components with an identifiable boundary, working together for some purpose (Hoffer et al., 1996). The major stages in the development of a system are:

- Requirements analysis and specifications.

- Design.

- Implementation.

- System testing.

- Installation.

- Problems.

Example of a GIS system for school was developed by the Council of government (COG) (http://mwvcog.org/gis/downloads/SchoolAdmin_GIS.pdf).

COG website hosts the School finder webpage that is serving up the latest revisions to the district's school attendance boundaries and other GIS applications, such as:

- Map your student data by location to analyze and discover trends.

- Analyze drive times to find the best routes for buses.

- Combine student or attendance boundary data with 2000 Census data using.

- Digitize school facilities/blueprints to aid in resource allocation or development of emergency response plans.

- Map local government crime data to monitor trends or patterns in proximity to bus routes and schools

- Create maps, charts and graphs for distribution via paper, email or the web

With web enabled mapping. School attendance information and bus routes are available to the public on line, reducing calls to staff

(http://mwvcog.org/gis/downloads/SchoolAdmin_GIS.pdf).

2.2.7   Hot Spot Analysis

The Hot Spot Analysis tool calculates the Getis-Ord Gi* statistic for each feature in a weighted set of features. The G-statistic tells whether features with high values or features with low values tend to cluster in a study area. This tool works by looking at each feature within the context of neighboring features. If a feature's value is high, and the values for all of it's neighboring features are also high, it is a part of a hot spot. The local sum for a feature and its neighbors is compared proportionally to the sum of all features; when the local sum is much different than the expected local sum, and that difference is too large to be the result of random chance, a statistically significant Z score is the result (ESRI, 2005).

GI* Static data Interpretation

The Gi* statistic is actually a Z score. For statistically significant positive Z Scores, the larger the Z score is, the more intense the clustering of high values. For statistically significant negative Z scores, the smaller the Z Score is, the more intense the clustering of low values.

Hot spot analysis can be used for many school management issues such as monitoring diseases within schools and enrolment.

For example in Toronto, geography students conducted a research experiment to determine where influenza bacteria are likely to be found (hot spots).

They found that some areas like high traffic areas, stationary computer, the enter button had more bacterial content and washrooms had the most bacterial content. (http://www.cordweekly.com/cordweekly/myweb.php?hls=10034&news_id=1078)

In Ontario, they produce a comprehensive enrolment landscape that is projected through time which encompasses all board types (EP\EC\FC\FP) and school types (elementary\secondary). Ministry staff can use this to get a bird's eye view of the areas to expect enrolment pressures between all board types, and where one school board could alleviate the enrolment deficit of another board. The basic unit of measure is school spaces which is equal to Capacity-Enrolment where Capacity is only 'On-the-Ground' and does not include non-permanent spaces. Enrolment and Capacity data comes from school board uploaded information through the Capital Planning component of the SFIS system. Status types included are 'Open', 'New', and 'Closed' (http://gis4u.edu.gov.on.ca/website/GISUserGroup/Tools/Hotspots/EnrolmentGrowt hAreas.doc).

Chapter 3

GIS in UAE

Chapter 3

GIS in UAE

3.1 Introduction

The revenue from oil has played a major role in the increase in the number of schools during the last few years (Figure 3.1). It also helps in providing information technology (IT) infrastructure for schools.

Since the beginning of the IT revolution in this country the Ministry of Education is supporting IT. For example, one of the goals is to provide a computer for every ten children in kindergarten, every five pupils in primary schools, every two students in preparatory schools and one computer per student in universities. That IT education in the formative years has became a major priority for UAE and is underlined by the success of the Sheikh Mohammad Bin Rashid IT Education project (ITEP), which was launched 2000. As well as installing computer labs in all participating schools and creating a comprehensive cutting-edge curriculum, ITEP also provides an invaluable online educational resource.
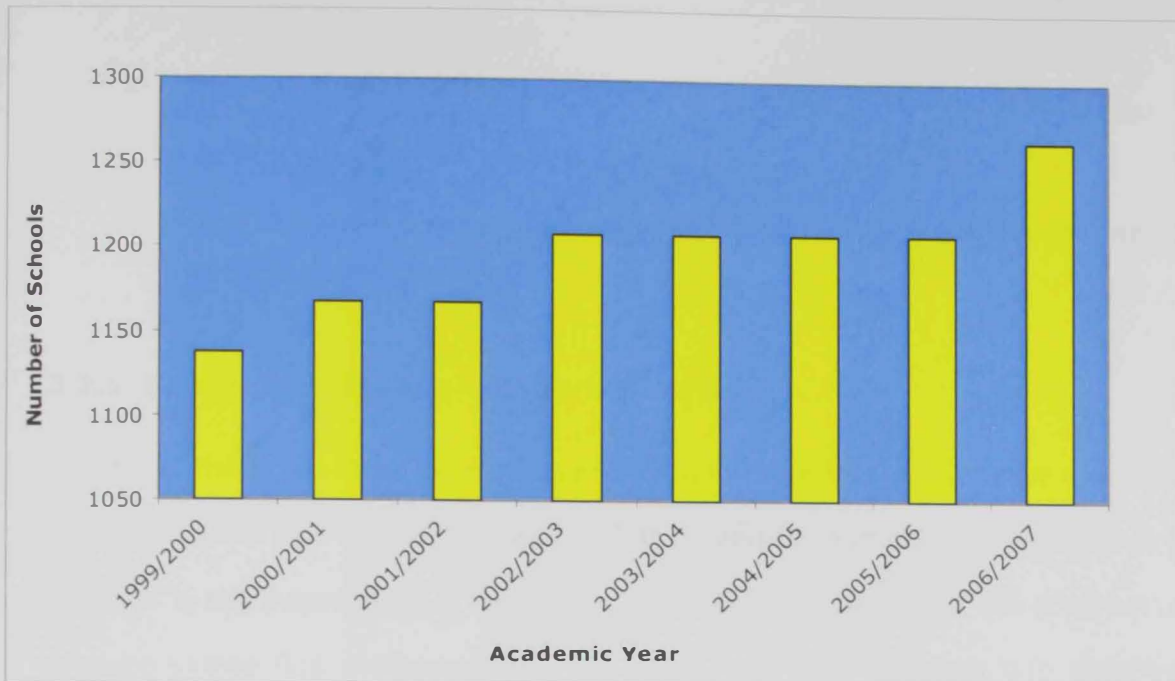
Figure 3.1: Number of the schools in UAE between 1999 - 2007

Source: Al Abed et al. , 2005 ; Al Abed et al. , 2007

ITEP now provides courses in 40 high schools in UAE (20 in Dubai, 20 in Abu Dhabi) and over 13000 students pass through the programme every year (Al Abed et al; 2007).

The IT infrastructure will help in any plan for introducing of GIS in schools. Graduates from GIS fields and applications of GIS in governmental departments will also assist in using GIS as a tool for schools management and its introduction in the curriculum.

3.2 GIS Education in UAE

Each day more universities and colleges are seeking information on how to begin remote sensing and GIS programs. The reasons are many, but four of the most important are (ESRI, 1998):

- The mandate for universities and colleges to upgrade technological education.

- The need for universities and colleges to find new sources of funding.

- Advances in hardware and software.

- The demand for more professionals trained in GIS by government and the private sector.

3.2.1 GIS at graduate and undergraduate level

Currently, there are three public universities and more than ten private universities in the UAE. The UAE University was the first university in the UAE to establish a GIS program in the Department of Geography in 1999. The objective of the program is to produce skilled GIS graduates who can build, use, and maintain GIS databases. Courses of the curriculum are designed to meet this objective. The curriculum covers basic English courses, as English is used as a medium of instruction for 6 courses (Table 3.1), and geographical courses such as physical geography, human geography, geography of the UAE, and geography of Arid Zones. The courses related to remote sensing and GIS are taught in English and this reflects the *globalization* of these courses; moreover the text books assigned to these courses are also used by universities in developed nations (Table 3.1). Upon completion of 132 credit hours (24 credit hours in the field of geo-science), a student will earn a B.Sc. in Geography with GIS. To make the courses more flexible and global, a special web site has been designed to provide students with online material related to geo-science. In addition, a comprehensive summary of a number of programs around the world that offer distance learning in the geo-science discipline is provided (Geocommunity, 2003).

Currently, the Department has 4 faculty members specialized in remote sensing and GIS and another 12 faculty teaching other geographical courses. The total number of students is 300, with 70% of them females. The Department's GIS labs (at the Men's

and Women's campuses) have a wide range of computing facilities (77 PCs). Input devices include 10 digitizers, 3 handheld GPS receivers and two scanners. Colour graphics output is provided by two HP color laser printers and an HP plotter. The hardware is complemented by a comprehensive suite of software tools for geographical information processing. These include ESRI ArcView, ArcGIS, and ERDAS Imagine.

GIS and remote sensing activities are not limited to the Department of Geography, but other departments in the UAE University offer courses related to remote sensing and GIS, for instance, the Departments of Civil Engineering and Environment, Architectural Engineering, and Geology. An important factor in the development of remote sensing and GIS in the UAE University is that the top decision makers (champions) are supporting Information Technology in general and remote sensing and GIS in particular.

The UAE University has approved M.Sc. program in remote sensing and GIS. The program started in September 2005 and it's the first educational track of its kind in the area. The M.Sc. is designed to provide a unique educational opportunity for understanding of remote sensing and GIS, together with their impact on society. This program has been developed as an interdisciplinary program to be offered jointly by the Geography, Geology, Civil Engineering, and Urban and Regional Planning departments, with support from the IT and Business departments.

In this way and through GIS, isolated departments are starting to work together and at the same time each department feels a responsibility towards remote sensing and GIS. Moreover, the lobby to convince the University of the value of such a program is

becoming stronger. Therefore, universities in developing countries can use this model of creating an interdisciplinary program.

Core courses encapsulated in the program include principles of remote sensing and GIS, digital image processing, spatial analysis, database management system, and geo-statistics. Elective courses include project management, environmental planning and impact analysis, water resource management, and selected topics in remote sensing and GIS. In addition to the core courses and elective courses, students have to develop an M.Sc. thesis. By the end of the program, students have to complete 30-34 credit hours within two years for full time students and within 3 to 4 years for part time students (Yagoub, 2005).

Course	Textbook used by UAE University
Cartography	Robinson, A. H., J. L. Morrison, P.C. Muehrcke, A.J. Kimerling and S.C. Guptill 1995. *Elements of cartography*. New York: John Wiley & Sons, Inc.
Computer Cartography	Slocum, T. A. 1999. *Thematic Cartography and Visualization*. New Jersey: Prentice Hall.
Remote sensing I	Thomas Eugene Avery and Graydon Lennis Berlin, 1992. *Fundamentals of Remote Sensing and Airphoto Interpretation*, 5th ed. New York: Macmillan Publishing.
Remote sensing II	Jensen, J. R., 1996. *Introductory digital image Processing: A remote sensing perspective,* 2nd ed. New Jersey: Prentice Hall.
GIS I	Longley, P. A., M. F. Goodchild, D. J. Maguire, and D. W. Rihnd, 2001.*Geographic Information Systems and Science*. New York: John Wiley and Sons, Inc.
GIS II	Fotheringham, A. S. and P. A. Rogerson, 1994. Spatial analysis and GIS. London: Taylor & Francis Ltd.

Table 3.1: Geo-science courses and textbooks at the Department of Geography,

UAE University

Source: Geocommunity, 2003

3.2.2 GIS for Schools in UAE

Geographical Information Systems (GIS) have not yet been introduced to primary, intermediate and secondary schools as a major subject in the UAE while in world wide GIS is in about 10,000 secondary schools and estimated 150000 students study GIS each year (http://www.fh-kaernten.ac.at/eugises_2004/pdf/EUGISES2004_phoenix.pf).

However, there are some efforts for introducing GIS in schools, for example, Sheikh Zayed Private Academy School for Girls and through, GIS Educational Forum. The Sheikh Zayed Private Academy for Girls, located in Abu Dhabi, UAE is a private school for girls from KG1 through grade 12 (http://www.zayedacademy.ac.ae/).

The school offers an enriched program to its students combining the curriculum of the UAE for Arabic, Islamic, and Social Studies with a Canadian curriculum based on the expectations of the Ontario, Canada Ministry of Education program. Students from grade 7 - 12 are involved in the school's award-winning laptop program. Using their own laptop computers (purchased through the school), students integrate computer technology in all subject areas, improving their information literacy skills through course instruction and individual exploration of software licensed by the school.

Students are encouraged to submit projects completed through their courses to the bi-annual UAE IT Challenge. Students from grade kG1 – 6 are using the computer lab which contains of 20 computers and grade 1 – 6 they have 3 computers in each class room using it for several subjects. The school purchased ArcGIS software in 2005 and installed in grade 10 student's laptop and they tried to use it for the

geography class, unfortunately the language was the main problem for them so they stopped (Heather, 2006).

The first GIS Educational Forum was organized by the GIS Centre of Dubai Municipality in cooperation with the Ministry of Education at Dubai World Trade Centre as part of the Map Middle East 2006 conference.

Sixty students in the age group of 12-15 from 12 government schools in the UAE participated in the Forum, which provided the participants a first hand experience on map making and data collection, in addition to presentations by international experts in the field. During the hour-long session called, "Field Survey Game" held outside the Trade Centre, students joined a professional team led by Head of Geodesy Unit in the Planning and Survey Department at Dubai Municipality in conducting a field survey for map making. They were shown how the data for map making is collected and processed on location, and then how it is incorporated in a map on the computer. The students who participated in the Forum were selected based on their achievements and participation in extra curricular activities in the school as per the Ministry of Education standards (Figure 3.2)

(http://www.gis.gov.ae/en/news/news.asp?ID=73)

On February 21-22, 2007 a Second GIS Educational Forum was held at the Children City in Al Khor Park in Dubai as a first show and the final show was held on the map middle east 2007. The event was organized by Ministry of Youth and Education, Ministry of Social Affairs, and Zayed Center for Children of Special Needs and Children City in Dubai (Figure 3.3).

The Forum aims at spreading awareness and setting up a sound foundation of geospatial science and technologies by educating future generations. The forum

addresses the awareness and the need for GIS among the students and how it is going to help them in day to day life.

The main goals of this Forum were (http://www.mapmiddleeast.org/2007/conference/educationforum.htm):

- Familiarize school students with the techniques of GIS and remote sensing, and use of maps.
- Development of the child's personality through the encouragement of logical and analytical thinking about the surrounding challenge, as well as the development of the ability to debate, communicate and present.

- Provide educational resources for teachers: the practical application of the concepts of GIS and remote sensing.

The forum concluded with successful Participation School: boys / girls and preparation of a variety of technical research on the obstacles and challenges facing environment, and analysis using GIS techniques to find solutions that suit every obstacle. Examples of topics presented included: water reservoirs, impact of pollution in the Al Ras Al Akhdar, solid waste in Abu Dhabi, spread of asthma among children in Zayed City, and tourism in Diba Fujairah (http://www.geopedia.ae/First%20Mini%20Papers%20Project/Program%20for%20first%20pr oject.pdf).

The Map Drawing Contest is targeting all GCC children aged 3 to 15 yrs, All participated maps displayed during the Map Middle East Conference, there where five winners selected from each country to participate in the World Map Competition in 2007 (Figure 3.4)

Figure 3.2: First GIS Educational Forum

Figure 3.3: Second GIS Educational Forum

Figure 3.4: Map Gallery, prepared by school studetnts

Source: photo by the author

Secondary School students in Al Ain and Abu Dhabi Learn also about GIS On November 15, 2006 in the GIS day celebration that was held at the Khalifa Bin Zayed School in Al Ain. The event was organized by GISTEC with the assistance of Abu Dhabi Municipality through Mustafa Al Muaswa and the director of Al Ain Educational Zone Authority, about 50 students, teachers and principals from different secondary school were attended (Figure 3.5) The GIS technology was explained to the students and their teachers, its importance, usage, and implementation. The students were provided with gifts including T shirts, GIS books and bags (GISTEC, 2007).

Figure 3.5: Secondary School students in Al Ain and Abu Dhabi Learns about GIS

Source: http://gistec.com/events/gis_day_photos/gis_day.htm

3.3   GIS Application in UAE

There are many Government (Federal & Local) and Private organizations in UAE that are using the Geographic Information Systems and remote sensing in their daily business.   Some of the following examples will give a good insight into the GIS implementation in different organisations of UAE country and this will encourage the use of GIS by schools and ministry of education.

3.3.1 Abu Dhabi Department of Municipalities and Agriculture

Typically, municipalities use GIS technology to manage their utilities like sewerage, water supply systems, road networks, etc. GIS is also typically used by Town Planners for preparing master plans, zoning maps and for monitoring building permits and cadastral information. An integrated GIS with data on local infrastructure can help to assess the risk to residents and buildings, and plan for protection measures or information campaigns. The potential is enormous. For municipalities, it is a combination of easy retrieval, spatial analysis and attribute presentation capabilities that makes a GIS package especially attractive to use. For many municipal functions, where attribute databases are directly related to plots,

digital property maps represent a key starting point for different applications. There are enormous benefits resulting from presentation and analyzing data with GIS across a municipality like administrative savings (no need to maintain paper maps / documents and storage facilities) and the ability to quickly and efficiently update and disseminate new information over the Internet.

The main role of municipal GIS is to re-engineer and support all major business processes across the local government in order to increase their efficiency and provide a greater return on the investment of public money (Kunka et al. , 2005; http:// www.mapmiddleeast.org/magazine/2005/jul_aug/theabua.htm)

3.3.2 Dubai Municipality

Dubai GIS Center has built an enterprise GIS that is serving the needs of Dubai Municipality, other government organizations of the Emirate and the private sector and it continues to seek innovative and effective means of applying GIS technology to improve Dubai Municipality's operational and planning capabilities and the quality of life of citizens & residents.

Advances in Geographic Information System (GIS) technology, coupled with the pervasiveness of the Internet has fundamentally changed the way geographic data is collected, stored, managed, maintained, disseminated and used. The GIS Center is taking advantage of latest GIS and Internet technologies to replace traditional channels for dissemination and use of geographic data (http://www.gis.gov.ae/en/content.asp?DocID=68&Cat=16&npage=1).

The main use of GIS in the municipality is in mapping and updating of master plans and utilities. The municipality introduced the latest technology in mapping, the Continuously Operating Reference Stations (CORS) system that helps surveyors,

GIS/LIS professionals, engineers, scientists, and others to position points for which GPS data have been collected. Governmental, academic, commercial, and private organizations can benefit from this system.

3.3.3 Sharjah Goverment

The Sharjah Geospatial Information Systems (GIS) Center (SGC) was established by the Sharjah Government to cater to the GIS needs of the Sharjah Government Departments, and coordinate between Sharjah Government and other parties, both in the public and private sectors. The GIS Data Interoperability Solution (GDIS) currently being implemented by GISTEC, aims to facilitate the smooth and lossless exchange of geospatial data between the following member organizations of SGC:

- Sharjah Municipality
- Sharjah Police
- Sharjah Department for Economic Development
- Sharjah Public Works Department
- The Directorate of Town Planning and Survey (DTPS)
- Sharjah Electricity and Water Authority (SEWA)
- Etisalat

The GDIS is one of the few implementations in the world involving several government agencies participating in a complete geographic data interoperability setup. Several business level and technical challenges were encountered by GISTEC team during the GDIS implementation. GISTEC team customized and developed on top of the core Spatial Direct and FME soft wares to meet some of the difficult security requirements of the GDIS project (GISTEC, 2006).

3.4 Analysis of Geography text books

The introduction of GIS concepts in schools will help in increasing awareness about GIS benefits, it may lead to more spending in the curriculum, and it will give a chance to the students to get a job with High School certificate. It will also facilitate school administration in using GIS for school management.

This section reviewed UAE Geography text books for grades 4 to 10 for the geographical concepts including GIS, GPS and Remote Sensing.

Text Book: Social Studies

Year: 2007/2008

Grade: 4

This book contains 6 chapters, 270 pages; the first chapter is bout UAE location, natural phenomena, coastal and interior plains, desert, climate, citizens of ancient civilizations in UAE region and unity project of UAE. The second chapter is about Islam and spread of Islam in Arab Peninsula and beyond, Islam in UAE and Oman and the impact of Islam on the Arab. The next chapter talks about foreign interference in the UAE and the Arab resistance, Emirates and Economic changes in the field of agriculture, fish, oil, industry, transportation and Etisalat, social and cultural change in UAE, the government and law. The forth chapter is about Population and human activity in UAE, economy in UAE, Islands issue, and water problem. Finally, the sixth chapter is about volunteer work and heritage in UAE (Al Muhairi et al. , 2007 /2008)

Some of the basic map uses are introduced in the text book, for example (Figure 3.6) shows that the map can be used for many fields e.g. TV uses the map in the

weather forecast, location of events, car drivers, pilot and ship's captain use the map to reach their destination and engineers use the map for planning.

The focus is the importance of maps and this is conveyed to students through a simple means (graphics) that is suitable to their age and degree of understanding. Other maps in the text book depicted the important location of the UAE and its impact on its inhabitants.

Figure 3.6 shows the importance of the map and different fields that are using the map like TV, car drivers and urban planner.

Basic principle of cartography such as use of colors, direction, legend, annotation and map design are encapsulated in maps that show local environment (Figure 3.7).

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Figure 3.6: The usage of the map
Source: Al Muhairi et al. , 2007 / 2008
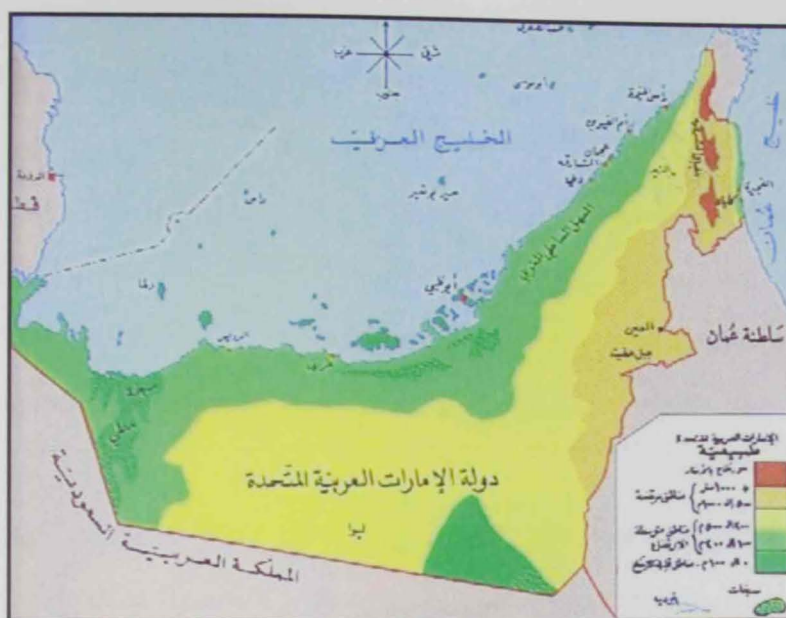
Figure 3.7: Natural Phenomena in UAE
Source: Al Muhairi et al. , 2007 / 2008

Text Book:	Social Studies
Year:	2007/2008
Grade:	5

This book contains 4 chapters, 153 pages. The first chapter is mainly about GCC state, location of GCC, natural appearance, ancient civilization, Islam in GCC and European colonialism. Students can see the location of GCC in the map and the surrounded countries in different colors and they can note the boundaries of GCC. In the second chapter students can see the geographical appearance, like terrain, climate (Figure 3.8), and natural plants are shown in different map with different colors and symbols within this chapter students can note the Archaeological sites in GCC map, like Jabal hafit and Al Hili. Students are exposed to the spread of Islam in

GCC and European colonialism in GCC through maps. Students can study the main reasons of the colonialism such as trade routes.

The main objective of the second chapter is the development comparison ability by examining two ideas or topics, list differences, similarities, and summarizes them. Students can do comparison between UAE and GCC according to their language, currency, customs and traditions, and Independence.

Third chapter is about GCC development and its main objective is reading charts, and their uses in textbooks, newspaper, magazines, TV, and drawings. The first section in this chapter is about population (Figure 3.9). Students can note the distribution of population and the reasons of growth through the map and usage of different colors and symbols. The last chapter is about life in Gulf cooperation council and the main objective is developing forecasting skill by data collection, data analysis, and presenting results. For example students here can present results about impact of high prices on family income (Al Khmairy et al., 2007/2008).

Figure 3.8: Climate in GCC

Source: Al Khmairy et al. , 2007/2008
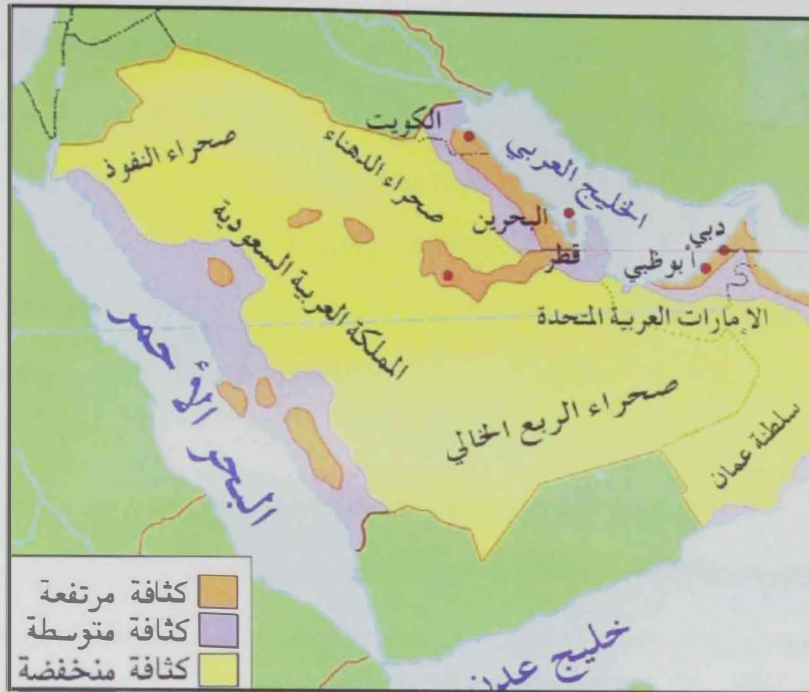
Figure 3.9: Distribution of Population in GCC
Source: Al Khmairy et al. , 2007/2008

Text Book:	Social Studies
Year:	2006/2007
Grade:	6

This book contains 10 chapters, 250 pages; the first chapter is about importance of the Arab world location. Second chapter is about topography, climate, natural plant and water of the Arab world. The third chapter shows population characteristic, growth and distribution in the Arab world (Figure 3.10), while in the forth chapter crops, fish and Mineral Wealth in the Arab world (Figure 3.11). The fifth chapter is about trade, tourist, industry and transportation in the Arab world, Next chapter is about geographic features of territory of the Arabian Peninsula, modern and

contemporary History of Arabian Peninsula and Arabian Gulf region. The Seventh chapter is about geographic features and modern and contemporary history of Iraq and Arab. Eight chapter is about geographic features and modern and contemporary history of territory of the Nile Valley. The next chapter is about geographic features and modern and contemporary history of horn of Africa. Finally the last chapter is about geographic features and modern and contemporary history of great Arab Maghreb (Qanem et al., 2006/2007)

The textbook focuses on the Arab world and provides students a regional overview about their surrounding countries. Some of the geographical concepts embedded in the textbook include use of colour, coloured maps classification, population density (Figure 3.10) and use of symbols (Figure 3.11)
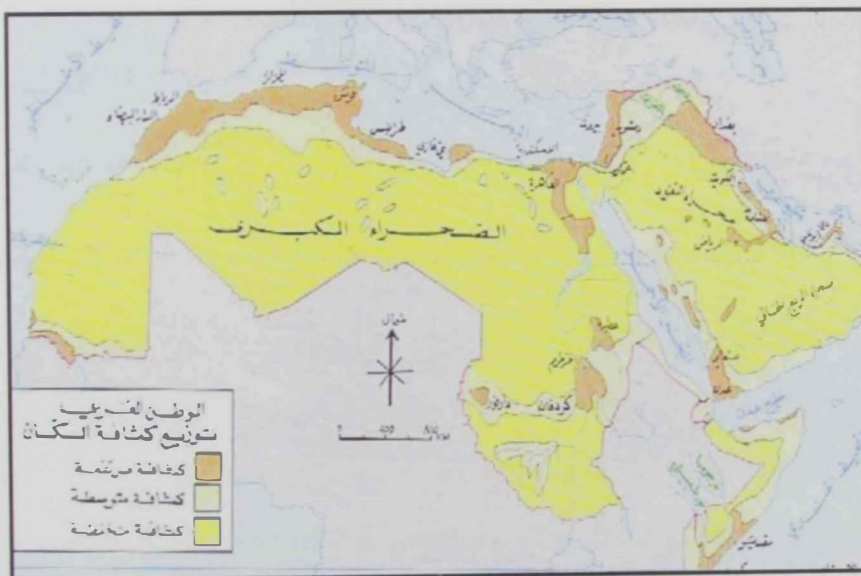
Figure 3.10: Population Density in the Arab World
Source: Qanem et al., 2006/2007
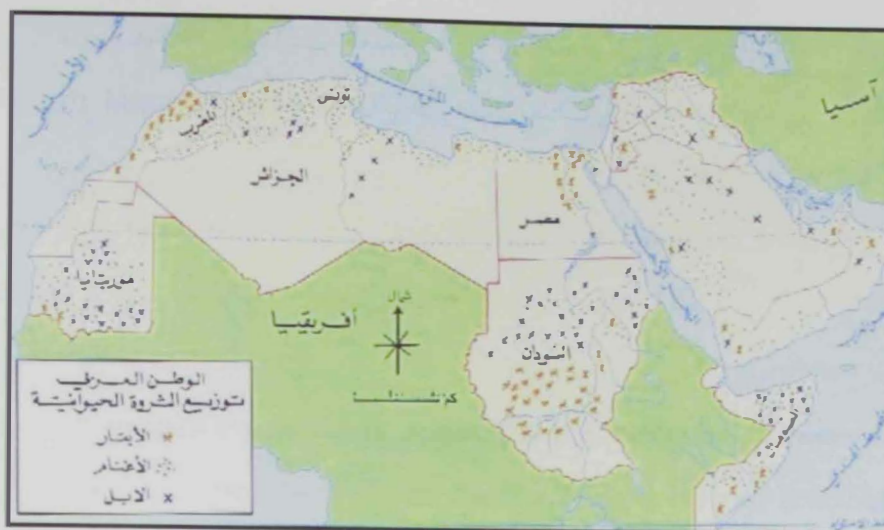
Figure 3.11: Livestock in the Arab World
Source: Qanem et al., 2006/2007

Text Book: Geography

Year: 2007/2008

Grade: 7

This book contains 4 chapters and 150 pages; the first chapter is about universe, Galactic, stars, planets, human and space and the earth. The second chapter is about topography, rocks, and influential factors in the formation of the Earth's surface and the problems and UAE topography. The third is about Hydrosphere, types of water, movement of the water in the ocean and sea and the problems of the hydrosphere. The Last chapter is about Atmosphere, weather and climate; influential factors in the climate, elements of change e.g. temperature and the wind and UAE natural plant, finally the problems of the atmosphere (Qanem et al., 2007/2008)

Figure 3.12 shows the distribution of the land and water on the globe from this map students see the location of the continents and oceans in the map.

Figure 3.13 shows the topography of UAE, students can suggest a title for the map from the colors and their indications on the map.

This textbook conveys to the students geographical concepts such interaction between atmosphere, hydrosphere, lithosphere, and its impact on distribution of human, animals, and plants (Biosphere).

Figure 3.12: land and Water on the surface of the globe
Source: (Qanem et al., 2007/2008)
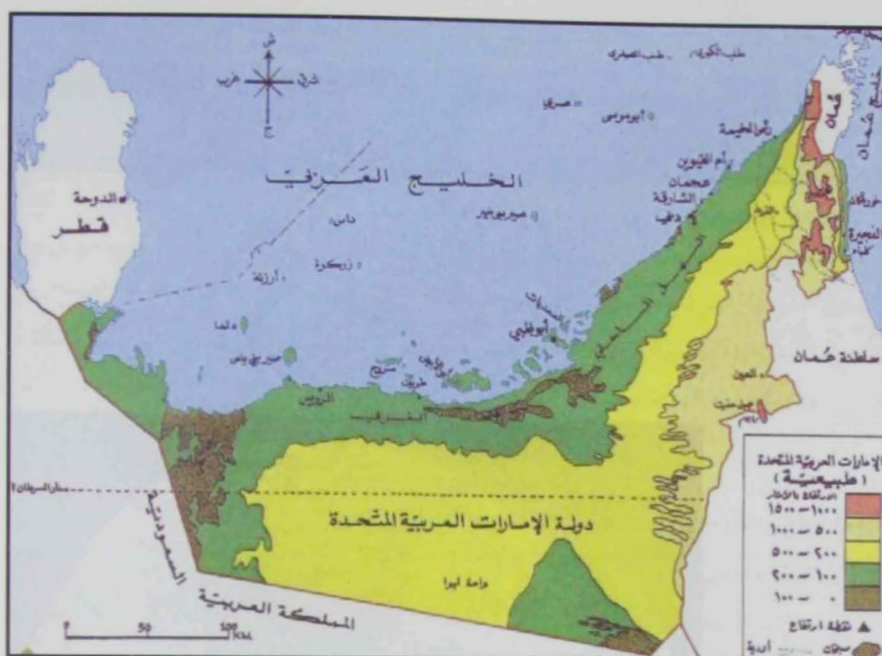
Figure 3.13: Topography of UAE
Source: (Qanem et al., 2007/2008)

Text Book:	Geography
Year:	2007/2008
Grade:	8

This book contains 4 chapter and 160 pages; the first chapter is about map definition and elements, types of maps, scale, and legend of the map. Student can use the scale on the map to measure the distance between the school and the house, longitude and latitude and their uses (Figure 3.14). Second chapter is about Population importance and distribution, factors affecting the distribution of the population, population growth, and causes of the growth and UAE population. The third chapter is about human and the environment, economic activities like agriculture, grazing and fishing, food production in the world, livestock and fish in

the Arab world, industry and agriculture in UAE. The last chapter is about energy definition and sources like oil, coal and natural gas (Qanem et al., 2007/2008).

The text book embeds geographical concepts such as measurements, distance and directions from a map using a ruler, protractor and scale of the map, it also highlights the relationship between population and economic activities (human geography)

Figure 3.14: Concepts of map and scale

Source: Qanem et al., 2007/2008

Text Book: Geography

Year: 2007/2008

Grade: 9

This book contains 7 chapters and 205 pages; the first chapter is about Asia and Africa profile (Area and Population), Islamic world countries, location, topography, climate and natural plant, population and economic resources. The second chapter is about Gulf Cooperation Council of Arab Gulf State location, natural characteristic, topography, climate and natural plant, population and economic resources. Next is about Federal Republic of Nigeria location, topography, climate and natural plant, population and economic resources. Forth chapter is about Australia location, topography, climate and natural plant, population and economic resources. The fifth is about Continental Europe profile (Area and population), West Europe Political units, natural characteristic, population and economic resources (Figure 3.15). Also it talks about France location, topography, climate, population and economic resources. Next chapter is about North American continent location, topography, climate and natural plant, population and economic resources. The seventh and last chapter talks about Latin America location, topography, climate and natural plant, population and economic resources and Argentina location, topography, climate and population and economic resources, (Ali, et al., 2007/2008) (Figure 3.16).

Geographical concepts encompass in the textbook include how variation in geographical location, climate, and topography may affect population distribution and their economical activities. It also reflects how color maps with various classifications and symbols can portray facts in a vivid way (Figure 3.15, 3.16)

Figure 3.15: Industry in West Europe

Source: Ali, et al., 2007/2008

Figure 3.16: Population distribution in Latin America

Source: Ali, et al., 2007/2008

Text Book: Geography

Year: 2006/2007

Grade: 10

This book contains 4 chapters and 188 pages; the first chapter is about how field studies, Aerial photo, GIS concept (Figure 3.17), Remote sensing definition (Figure 3.18), The second chapter is bout Hydrosphere, Water system and its component e.g. Ground water and surface water, water pollution and movement of the water. The third is bout the Atmosphere and its components, elements of weather change e.g. temperature and wind. The last chapter is about biosphere importance, its future and problems, natural plants influential factors and distribution (Ali, et al., 2006/2007)

In each chapter there are maps, charts and Tables reflect the contents of the chapter.

In the text book more elaboration is given on remote sensing and Geographic Information Systems (GIS). The level of students is suitable to introduction of GIS concepts such as the main components (hardware, software, data, people and methodology) and main functions such as input, processing and output (Figure 3.17). Students are also exposed to the principles of remote sensing such as radiation, reflection from objects, recording by satellite, sending signal to ground receiver, conversion of the signal to images and processing of the images and then conversion of the image into maps that can be utilized by various applications such

as environment and climate (Figure 3.19). The new (2007/2008) text book for

grade 10 includes more about remote sensing and GIS.
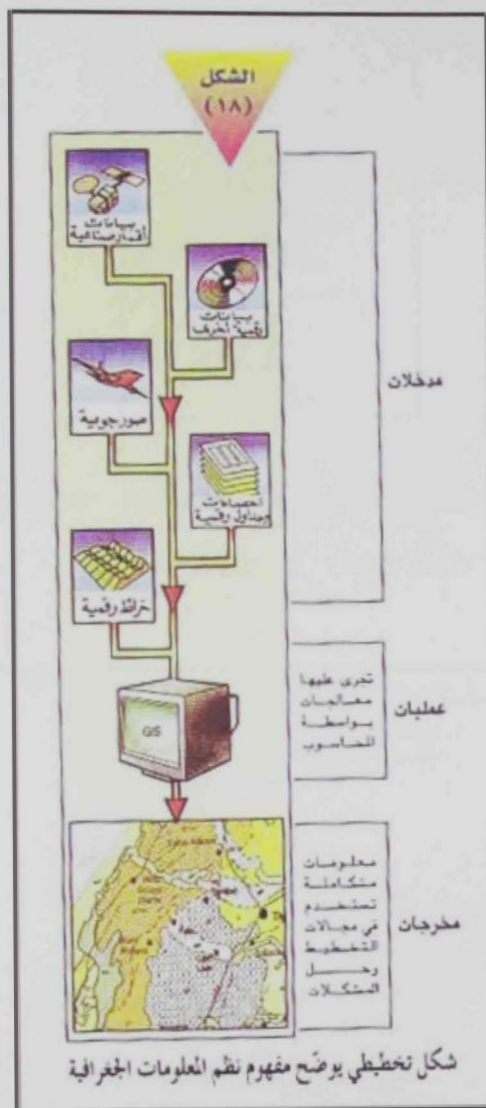
Figure 3.17: GIS Concept

Source: Ali et al. , 2006/2007

Figure 3.18: Remote sensing record the weather

Source: Ali et al., 2006/2007
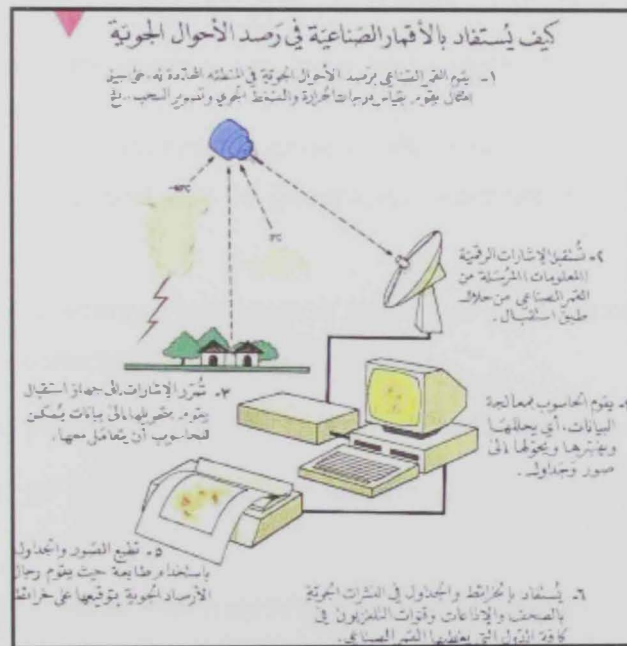
Figure 3.19: Remote sensing advantage

Source: Ali et al., 2006/2007

Generally, Geography text books in UAE for grade 4 to grad 9 include geographical concepts such as map reading, map design, use of coordinate system, use of scale and direction.

Grade 10 text book devotes more room for the discussion of remote sensing and GIS concepts and their applications. All the text books move with students from exploration stage to critical thinking stage in a very logical and smooth way.

3.5   Questionnaire for the teachers

3.5.1 Introduction

The objective of this questionnaire is to understand the knowledge of Geography teachers in computers, maps, and Geographical concepts, GIS and Remote Sensing Skills and their willingness to introduce GIS in schools. This will help in any plan for introduction of GIS in Schools for management and in the curriculum.

The questionnaire had been designed with 31 questions putting in to account direct feedback, e.g. questions are made short, clear and simple (Appendix A)

- Questions 1 and 2 addresses general information about the schools and percentage of male and female geography teachers in Abu Dhabi secondary schools.

- Questions 3 to 6 address information about using computer and Internet and how long time spending using them every day.

- Questions 7 to 10 examine the knowledge of software and hardware.

- Questions 11 to 19 examine the knowledge of map scale, distance and direction.

- Question 20 addresses new mapping technology such as Google earth

- Questions 21 to 24 address the background of Geographic Information systems and Remote Sensing.

- Questions 25 and 26 address the acceptability of geography teachers to the idea of introducing GIS in schools curriculum.

- Questions 27 to 30 address the available of IT infrastructure facilities (hardware) in schools.

- Question 31 check on the school Administration support to GIS.

3.5.2 Analysis and results of the Questionnaire

Sample Size:

The questionnaire was distributed to 23 private and governmental schools out of total 71 Schools. These 23 schools represent about 32% of total 71 schools (with grad 10). Data about schools were obtained from Abu Dhabi Education Zone, the questionnaire tries to find out the willingness of secondary school geography teachers and School administration to the use of GIS in their curriculum and administrative activities. The survey was carried out between March and May 2007, and it was distributed among the 23 schools (Figure 3.20) to 72 geography teachers. 64 teachers (40% male and 60% female) have replied to the questionnaire, and this is equivalent to 90 % of 72 teachers. The number indicates high response to the survey.

75% of the teachers are using computer more than 5 years and only 5% are using it for 1-2 years, this indicates that they are familiar with computers, that represents one of the GIS components (hardware, software, people, data and methods) (Figure 3.21)
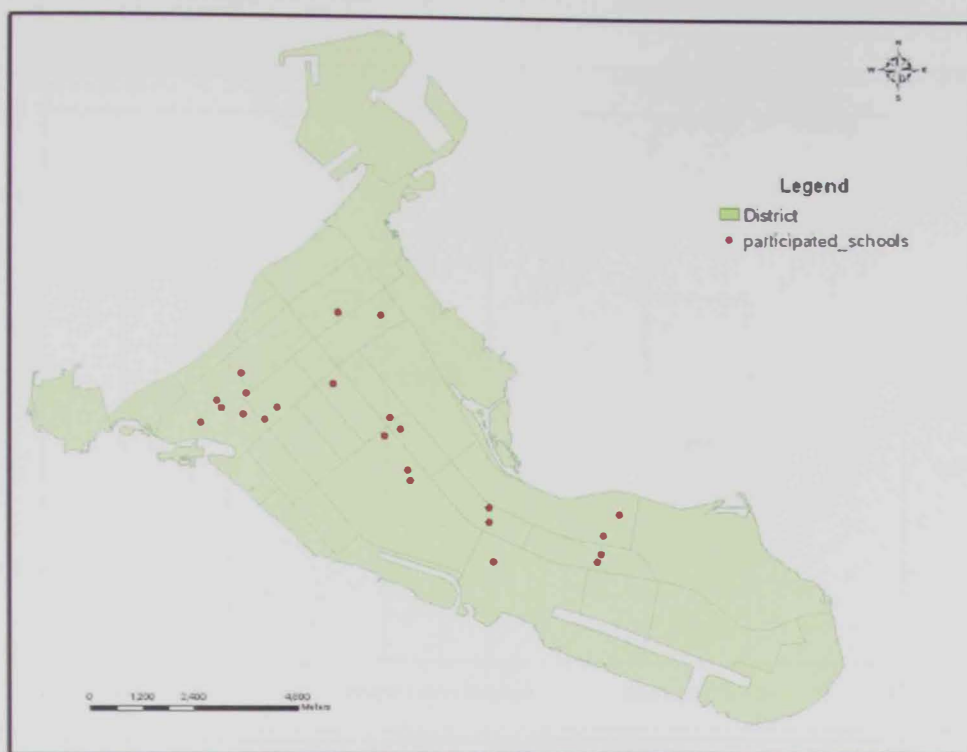
Figure 3.20: Governmental and private schools that participated in the survey
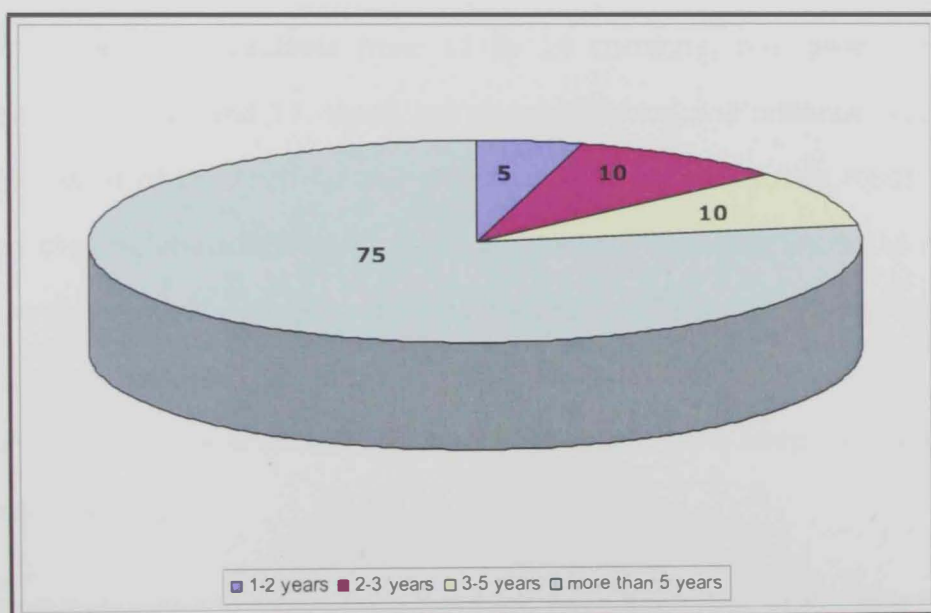
Figure 3.21: Percentage of teachers who are using computer

Generally, 90% of the respondents are familiar with the computer input, output, and processing and storage devices (Figure 3.22).
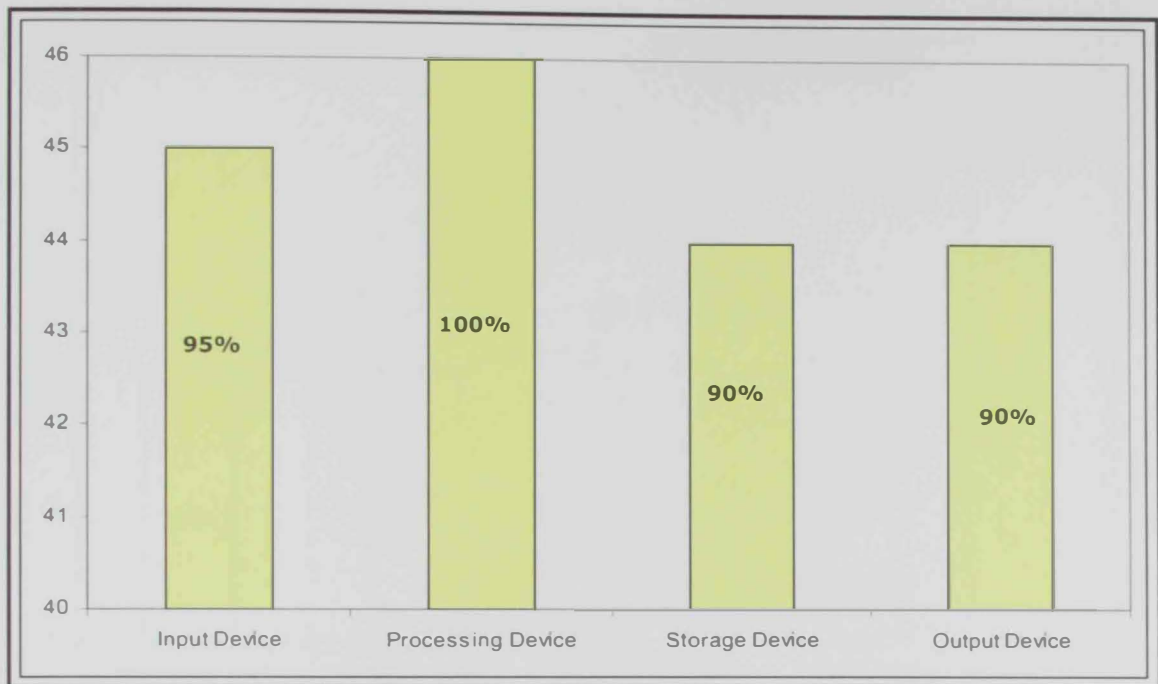
Figure 3.22: Percentage of the teachers who are familiar with computer devices

Questions 11 to 19 study the background of the teachers about reading map. 95% of teachers answer questions from 11 to 14 correctly, the lowest rate was for question number 16 and 17, those are about direction and distance. Teachers have used the name of the road for the direction (example Al Cornish road) and for the distance they estimate it without using a ruler and scale therefore the answer was not accurate. Question number 15 which is about the date of producing the map, 44% confuse between the date of production and date of acquisition. Question number 18 about the satellite data used in the map, 15% keeps it empty and 24% answered it wrongly.

Education Background: 13% of the teachers have Bachelors in Remote Sensing and 10% of have bachelor in GIS whereas as 14% of teachers have studied courses in GIS and Remote Sensing during their bachelor degree education (Figure 3.23).
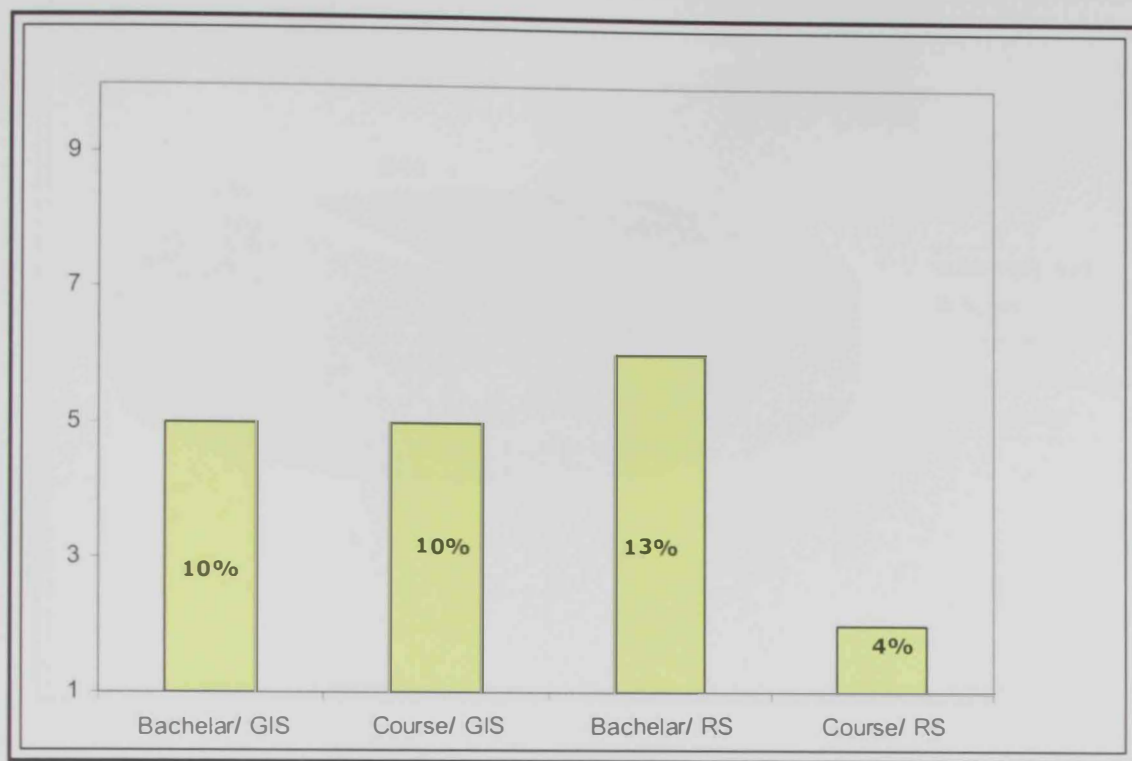
Figure 3.23: Educational Background of the teachers

Google Earth: 90% of teachers are using Google Earth and other 10% are willing to learn the Google earth software.

GIS in Schools: 52% of respondents strongly agree on the statement that *'GIS will enhance spatial thinking and problem solving of the students'* and 36% were just agreed while 4% of them were disagreed with the statement and another 8% were not commented on the statement (Figure 3.24).
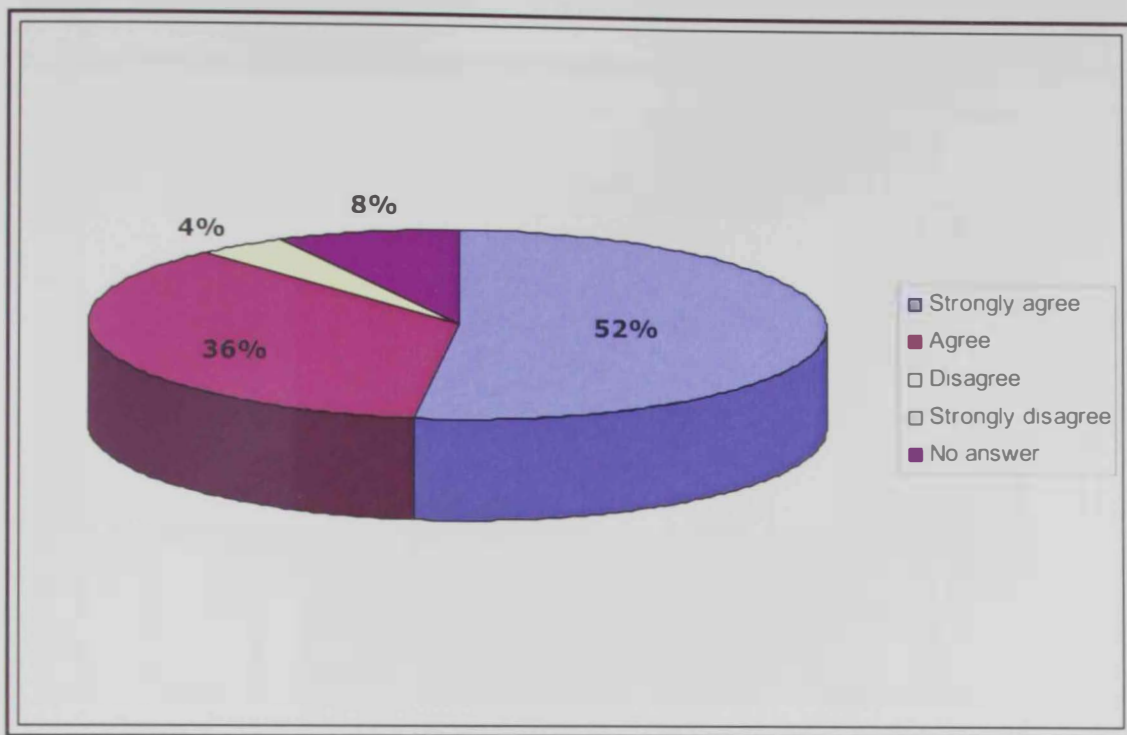
Figure 3.24: Percentage of teachers who support introduction of GIS in schools

Software Knowledge: Out of all the respondents 37%, of the teachers know how to use entire Microsoft office software package and other spreadsheet packages for daily academic and office work and 33% of the teachers know how to use the Microsoft Office only where as 15% of the teachers know only to use power point (Figure 3.25).

All schools have computer labs with capacity between 20 – 30 PCs with different models (PIII, PIV) and one school introducing laptop for its students from grade 7. This indicates there is a good hardware infrastructure for introducing GIS in schools.
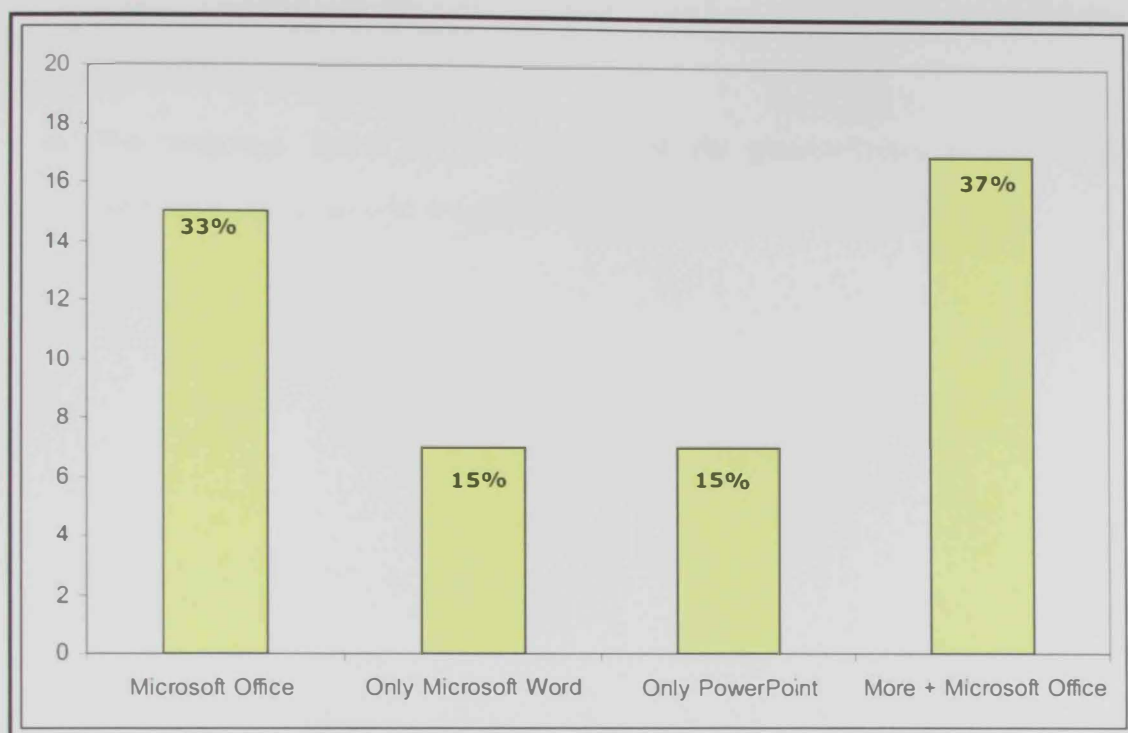
Figure 3.25: Number of teachers who are familiar with introduction of Microsoft Office and other Software

School Administration: All schools administrations of surveyed schools are willing to use GIS in their academic curriculum and are willing to use the GIS tools and software in their daily School Administrative and logistic activities and are fully supporting these new technologies.

Problems faced:

* Delays in receiving responses, only 5% responded in time and 95% have taken about 3 to 10 days for their final responses.
* 75% of the schools request approval from Abu Dhabi Education Zone.

❖ Timing was another problem, conflict between the working hours of the author and the schools working hours (7.30Am to 2.30Pm) and difficulty to take leave from work.

❖ The language, some teachers requested the questionnaire to be in Arabic language. So I have to translate the questionnaire into Arabic.

Chapter 4

GIS Analysis for Schools

Chapter 4

GIS Analysis for Schools

The objective of this chapter is to illustrate the methodology of GIS database development for Abu Dhabi Schools and to present the results of GIS analysis and Tool developments for Abu Dhabi schools. The Following GIS analyses and Tool developments were carried under this study:

- ❖ GIS database development of Abu Dhabi Schools.

- ❖ Correlation analysis between students, populations and schools.

- ❖ Service area analysis for selected schools.

- ❖ Spatial distribution and Hot Spot Analysis of schools.

- ❖ Site selection Analysis for new schools.

- ❖ Network System for shortest and best routes.

- ❖ Interactive GIS based School Finder Tool.

4.1 GIS database development for Abu Dhabi Schools

A comprehensive GIS database was developed for all the 71 schools of the Abu Dhabi Island. This database was prepared using **ArcGIS** in **Geodatabase** format. The final Geodatabase consist of four Feature datasets and each feature dataset contains relevant feature classes (Table 4.1).

Data	Source
Roadedge and Centerline	Abu Dhabi water and Electricity Authority
Attribute of Population	Department of planning and Economy
Districts	Department of planning and Economy
Attribute of the Schools	Abu Dhabi Education Zone
Location of the Schools	Abu Dhabi water and Electricity Authority

Table 4.1: Data and the source

Methodology:
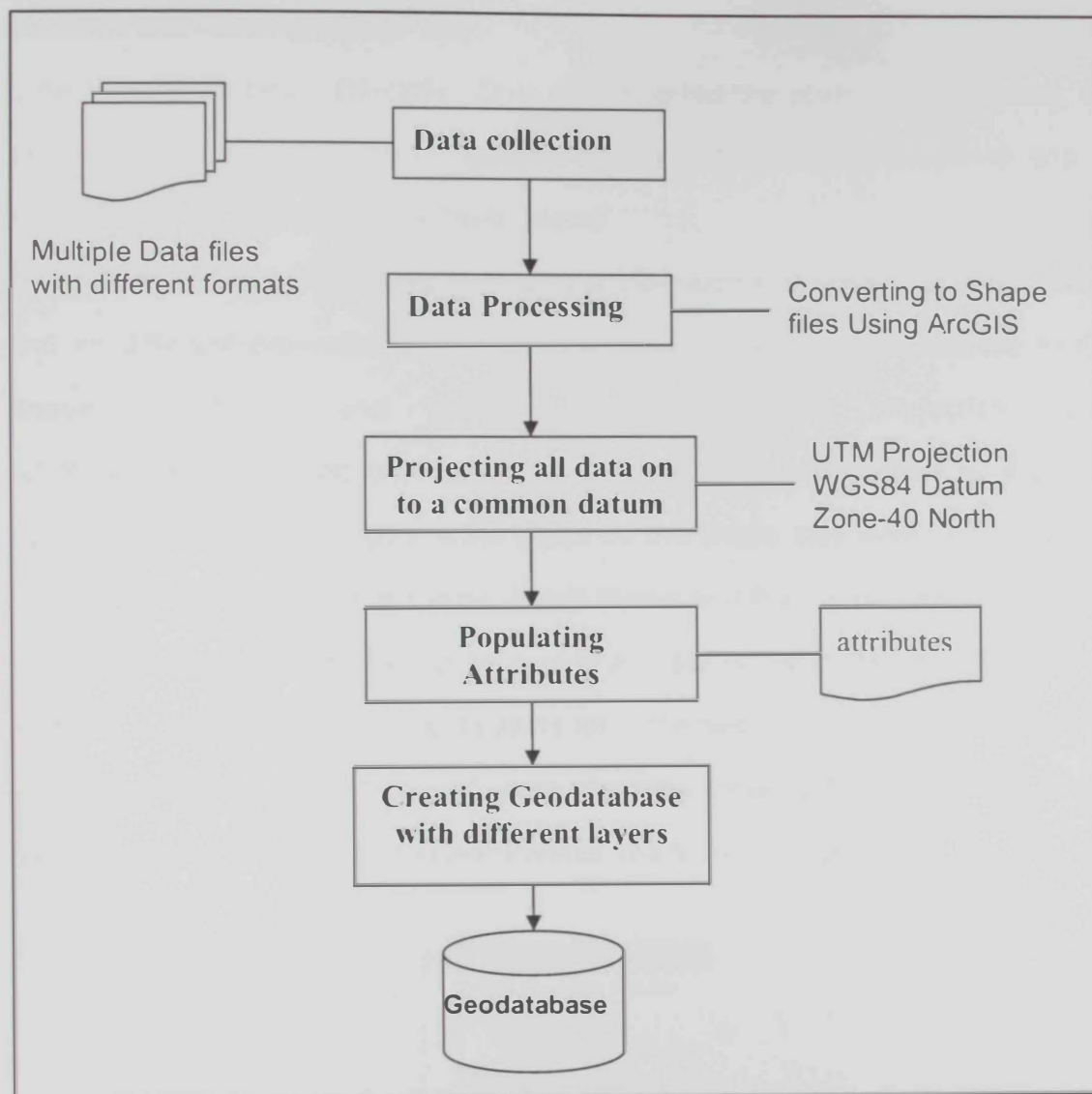
Figure 4.1: Methodology of creating the school Geo database

Spatial Data and attribute information were collected from different organizations in Abu Dhabi. Abu Dhabi satellite image (IKONOS-2006), Abu Dhabi Zones & Divisions, Roads, centerline, location and names of the schools were collected from Abu Dhabi water and electricity authority (ADWEA) as shape files. Information about the schools such as name of the school, grade, gender, number of students, Telephone

and Fax numbers were collected from Abu Dhabi Educational Zone as Excel and PDF files. Population data of Abu Dhabi Island was collected from Department of Economy and Planning as PDF files.

Later visited Abu Dhabi Education Zone and collected the attribute information, such as Name of the school, grade, gender, number of students, Telephone and Fax numbers, for 71 schools in Abu Dhabi Island.

All the data and layers gathered from different departments were in different formats and on different projection systems. All these data sets were converted to ESRI Shape file format and brought onto a common Projection System (UTM_WGS84_ZONE40N) then collected attribute data were added to each layer using ArcGIS software (Figure 4.1). Then all the shape files were classified into 3 different themes viz. Schools theme, Roads theme and Population theme (Figure 4.2) Later a Geodatabase was created In ArcGIS ArcCatalog using the same classification system i.e. it contains 3 feature datasets for 3 themes. Then each theme shape files were exported to Geodatabase feature datasets individually. Figure 4.2 gives a detailed picture of the resulted Geodatabase and feature datasets.
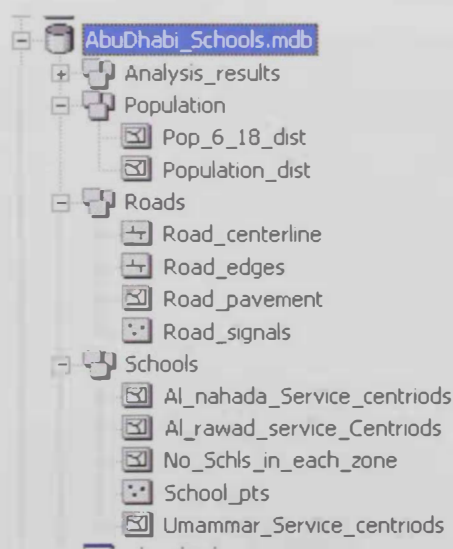
Figure 4.2: The three main feature datasets

School dataset:

This dataset contains detailed database of 71 schools with their locations as feature

class (Figure 4.3) and description information as attribute Table (Table 4.2).
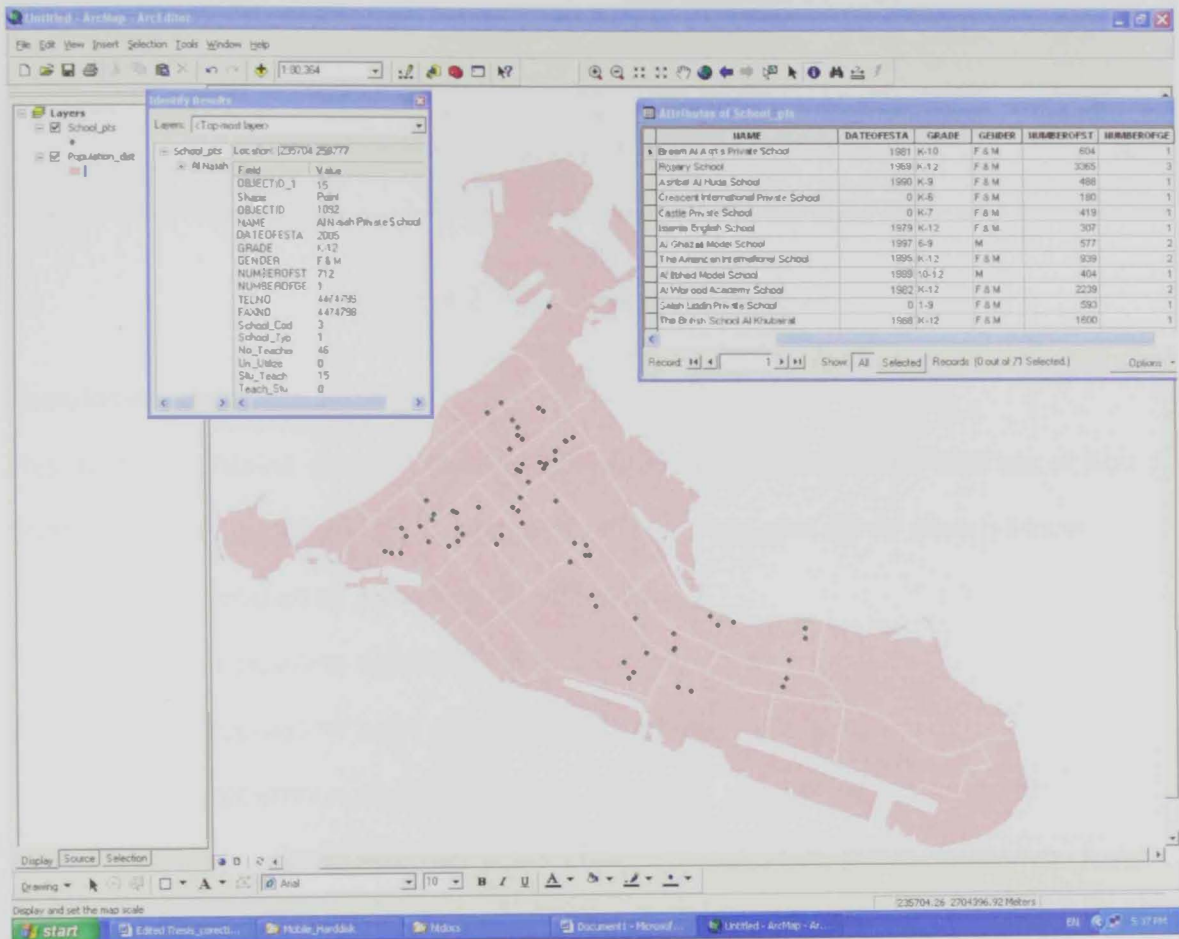
Figure 4.3: School Dataset

NAME	DATEOFESTA	GRADE	GENDER	NUMBEROFST	NUMBEROFGE	TELNO	FAXNO	S
Braam Al Aqsa Private School	1981	K-10	F & M	604	1	6668561	6675121	
Rosary School	1969	K-12	F & M	3365	3	4452500	4459237	
Ashbal Al Huda School	1990	K-9	F & M	488	1	6415912	6420253	
Crescent International Private School	0	K-6	F & M	180	1	6818852	6818853	
Castle Private School	0	K-7	F & M	419	1	6412960	6412961	
Islamia English School	1979	K-12	F & M	307	1	6417773	6418958	
Al Ghazali Model School	1997	6-9	M	577	2	6676800	6676966	
The American International School	1995	K-12	F & M	939	2	4444333	4444005	
Al Ittihad Model School	1999	10-12	M	404	1	6665880	6659533	
Al Worood Academy School	1982	K-12	F & M	2239	2	4447655	4449732	
Salah Uddin Private School	0	1-9	F & M	593	1	4452552	4463554	
The British School Al Khubairat	1968	K-12	F & M	1600	1	4462280	4461915	

Record: |◄ ◄ | 1 | ► ►| Show: All Selected Records (0 out of 71 Selected.) Options ▼

Table 4.2: attribute of the schools

Population dataset:

This dataset contains detailed database of population for all 33 sub districts of Abu Dhabi Island. Population data collected in different age groups as shown below.

1) Population aged from 0 to 5 years

2) Population aged from 6 to 18 years

3) Population aged from 19 to 25 years

4) Population aged from 25 to 40 years

5) Population aged 45 years and

6) Total Population

(Table 4.3) shows the total population data collected for the 33 Sub districts

OBJECTID'	SubDistric	Pop0_5	Pop6_18	Pop19_25	Pop26_40	Pop_41Plus	P_total_N	PopDensity
1	Al Markazi	8514	15013	8730	29782	17571	79685	42978
2	Al Mina	27	55	87	517	279	965	121
3	Madinet Za	6253	10602	6544	21107	12061	56567	27181
4	Al Dhafra	3069	4992	3373	10934	6194	28562	17215
5	Al Wahda	2937	4238	2502	8292	4457	22432	20219
6	Hadbet Al	1381	2464	1386	3355	1787	10423	6467
7	Al Mattar	263	450	252	707	234	1953	246
8	1DX	7916	12974	9266	29567	16407	76130	26225
9	Qasr Al Ba	0	0	28	78	64	170	35
10	2DX	258	217	283	782	419	1959	541
11	3DX	631	1013	664	2161	1109	5581	5776
12	4DX	3497	6535	3691	8586	4434	26844	6443
13	5DX	290	451	492	2172	924	4336	2412
14	Al Markazi	1036	2097	1271	3497	2617	10518	22698
15	Al Manhal	3856	6668	3582	11163	5943	31212	16533
16	Al Butain	569	1199	981	2328	1240	6317	1881
17	Al Hisn	1134	2204	1336	4061	2678	11413	21832
18	Al Dabiyya	442	382	232	784	365	2205	3938
19	Al Karama	1518	2568	1407	4392	2762	12647	10497
20	Al Mushrif	1659	2602	1832	4444	2463	13000	1976
21	Al Sferat	9	16	27	52	42	146	73
22	Al Madina	119	219	167	384	306	1195	310
23	Al Maquta	2	4	73	247	289	615	140
24	Al Khalidi	1167	2545	1363	3403	2985	11463	15955
25	Al Rawdha	291	684	354	959	683	2355	2046
26	Al Ras Al	0	0	0	0	0	1	0
27	Al Kubira	63	274	156	343	385	1221	1034
28	21DX	1127	1775	1403	2977	1349	8631	1233
29	22DX	1030	1919	1401	2703	1323	8376	6261
30	23DX	1028	2105	1016	2485	1657	8291	5852
31	24DX	153	307	131	377	289	1257	1050
32	25DX	225	423	252	545	212	1657	1466
33	27DX	123	242	208	339	305	1217	345

Record: I◄ ◄ [0 ► ►I] Show: All | Selected | Records (0 out of 33 Selected.)   Options ▼

Table 4.3: Attribute of Population

Later population Density per Square Kilometer was calculated for all the 33 Sub Districts using the following formula.

Population Density / KM^2 = $\dfrac{\textbf{Total Population of the Sub District}}{\textbf{Total Area of the Sub District}}$

Total population Map: (Figure 4.4) shows the Total population of each District as Extrusion Map.
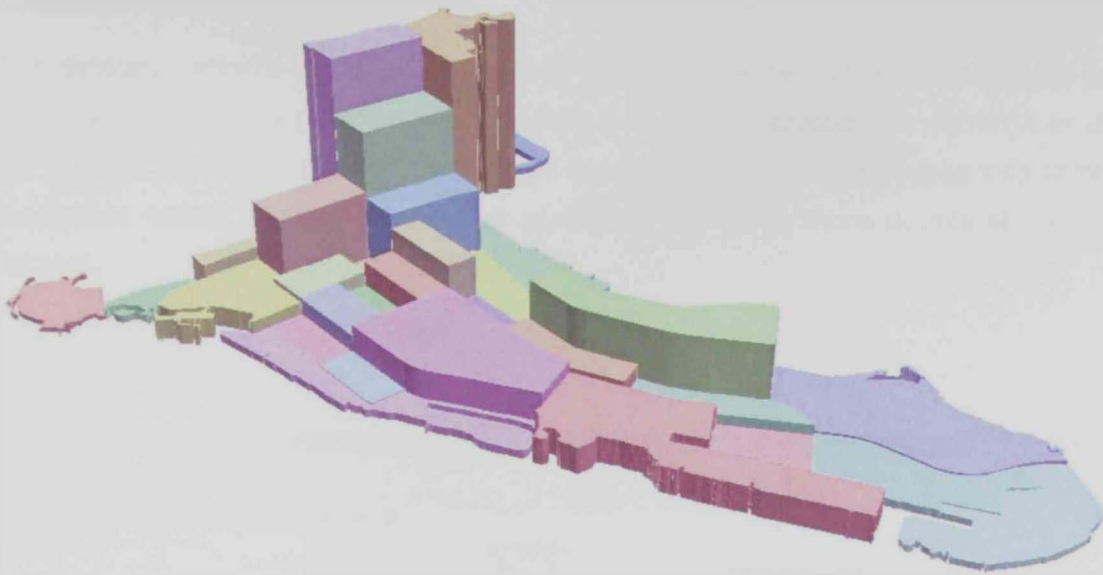
Figure 4.4: Total Population

6-18 age population Map: (Figure 4.5) shows the 6-18 age population of each District as Extrusion Map. In this study this age group of population was considered as the prospective Student population.
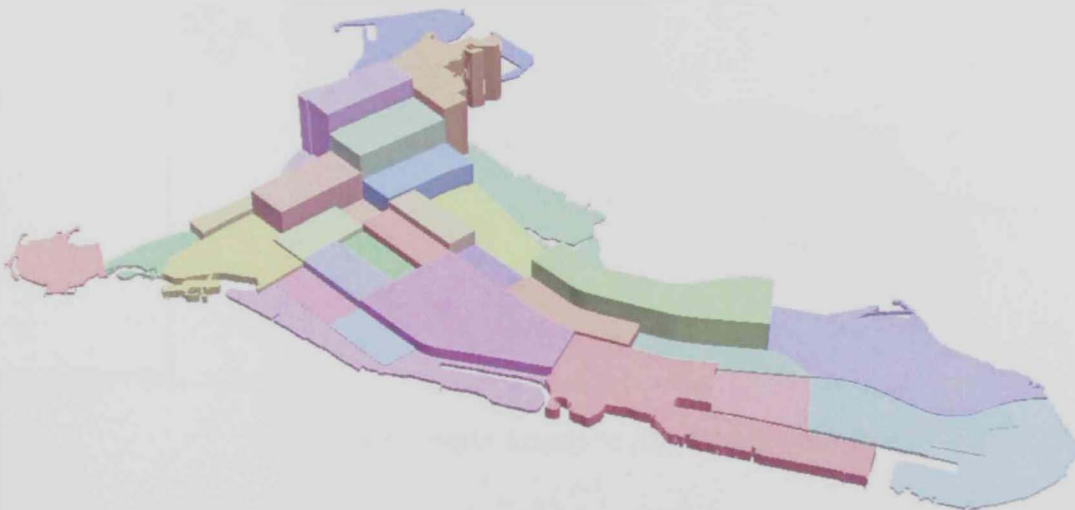
Figure 4.5: Population (6-18) group age

Roads dataset:

This dataset contains detailed database of Road centrelines, Main Roads, Road Edges and Road Pavements (Table 4.4). This data is mostly collected from ADWEA in shape file format. Some editing has been done for classifying the road types into Different categories based on their service types. Figure 4.6 gives more details of the Roads dataset.
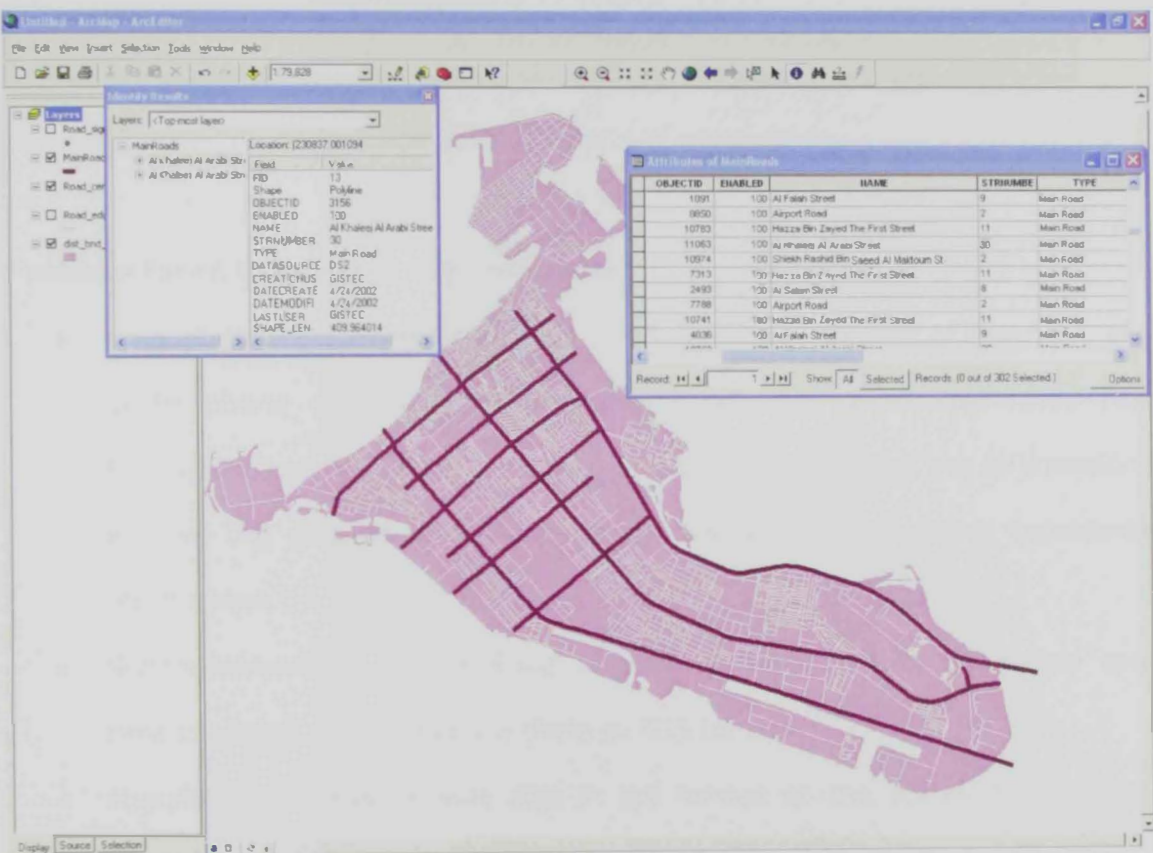
Figure 4.6: Main Roads in Abu Dhabi Island

Table 4.4: Attribute of main roads

Problem faced in building the database:

- Lack of data, for example schools information like number of teachers, some of telephone number and fax number are not recorded in Abu Dhabi Education Zone so author have to call each school and get the information as well as the date of establishment of the school, this takes considerable efforts from the author.

- School information was in Excel sheet as a hard copy so the author spend time in typing and converting them to GIS format.

- Population information was also in pdf format so the author spent time to convert it to GIS format.

4.2 Spatial Distribution

The objective of this analysis is to investigate the distribution of the population and the school.

4.2.1 Population distribution:

The observation of the Population datasets reaveled that most of the Population is concentrated mainly in North-Eastren districts of the Abu Dhabi Island (Figure 4.7), Viz: **AlMarkazi, 1DX, Madinat Zaed, Al Manhal, Al Dhafra** and **4DX.** Actually these areas in common are known as Central Business Districts of(CBD) Abu Dhabi.
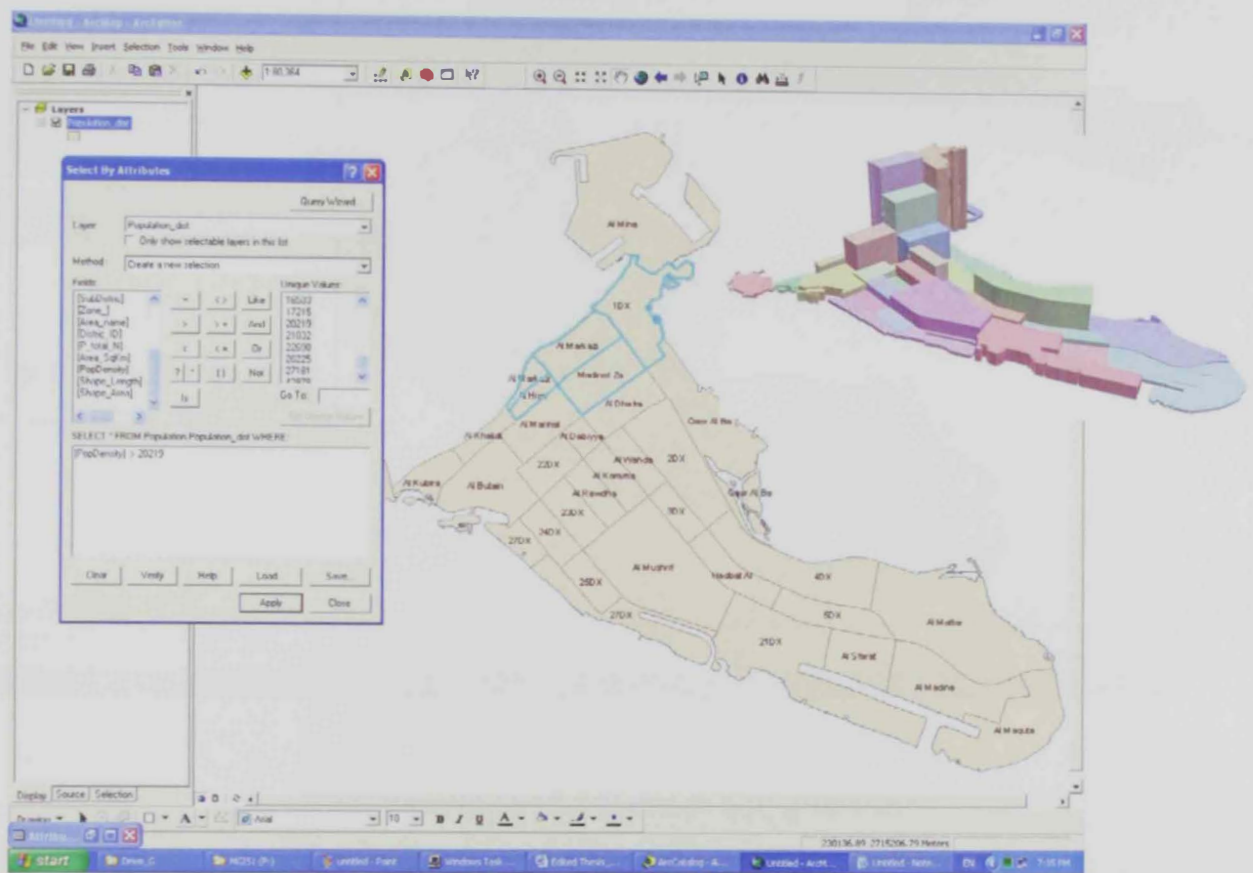
Figure 4.7: Population Distribution

Note: Highly populated areas are shown in blue

Similarly If you Observe the Population in age group 6 to 18 years which is considered as prospective students group is also concentrated mostly in same

districts (Figure 4.8), but other two districts viz: **Al Wahda, Al Khalidi** are also

having High concentration of 6-18 age group population (Figure 4.9).
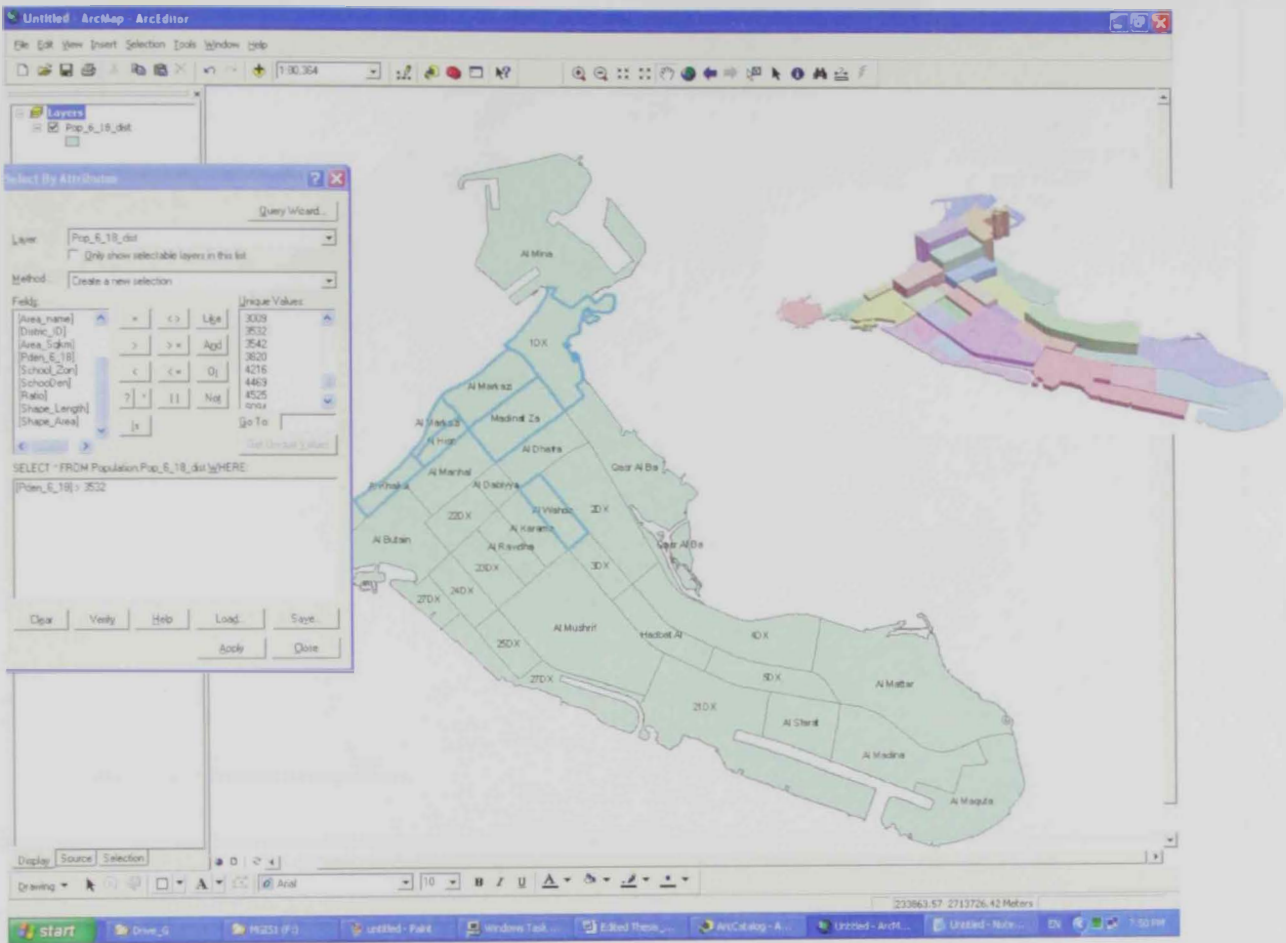
Figure 4.8:   Population (6-18) group age Distribution

Note: Highly populated areas are shown in blue
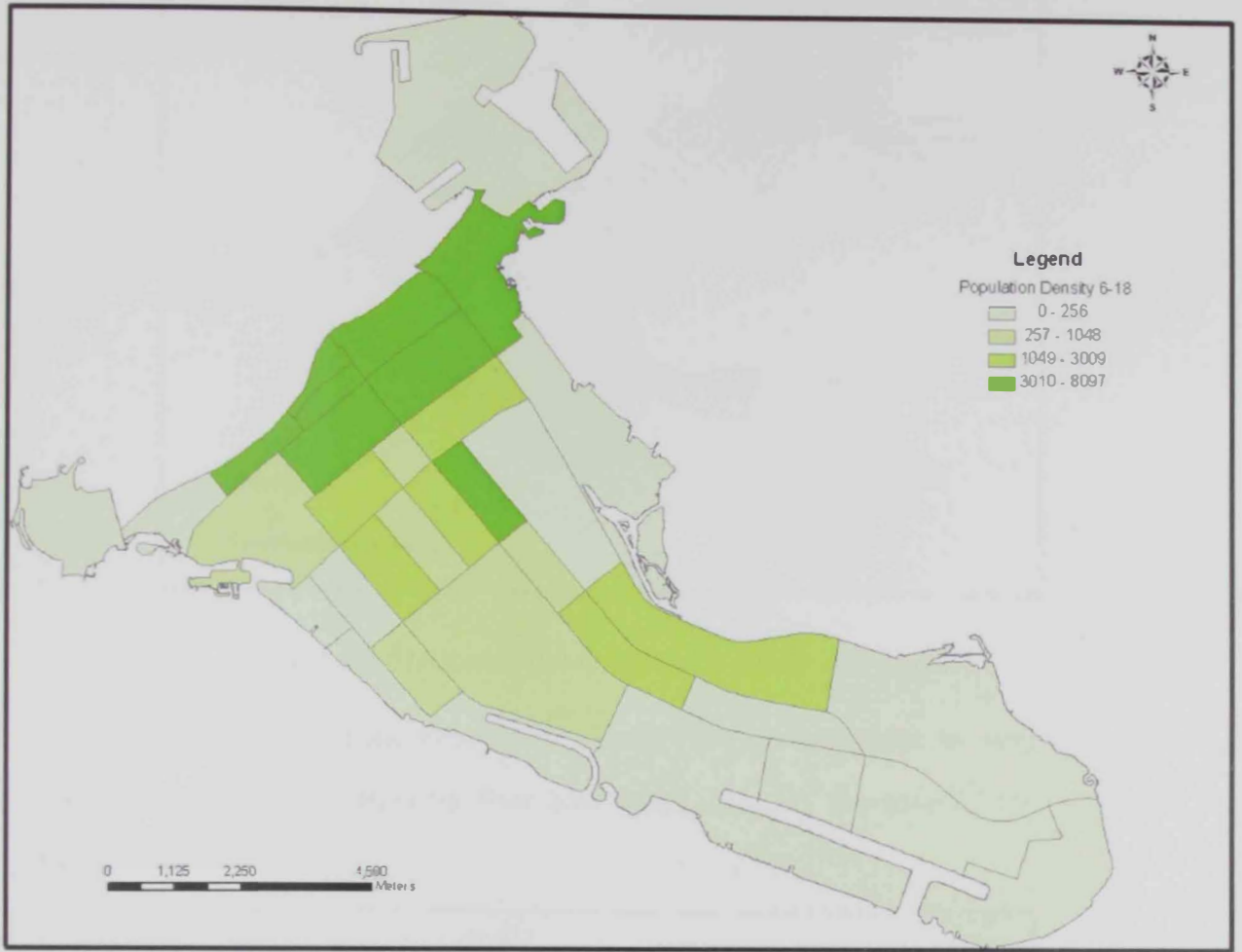
Figure 4.9: Population 6-18 group age density

If you look into the distribution of National and Expatriate population in 6-18 age group, the national Population(6-18 years) are distributed randomly in (north and east) Al Markzia East, Al Dhafra, Madinat Zayed, Al Khalidia, Al Wahda, Al Hisn, Hadbat Al Zafrana, 4DX and 22 DX (Figure 4.10)
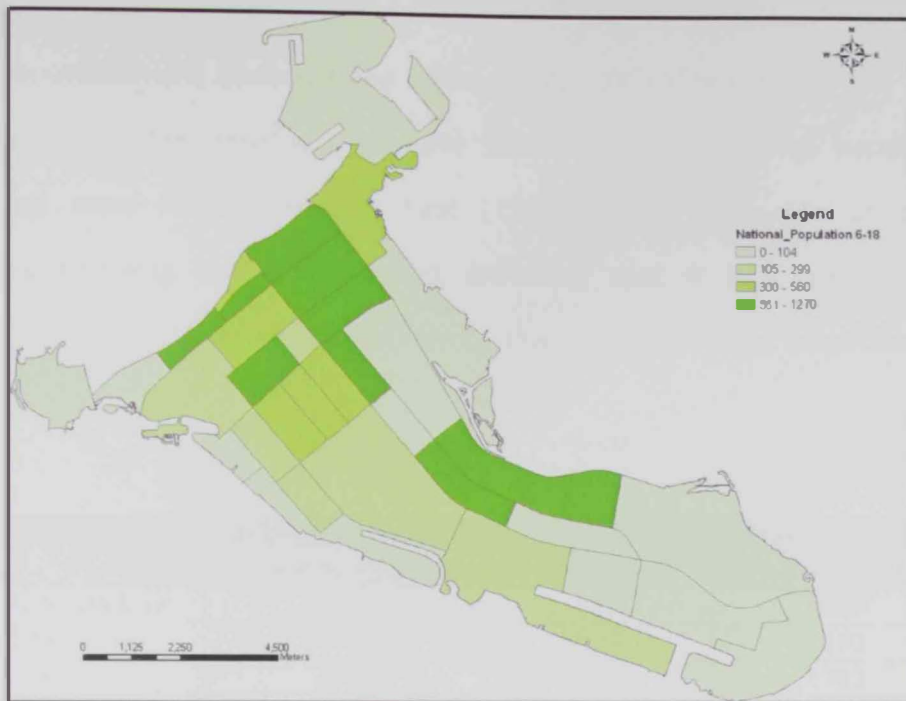
Figure 4.10: National Population 6-18 group age Density

Where as expatriates population (6-18 years) are concentrated in north east of Island consisting of Al Markzia East and West, Madinat Zayed and 1DX districts (Figure 4.11)

Figure 4.11: Expatriates Population 6-18 group age Density

National population are concentrated more in 22 DX (12%) where the residence houses and villas are existing. On the other hand Expatriates population are concentrated more in Al Markazia East (18%) where High rise buildings and residence apartments are concentrated, traveling cost is less (near work) and accessibility to the facilities at the city center like shopping malls, hospitals,….

(Table 4.5)

SubDistrict	Population Density (Total)	Nationals Density	Expatriates Density
Al Markazia East	**8097**	695	**7403**
Madinat Zayed	5094	824	4270
Al Dhafra	3009	706	2303
Al Wahda	3820	681	3139
Hadbat Al Zafarana	1529	706	823
Al Markazia West	4525	429	4096
Al Manhal	3532	468	3064
Al Butain	357	275	82
Al Hisn	4216	641	3575
Al Karama	2131	560	1571
Al Mushrif	396	206	189
Al Khalidia	3542	**859**	2684
Al Rawdha	594	359	235
Total	40842	7409	33434

Table 4.5: Population Density (6-18) group age: Total, Nationals and Expatriates

4.2.2 Schools distribution:

Schools are distributed randomly in different districts of Island and clustered in the first three districts (Table 4.6); however most of the Schools are concentrated in only four districts Viz. **Al Dhafra, Al Butain, Madinat Zayed** and **22DX** with 12, 8, 7 and 7 Schools respectively (Figure 4.12)

Figure 4.12: Distribution of the Schools

Note: The numbers in the map with the red color indicate the number of schools

SubDistric	No_Schls	No_Stu
Al Dhafra	12	5441
Al Butain	8	4850
Madinat Za	7	3157
Al Mushrif	7	9557
22DX	7	4594
4DX	6	3492
Hadbat Al	4	2131
Al Karama	4	2279
3DX	3	4217
Al Markazi	2	655
Al Wahda	2	991
5DX	2	3178
Al Manhal	2	458
Al Rawdha	2	974
21DX	2	1399
1DX	1	235
Al Mina	0	0
Al Mattar	0	0

Record: 14 4 | 0 ▶ ▶I | Show: All Selected

Table 4.6: Number of schools in each district

By analyzing the Number of students in each school and number of schools in each district we can find out the correlations between the numbers of students in each district with its population.

From the data Analysis it shows that the student density is more in only 3 districts.

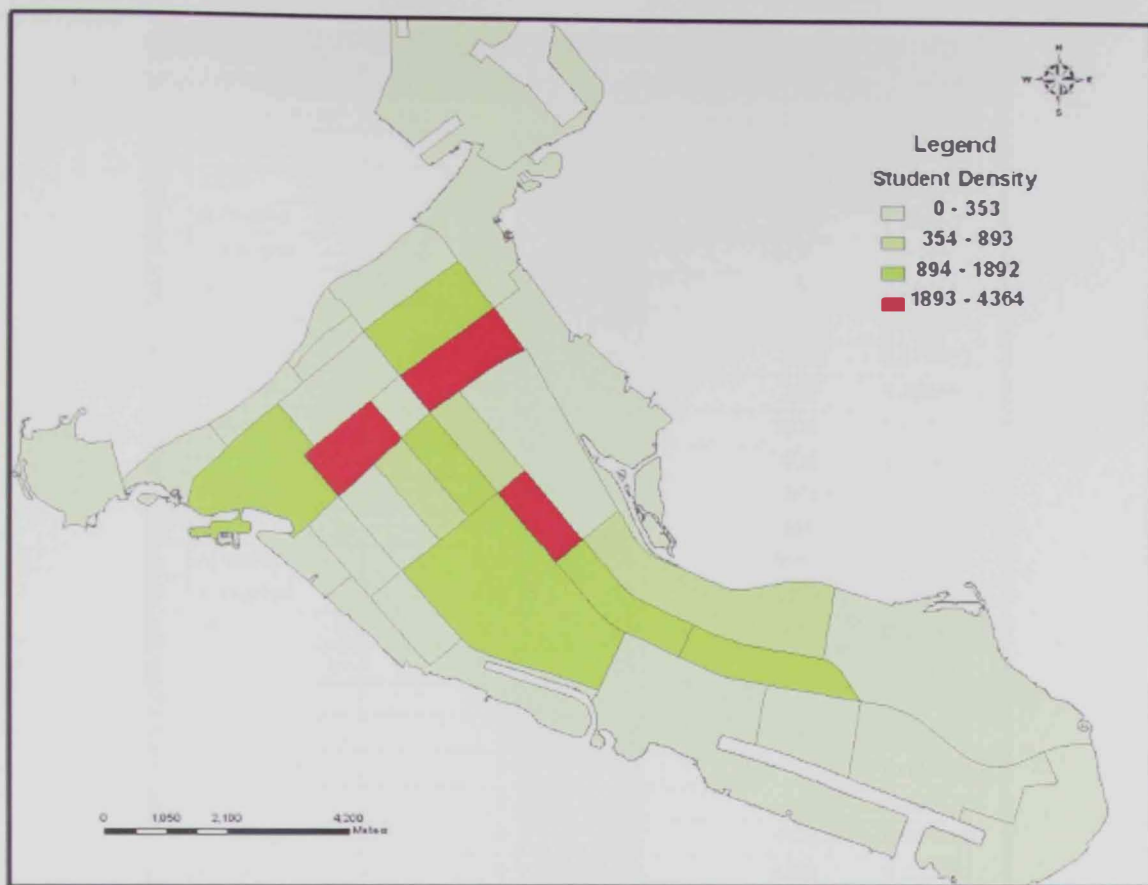Those districts are **Al Dhafra, 22DX and 3DX** (Figure 4.13)

Figure 4.13: Student Density

(Table 4.7) gives a detailed description of the Number of students, Student Density, and population density in each district. According to the Student density values the first 3 places are occupied by **3DX, 22DX** and **Al Dhafra** districts.

Attributes of No_Schls_in_each_zone

SubDistric	No_Stu	Stu_den	Pden_6_18	Area_Sqkm
3DX	4217	4364	1048	0.966321
22DX	4594	3434	1434	1.337760
Al Dhafra	5441	3279	3009	1.659100
Al Karama	2279	1892	2131	1.204804
5DX	3178	1768	251	1.797772
Madinat Za	3157	1517	5094	2.081121
Al Mushrif	9557	1453	396	6.577452
Al Butain	4850	1444	357	3.358483
Hadbat Al	2131	1322	1529	1.611774
Al Wahda	991	893	3820	1.109433
Al Rawdha	974	846	594	1.150993
4DX	3492	838	1569	4.166254
Al Markazi	655	353	8097	1.854079
Al Manhal	458	243	3532	1.887858
21DX	1399	200	254	6.998412
1DX	235	81	4469	2.902955
Al Mina	0	0	7	7.968434
Al Mattar	0	0	57	7.954713
Qasr Al Ba	0	0	0	4.827833
2DX	0	0	60	3.620539
Al Markazi	0	0	4525	0.463385
Al Hisn	0	0	4216	0.522759
Al Dabiyya	0	0	682	0.559953
Al Sfarat	0	0	8	2.000431
Al Madina	0	0	57	3.853935
Al Maquta	0	0	1	4.378164
Al Khalidi	0	0	3542	0.718451
Al Ras Al	0	0	0	2.208815
Al Kubira	0	0	232	1.180415
23DX	0	0	1486	1.416880
24DX	0	0	256	1.197670
25DX	0	0	374	1.130323
27DX	0	0	69	3.524317

Table 4.7: Student Density in each district

After careful observation and analysis of these Tables and maps and considering a spatial relationships between the Population (6-18 years) Density, School density and Student density. The Following correlations were observed and reported.

4.3 Correlation analysis between students, populations and schools

The objective of this analysis is to investigate spatial distribution of the schools with respect to population density and to study the relationship between population density and student density in each district.

4.3.1 Correlation between School Density and Student Density.

A direct positive correlation has been observed between the School Density and Student density. This can be justified as the numbers of schools are increasing in each district the student number is also increasing (Figure 4.14a). This may not be true in all cases. As only one school can have highest number of students where as other schools may have very less number of students. Figure 4.14b shows the positive correlation between the Student density and School Density.
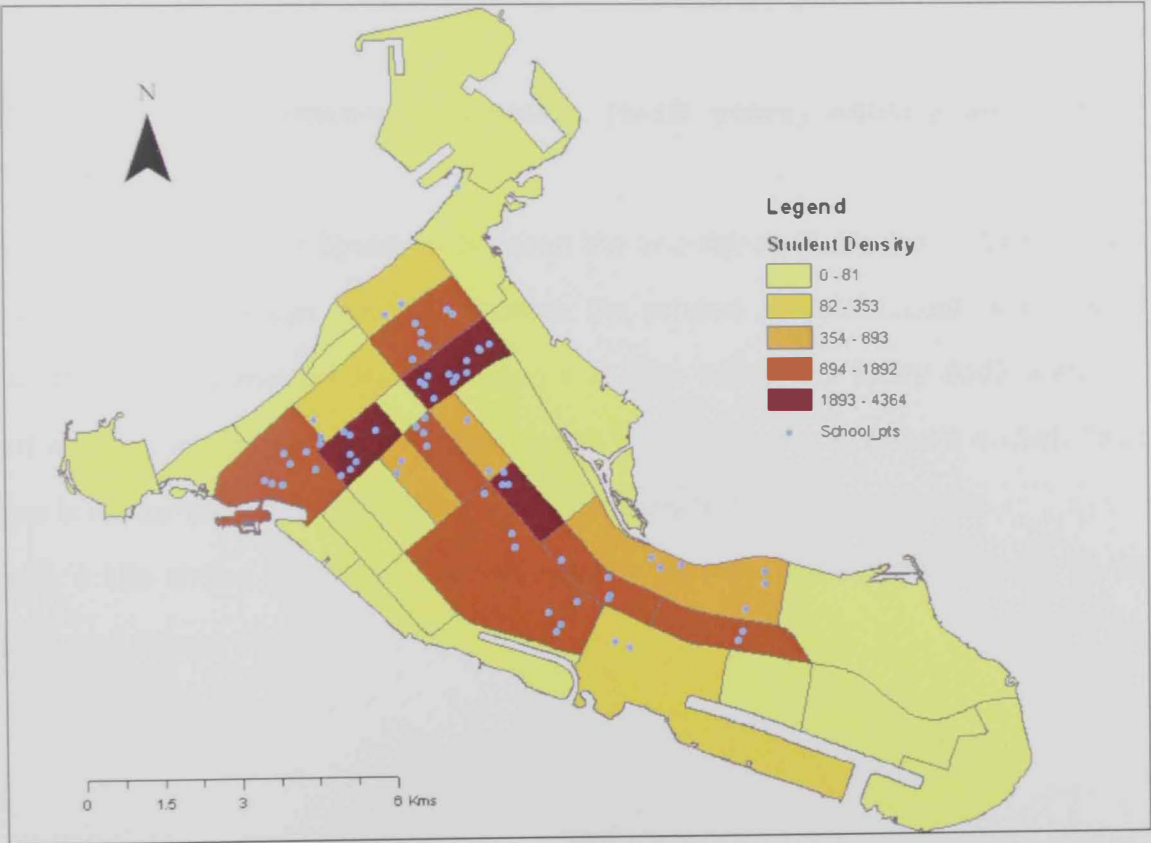
Figure 4.14a: Student density and School Density
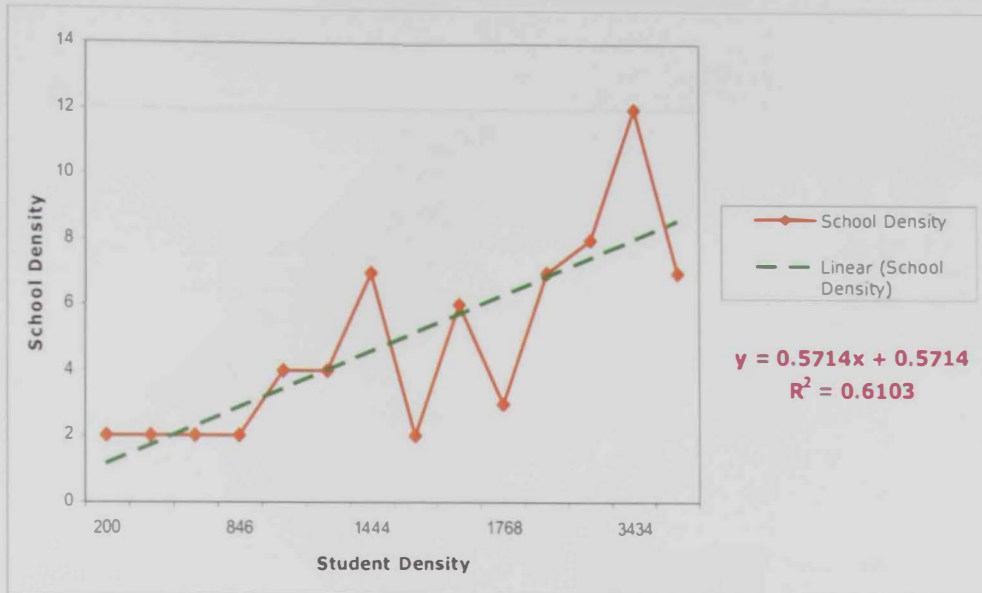
Figure 4.14b: Student density and School Density

4.3.2 Correlation between Population (6-18 years) density and School Density

No correlation has been observed between the population (6-18 years) Density and school density. This can happen, because the schools are distributed randomly in Abu Dhabi Island and generally in open and calm areas and every body prefer to start a school in a place which is free from all type disturbances (Figure 4.15a). Thus there is no correlation between the population density and School Density.

Figure 4.15b shows that there is no correlation between Populations Density (6-18 years) and School Density.

Figure 4.15a: Population density (6-18) group age and school density

Figure 4.15b: Population density (6-18) group age and school density

4.3.3 Correlation between Population (6-18 years) density and Student Density.

A negative correlation has been observed between the population (6-18 years) Density and Student density. This is because there is a positive correlation between Students density and School density and then there is a negative correlation between the Population (6-18 years) density and School density. Therefore certainly there will be negative correlation between Population (6-18 years) density and Student Density and same was observed after the Data analysis (Figure 4.16a). Figure 4.16b shows the negative correlation between Population Density (6-18 years) and Student Density.
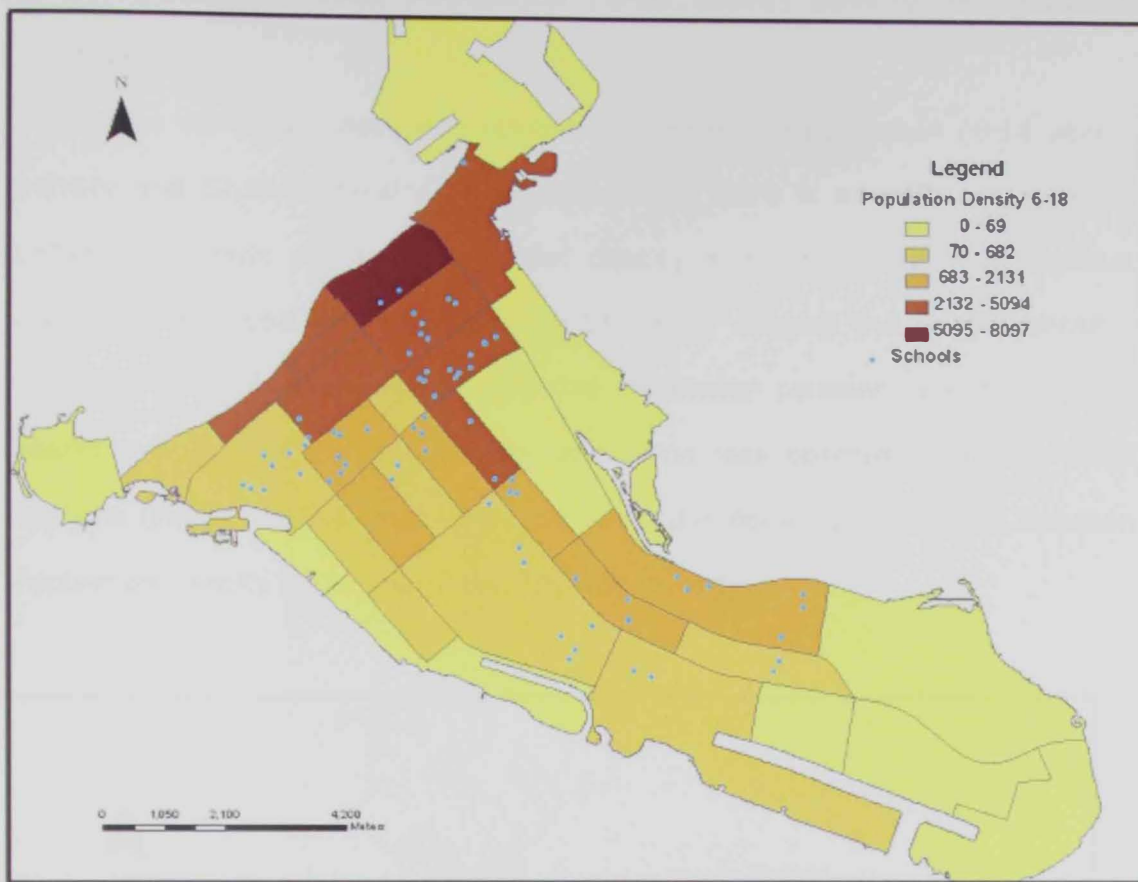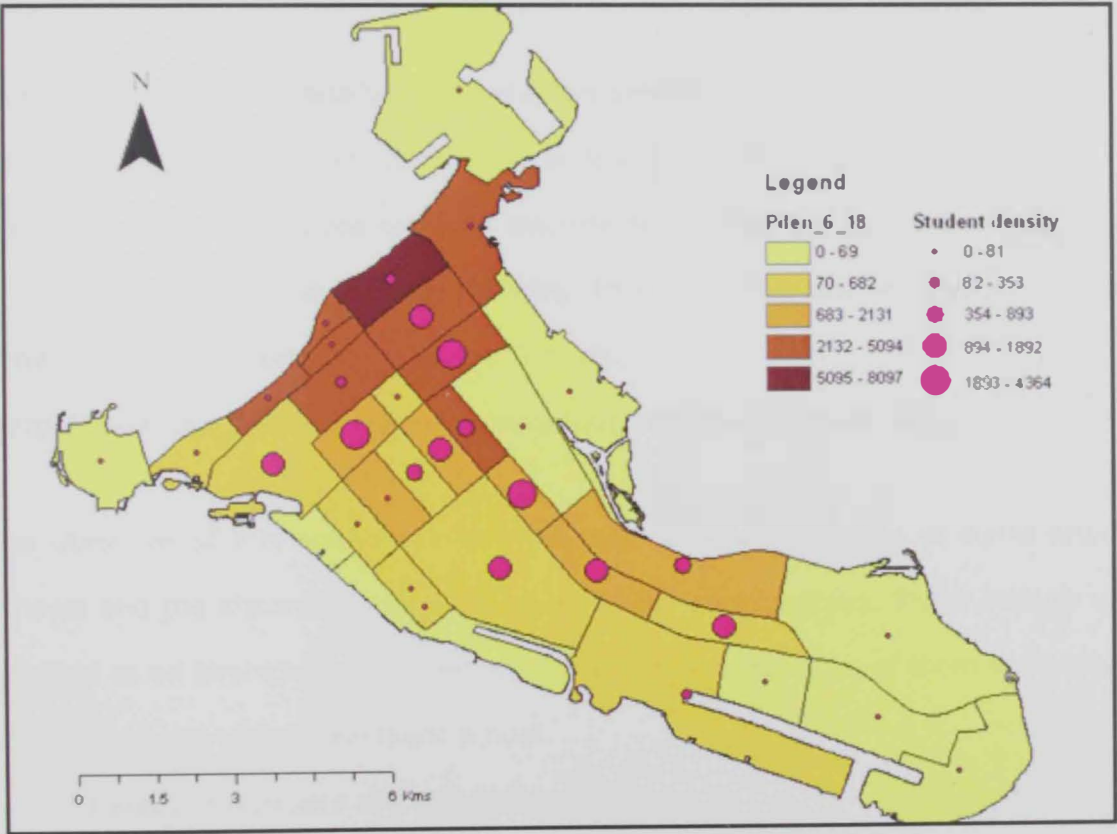

Figure 4.16a: Population density (6-18) group age and Student density
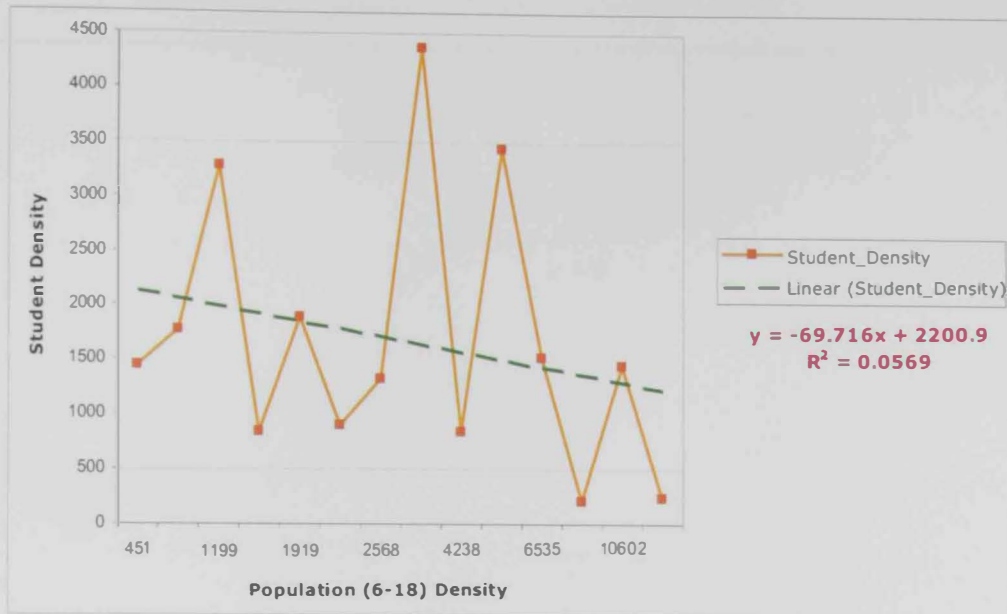
Figure 4.16b: Population density (6-18) group age and Student density

4.4   Service Areas analysis of selected schools

Defining service areas or zones is a widely supported facility within many GIS packages. These areas are typically discrete zones that are closer in distance and time and serving by the selected facilities. These facilities can be Shopping malls or coffeehouses or hospitals or even the Schools.

(http://www.spatialanalysisonline.com/output/html/Serviceareas.html)

The objective of this analysis is to investigate the service areas of some selected schools and the distance from each school to the service areas. Three schools were selected as an example for calculation of the service areas, two of them were private schools and one was government school.

   Selected Schools are (Figure 4.17):
   - Al Nahda International School
   - Um Ammar School for girls
   - Al Rawafed private school
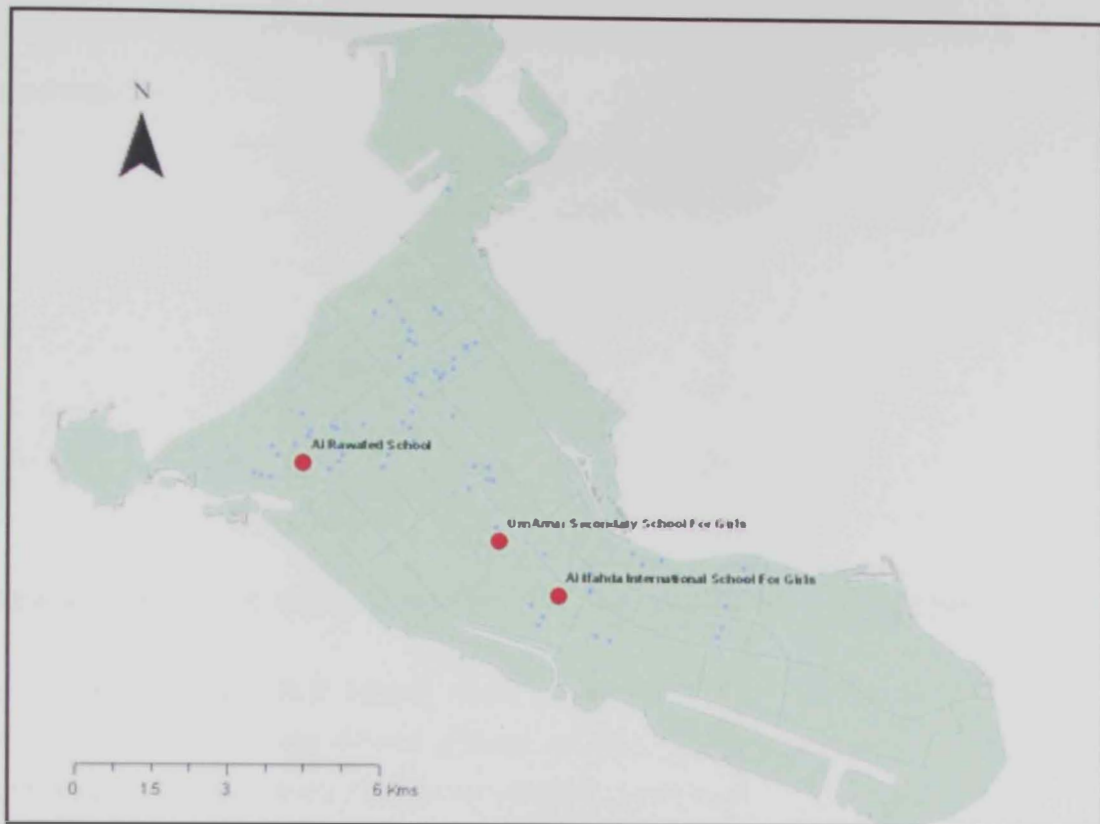
Figure 4.17: The three selected schools for service areas analysis

Al Nahda National School

Al Nahda national private School is a girl's school. There are about 409 Students, who are coming from different districts of the Island. All the addresses of the students were summarized based on district name. Centroids of each district to which this school is serving were created. Then the school point layer is added and the distance from each district centroid was calculated (Figure 4.18).

Al Nahda School serves to different districts with different number of students (Table 4.8); the maximum number of students from one district is 100 i.e. about with 24% of the total students. Commonly it is expected that the more students will come from nearest districts, but data analysis shows this is not always true. It may be because

of the different reasons such as, reputation of the school, School Curriculum (American or British or others), School fees and facilities, and finally the location of the school.

Servicing Districts	Number of students
Madinat Zayed	25
Al Wahda	26
1DX	28
4DX	55
Al Markazia	25
Al Butain	20
Al Hisn	80
Al Mushrif	50
Al Khalidia	100

Table 4.8: Servicing Districts with Number of students of Al Nahda National School

Actually this is only GIRLS School; most of the parents in this country prefer to send their daughter to a Girls school instead of co-education school. This school gets more students from the districts where female population (6-18 years) is high.
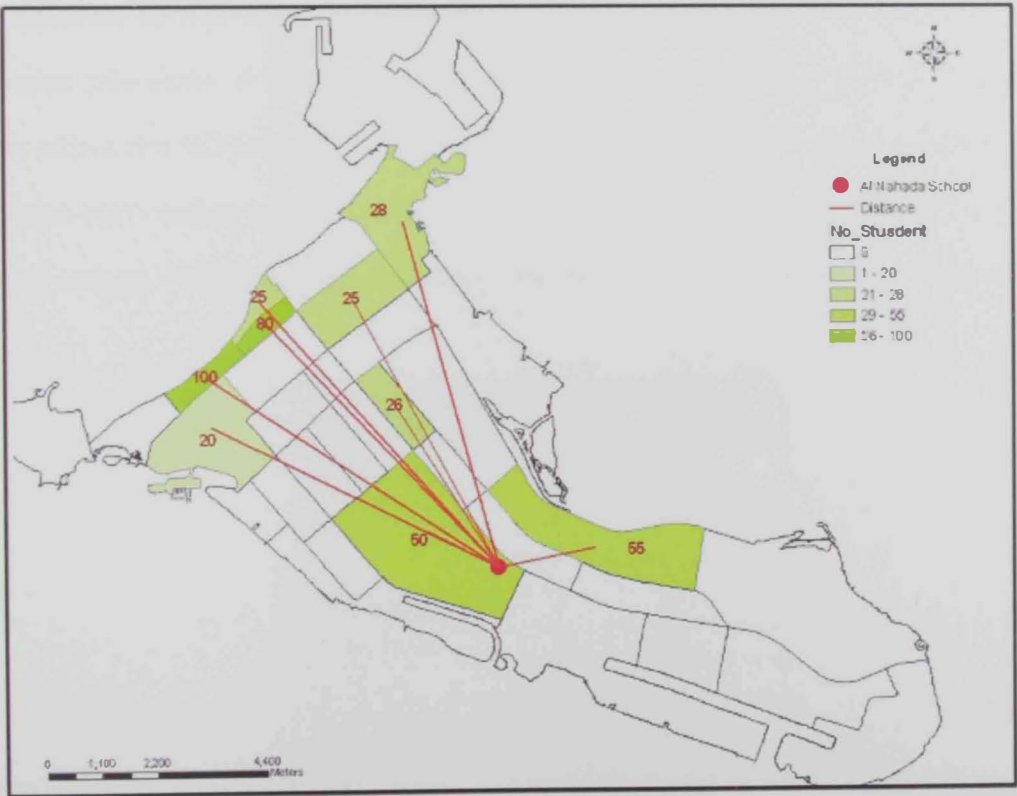

Figure 4.18: Al Nahda National School Service areas

Al Rawafed private school

Al Rawafed Private School is a girls and boys school. There are about 249 Students, who come from different districts of the Island. All the addresses of the students were summarized based on district name. Centroids of each district to which this school is serving were created. Then the school point layer is added and the distance from each district centroid was calculated (Figure 4.19).

Al Rawafed School serves to different districts with different numbers of students (Table 4.9); the maximum number of students from one district is 35 i.e. about 14% of the total students. Commonly it is expected that more of students will come from nearest districts, but data analysis shows this is not always true. It may be because of the different reasons such as, School offers a broad and challenging elementary to College Preparatory Program in the English language to the students of all nationalities. Drawing on the best of American, British and other curriculum models and sensitive to the Arabian environment, the school delivers a comprehensive academic education in partnership with parents. In grade 10 students choose to follow either the British or the American Program. The school organizes after-school activities each semester, Students are given opportunities to sign up for the activities of their choice. The reduction of fees is also an important factor for the parents.

Servicing Districts	Number of students
Al Dhafra	30
Al Wahda	28
1DX	34
4DX	32
Al Markazia	31
Al Butain	33
Al Hisn	26
Al Khalidia	35

Table 4.9: Servicing Districts with Number of students of Al Rawafed private School
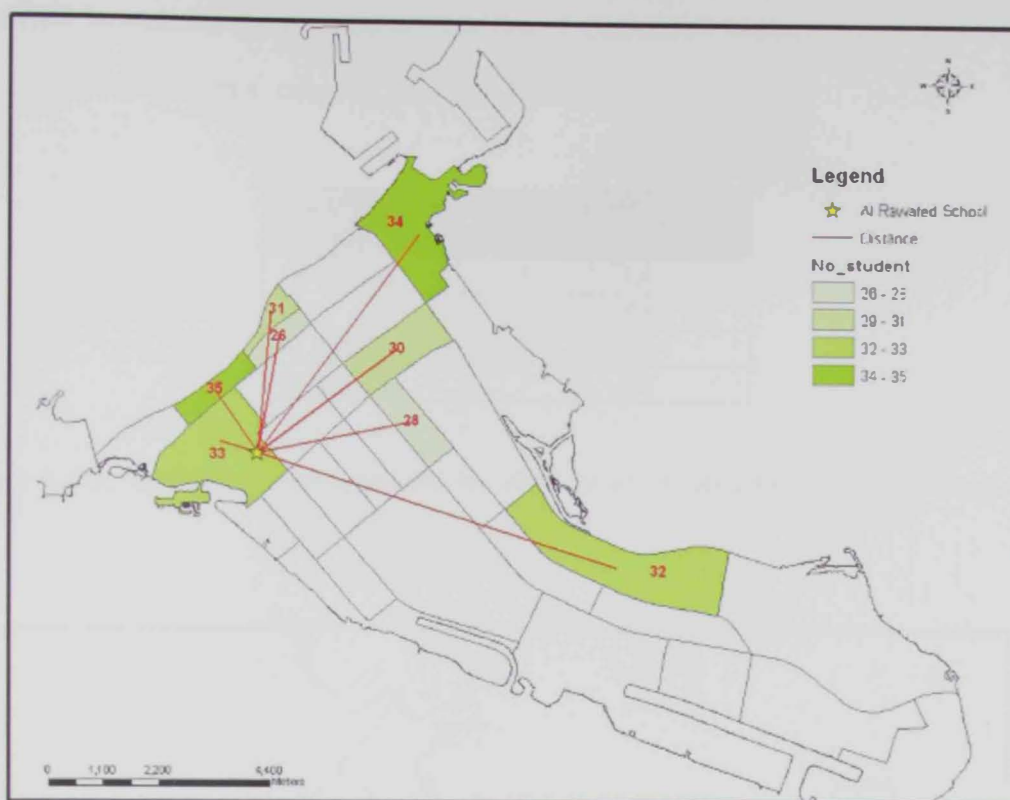
Figure 4.19: Al Rawafed private School Service Areas

Um Ammar Secondary School

Um Ammar School is a governmental girl's school. There are about 299 Students, who come from different districts of the Island. All the addresses of the students were summarized based on district name. Centroids of each district to which this school is serving were created. Then the school point layer is added and the distance from each district centroid was calculated (Figure 4.20).

Um Ammar School serves different districts with different numbers of students (Table 4.10); the maximum number of students from one district is 62 i.e. about 20% of the total students. There are many factors let parents chose Um Ammar School, it is one of the schools that is associated with UNESCO and it is associated

with Sheik Mohamad Bin Rashed Al Maktom IT Education Project. In addition to that it teaches governmental courses and it is free.

Servicing Districts	Number of students
Al Wahda	58
3DX	54
Al Butain	62
Al Karama	55

Table 4.10: Servicing Districts with Number of students of Um Ammar Secondary School

Figure 4.20: Um Ammar Secondary School Service Areas

4.5 Hot Spot analysis

The objective of this analysis is to investigate the clustering of students in schools and in districts. This hot spot analysis will give an idea whether the schools with high number of students or schools with low number of students tend to cluster or not. Similarly this analysis gives an idea about which districts are hot spot areas based on the number of students in each district.

4.5.1 Hot spot analysis of number of students in each School

This analysis works by looking at each school within the context of neighbouring schools. If a school is having high number of students, and the number of students in neighbouring Schools is also high, then it is a part of a hot spot. The local sum for a school and its neighbouring schools is compared proportionally to the sum of all schools; when the local sum is much different than the expected local sum, and that difference is too large to be the result of random chance, a statistically significant Z score is calculated, that is called as GI* Statistic score (Figure 4.21).
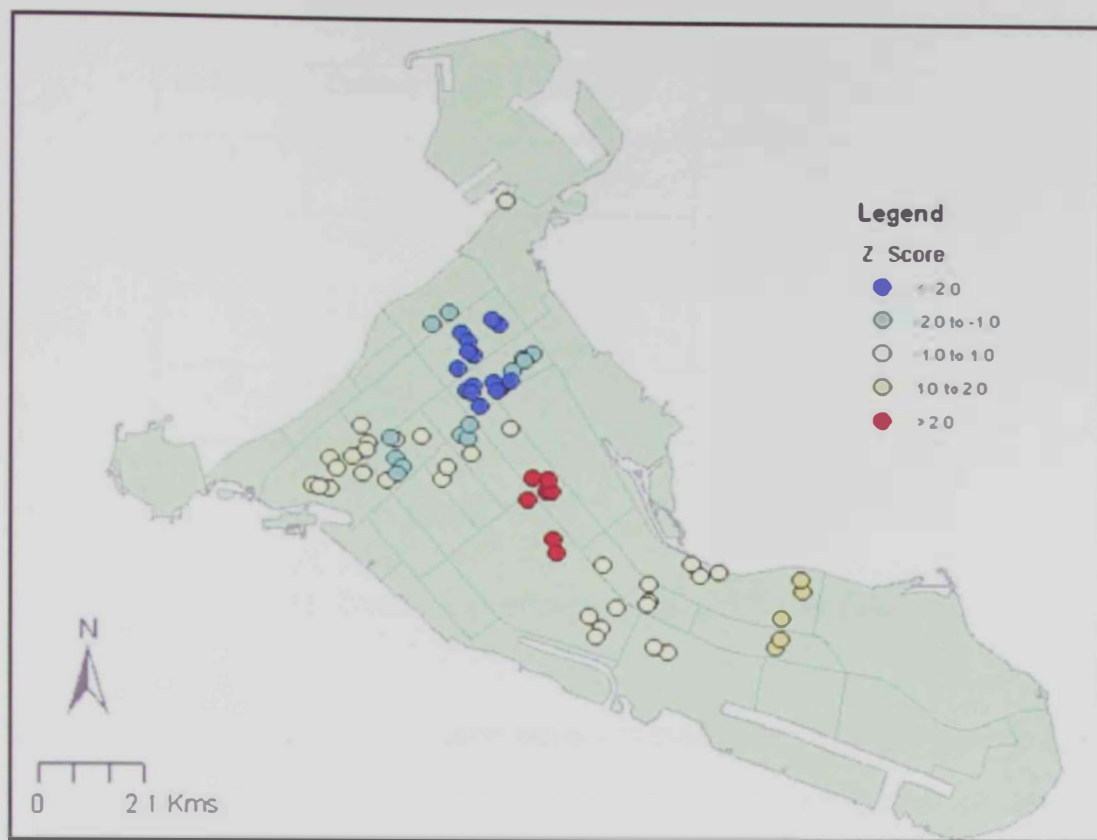
Figure 4.21: Hot Spot Analysis of number of students in each school

Z score Interpretation

The Z score is called as The Gi* statistic. The schools with statistically significant positive Z Scores (Red colour) are considered as more intense clustering of schools with high number of students. And the schools with statistically significant negative Z scores, (Blue colour) are considered as more intense clustering of schools with low number of students. Other groups will range in between these red and blue zones.

Table 4.11 shows the details of **Z score** classification and number schools with these values.

S. No	Colour code (Z score)	No of schools
1	Blue (< -2)	15
2	Cyan (-2 to -1)	13
3	Yellow (-1 to 1)	31
4	Orange(1 to 2)	5
5	Red (> 2)	7

Table 4.11: Z score classification and number of schools

After the Hot spot analysis it has been observed that the following 7 schools (Table 4.12) are with High positive Z score that means these are Hot spot areas with high number of students with high local sum.

Selected Attributes of GI Stats of Num of Student

NAME	NUMBEROFST	GiZ1500
Rosary School	3365	3.082820
The British School Al Khubairat	1600	3.023080
The International School Of Choueifat	3110	2.878810
Um Amar Secondary School For Girls	588	3.108420
Al Mustqbal School	572	2.959340
Dass School	343	3.439280
Al Sades Mn Agustus School	509	3.082820

Table 4.12: Hot Spot Schools

4.5.2 Hot spot analysis of number of Students in each district

Similarly the results of the hot spot analysis of number of students in each district has revealed that the two districts **Al Mushrif** and **3DX** (Figure 4.22) have High

positive Z scores that means these are Hot spot areas with high number of students with high local sum (Table 4.13).

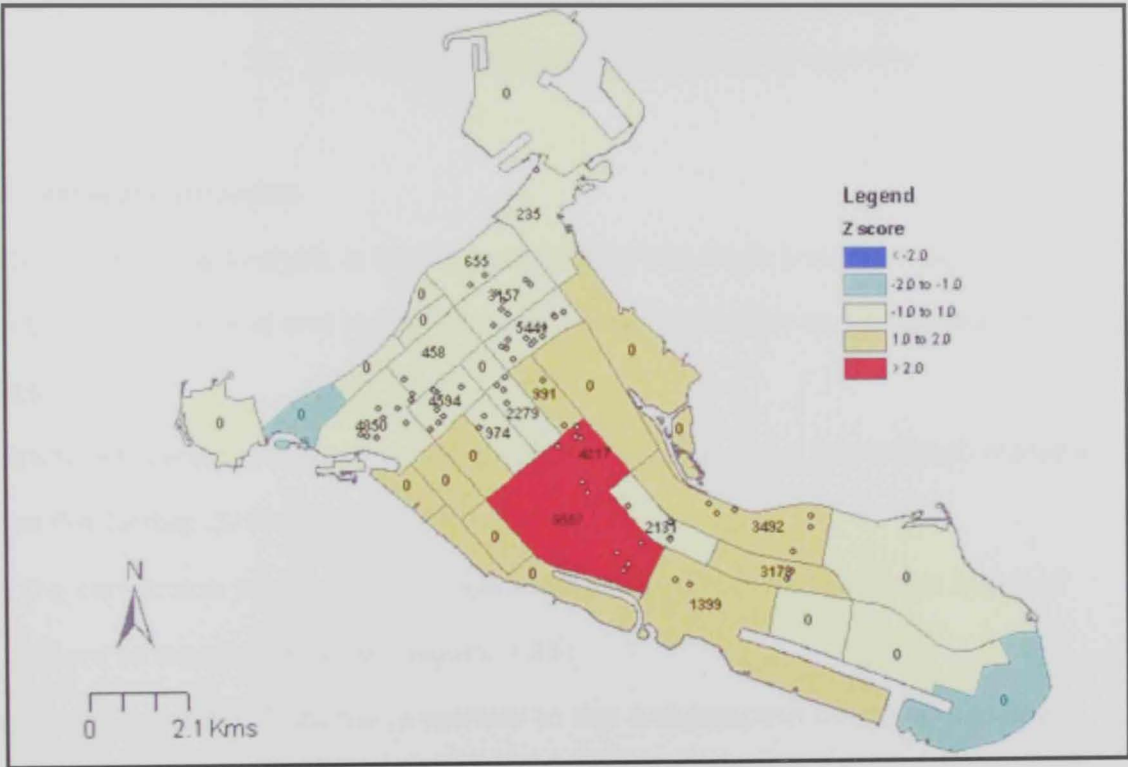| SubDistric	No_Stu	GiZ5000	Z
3DX	4217	2.341790	
Al Mushrif	9557	2.334230	

Table 4.13: Hot Spot Districts

Figure 4.22: Hot Spot analysis of number of students in each district

Table 4.14 shows the details of **Z score** classification and number districts with these values.

S. No	Colour code (Z score)	No of Districts
1	Blue (< -2)	0
2	Cyan (-2 to -1)	2
3	Yellow (-1 to 1)	19
4	Orange(1 to 2)	10
5	Red (> 2)	2

Table 4.14: Z score classification and number of districts

4.6 Network Analysis

The objective of this analysis is to find out the shortest route from a school to a house this will save time and money, for school administration as well as student's families.

The inputs are vector data such as the plots, Road center lines, and schools stored as a shape file format .SHP (Figure 4.23)

Using the conversion tools in Arc toolbox application to convert the shape files and export them to the Geodatabase (Figure 4.25)

Building the Street Net from the properties to the Geodatabase Using Arc Catalog (Figure 4.26)
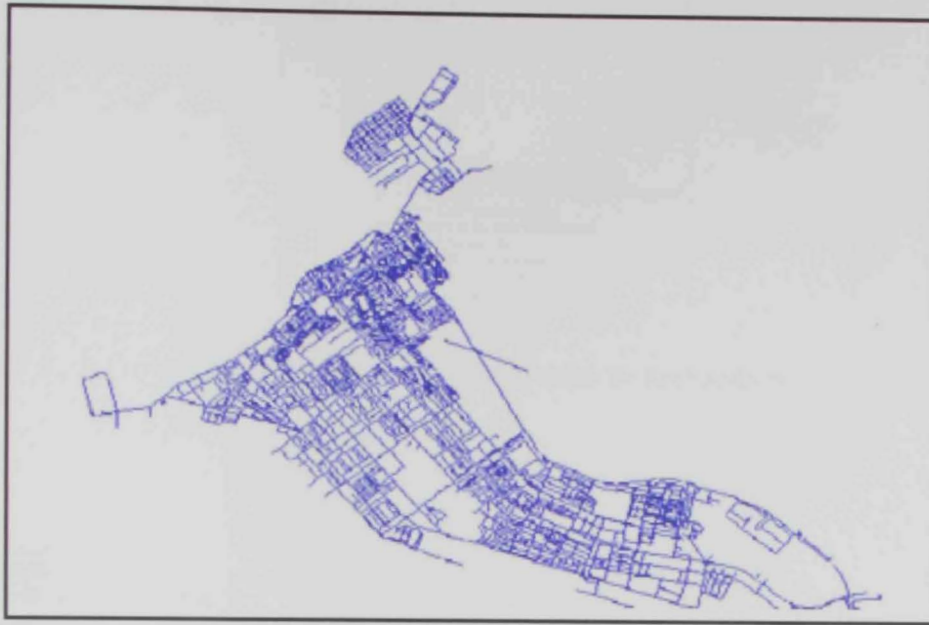
Figure 4.23: Abu Dhabi Street Network

Plot.shp
ROAD_CENTRE_LINE_polyline.shp
Schools.shp

AbuDhabi_roads.mdb
  Street_Network
    house
    ROAD_CENTER_LINE
    Street_Network_Net
    Street_Network_Net_Junctions
  PLOT

Figure 4.24: Layers that used to create the network analysis
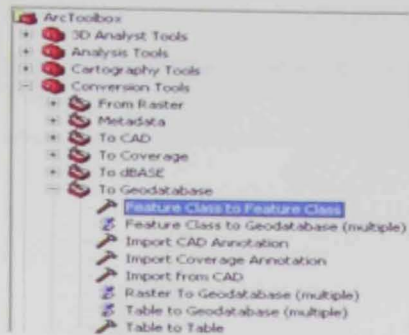
Figure 4.25 Conversion tools in Arctoolbox
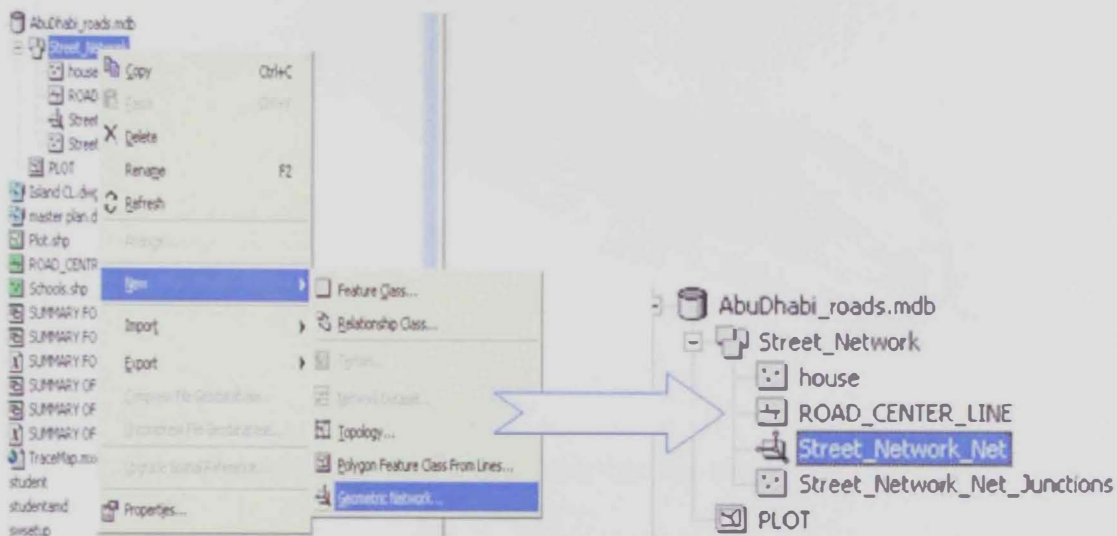
Figure 4.26: Street network

Depending on the length of the streets the shortest path will be calculated using the weights property in the street network, the following weight name shortest_way from type double related to the road_center_line feature class using the shape_length field

Testing and validating the street network is applied using Arcmap application and utility network analyst toolbar (Figure 4.27)

Figure 4.27: The result after testing the street network

The figures below show the results before and after using the shortest route (Figures 28, 29, 30).

Figure 4.28: Trace without using the shortest path

Figure 4.29: Trace depending on the shortest path weight **(Random Result)**
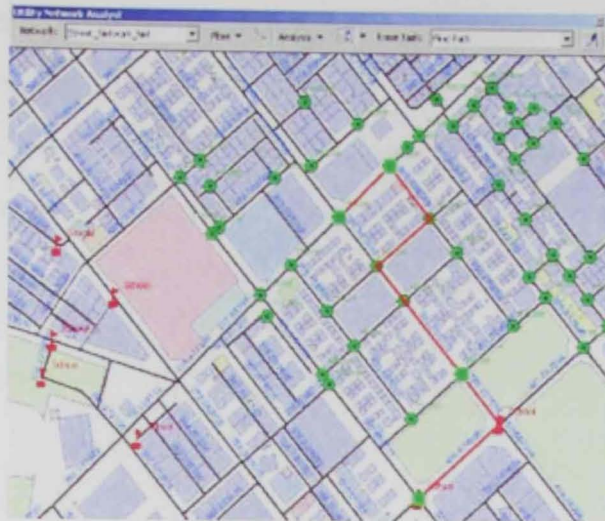
Figure 4.30: Trace depending on the shortest path weight **(Shortest way)**

4.7   Site selection Analysis for new schools

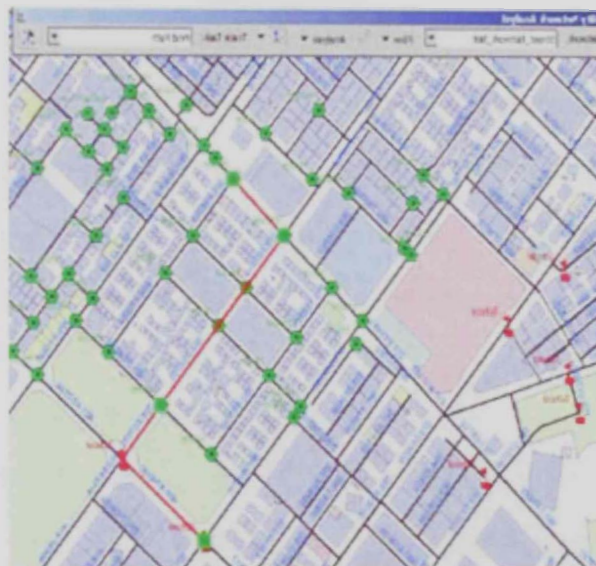The objective of this analysis is to find out the prospective sites for opening new schools in near future considering the current and future demand.   Abu Dhabi Municipality Planning department follows a standard method for calculating the future demand for new schools.   Following are the formulas that were considered to calculate the required number of schools in Abu Dhabi Island.

Number of Kindergarten Schools   = $\dfrac{15\% \text{ of the population (6-18 age)}}{400 \text{ students}}$

Number of Primary schools   = $\dfrac{40\% \text{ of the population (6-18 age)}}{500 \text{ students}}$

Number of Upper Primary schools   = $\dfrac{25\% \text{ of the population (6-18 age)}}{350 \text{ students}}$

Number of Secondary schools   = $\dfrac{20\ \% \text{ of the population (6-18 age)}}{500 \text{ students}}$

The total national population (6-18) age group in Abu Dhabi Island is 21626

So by applying the above formulas the required number schools are as follows:

Number of Kindergarten Schools $= \dfrac{15\% \text{ of } 21626}{400 \text{ students}} = \dfrac{3243}{400} = \mathbf{8}$

Number of Primary schools $= \dfrac{40\% \text{ of } 21626}{500 \text{ students}} = \dfrac{8650}{500} = \mathbf{17}$

Number of Upper Primary schools $= \dfrac{25\% \text{ of } 21626}{350 \text{ students}} = \dfrac{5406}{350} = \mathbf{15}$

Number of Secondary schools $= \dfrac{20 \% \text{ of } 21626}{500 \text{ students}} = \dfrac{4325}{500} = \mathbf{8}$

By observing the above results and present number of schools following conclusions were made in the form of a table (Table 4.15).

S. No	School Type	Required number	Existing number	New Schools
1	Kindergarten	8	5	3
2	Primary	17	13	4
3	Upper Primary	15	13	2
4	Secondary	8	10	No need

Table 4.15: Number of schools needed in Abu Dhabi Island

Now the problem comes where to open or construct these new schools. Thus it requires a GIS site selection analysis for selecting prospective locations satisfying some pre-defined criteria.

This objective has been achieved through developing a GIS Model using ArcGIS model builder (Figure 4.31). Following criteria have been considered in developing the School site selection model.

School Site selection criteria:

Criteria 1:   School site should be vacant parcel and it should be owned by the Abu Dhabi Government.

Criteria 2:   New School site should be with in a quarter Kilometre distance form the high population density (6-18) group age areas.

Criteria 3:   New School site should be with in two Kilometre distance form recreational areas such as public gardens and Play grounds.

Criteria 4:   New School site should be with in 1 Kilometre distance form Residential Areas.

Criteria 5:   New School site should be at least 1 Kilometre away form existing similar Schools.

Criteria 6:   New School site should be at least 2 Kilometre away form industrial pollution and Noisy areas.

Criteria 7:   New School site should be at least 100 meters away from Main roads.
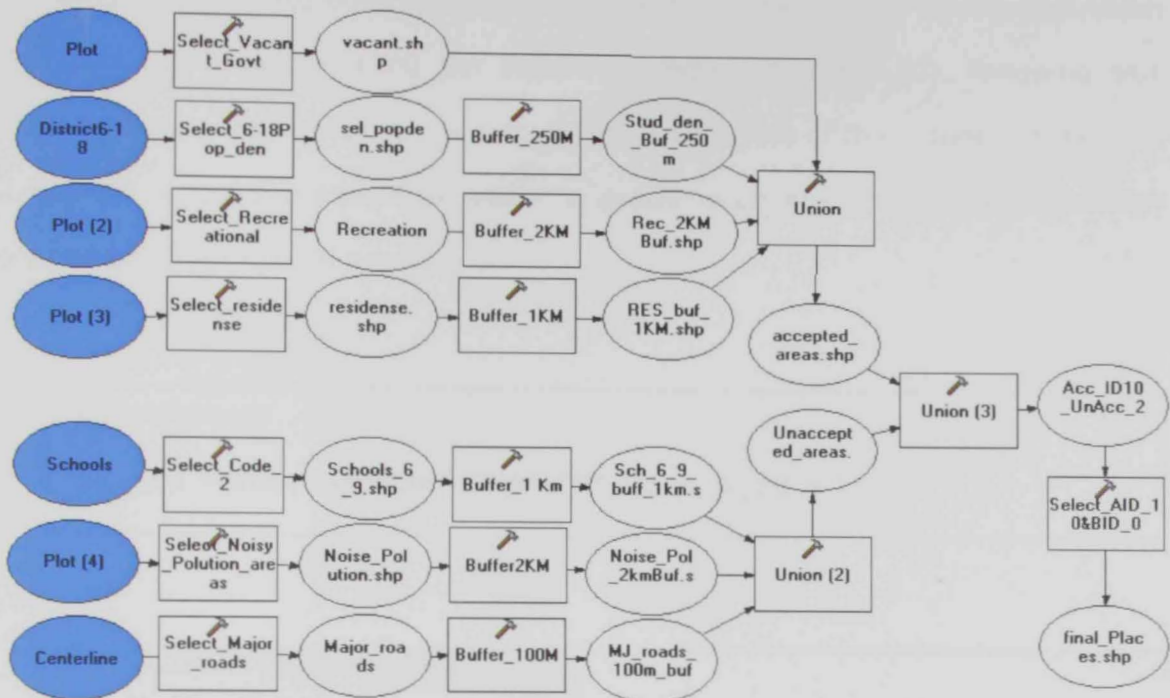
Site Selection Model for New Schools

Figure 4.31: Model for site selection of new school

The above model was executed in ArcGIS environment to generate the final sites.

Following step by step procedure explains more details of the model execution

process.

Step -1:

By Using select by attribute option, model selects all the parcels that are **vacant** and

owned by the Abu Dhabi Government. Following SQL statement will be used to select

the parcels that satisfy the criteria number one .i.e. "School *site should be vacant*

parcel and it should be owned by the Abu Dhabi Government"

SQL statement

   SELECT * from Plot WHERE Status = 'vacant' and Owner = 'Govt'

Step- 2:

By Using select by attribute option, model selects all the districts having population Densities (6-18 age) > 1000 per square kilometer (Figure 4.32). Following SQL statement was used to select the parcels that satisfy part of the criteria number two .i.e. *"New School site should be with in a quarter Kilometre distance form the high population density (6-18 age) areas."*

SQL statement

SELECT * from District6-18 WHERE Pden_6_18 > 1000
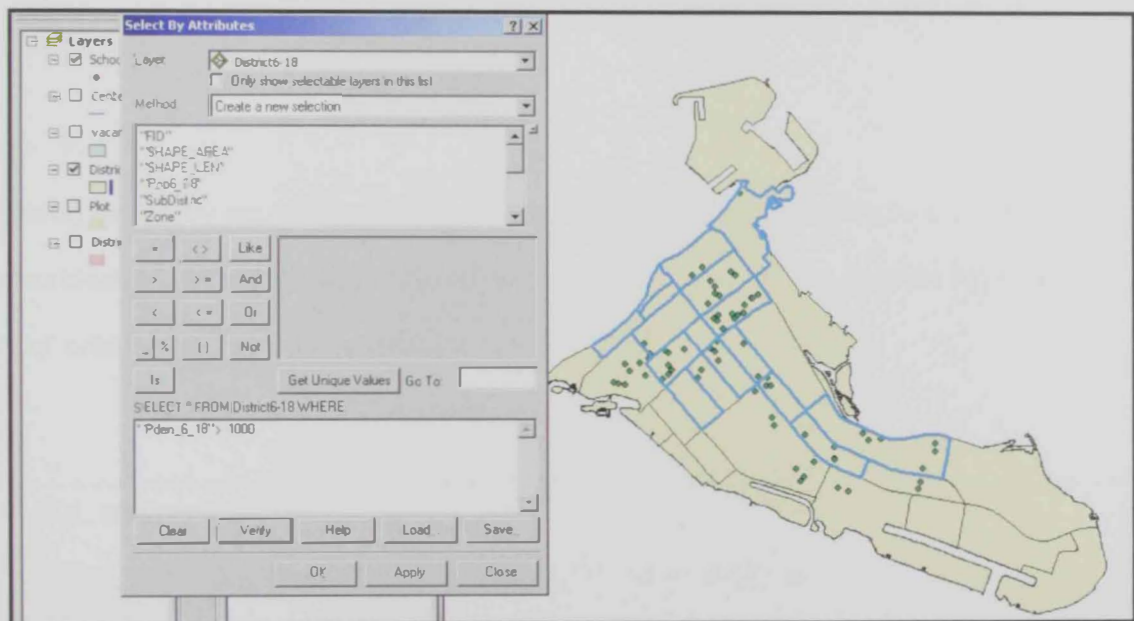
Figure 4.32: Population (6-18) group age > 1000

These selected areas were buffered to 250 meters by using buffer tool in order fully satisfy the criteria 2 (Figure 4.33).
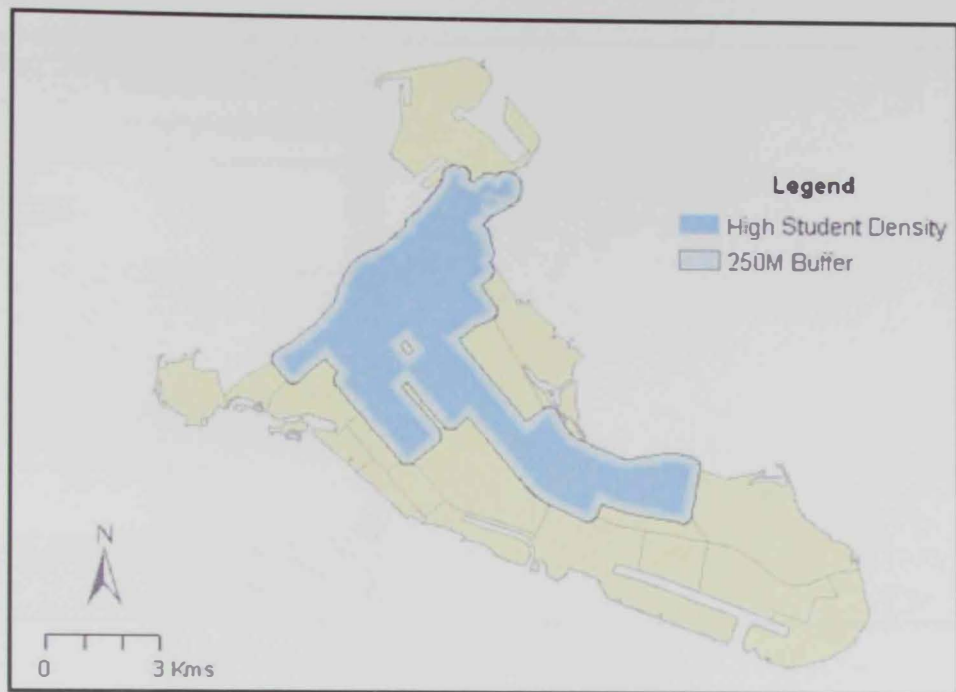
Figure 4.33: High Density Student Areas

Step- 3:

By Using select by attribute option, model selects all the parcels whose usage type is
recreational. Following SQL statement was used to select the parcels that satisfy a
part of criteria number three (Figure 4.34).

SQL statement

**SELECT * from Plot WHERE USAGE_TYPE = 'REC' or
USAGE_TYPE = 'Playground'**

Figure 4.34: Procedure of selecting areas with 2 Km buffer from recreational places

These selected areas were buffered to 2 kilometers by using buffer tool in order fully satisfy the criteria 3 (Figure 4.35, Figure 4.36).
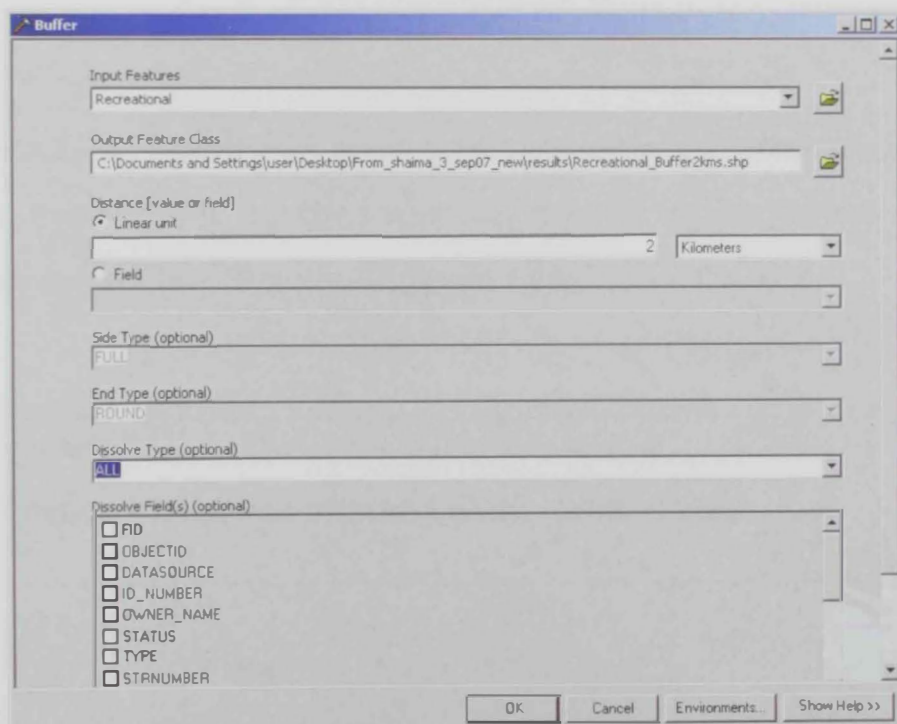
Figure 4.35: 2Km buffer for recreational places
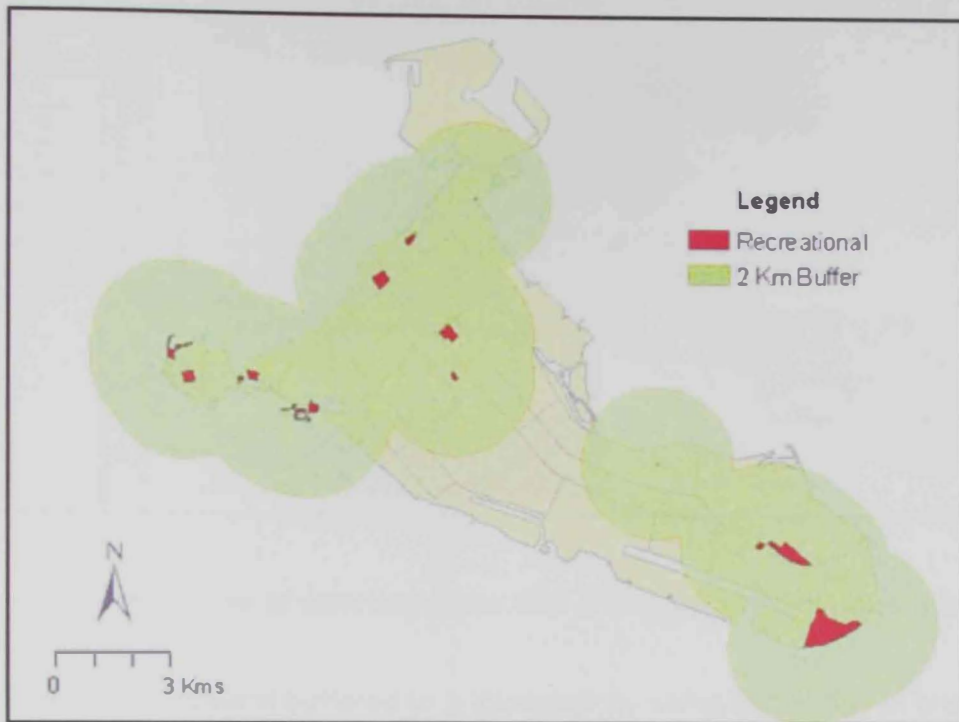
Figure 4.36: Recreational Areas with 2 Km buffer

Step- 4:

By Using select by attribute option, model selects all the parcels whose usage type is **Residential**. Following SQL statement was used to select the parcels that satisfy a part of criteria number four (Figure 4.37, Figure 4.38).

SQL statement

SELECT * from Plot WHERE USAGE_TYPE = 'Villa'
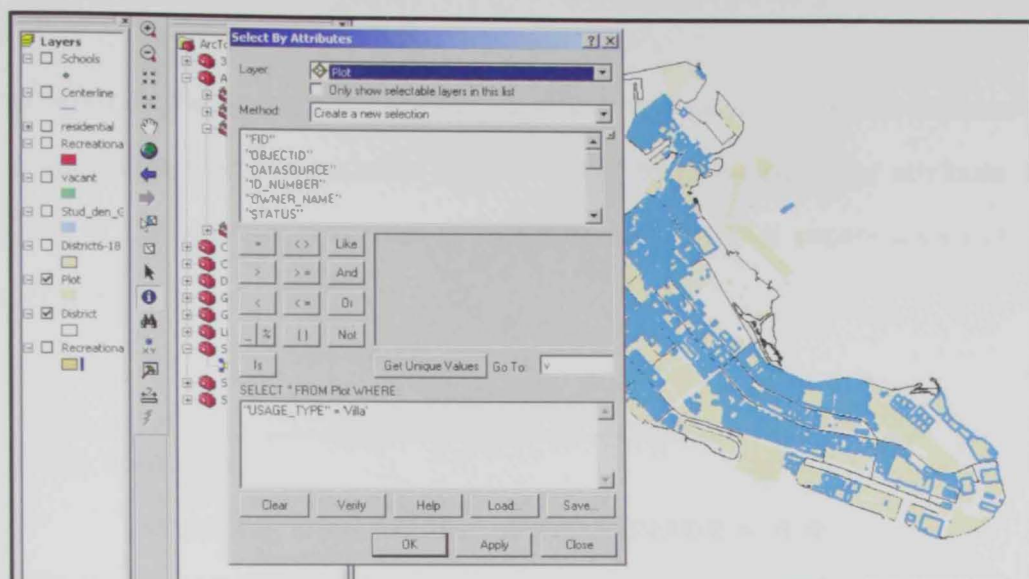
Figure 4.37: Procedure of selecting areas with 1 Km buffer from Residential places

These selected areas were buffered to 1 kilometer by using buffer tool in order fully satisfy the criteria 4.
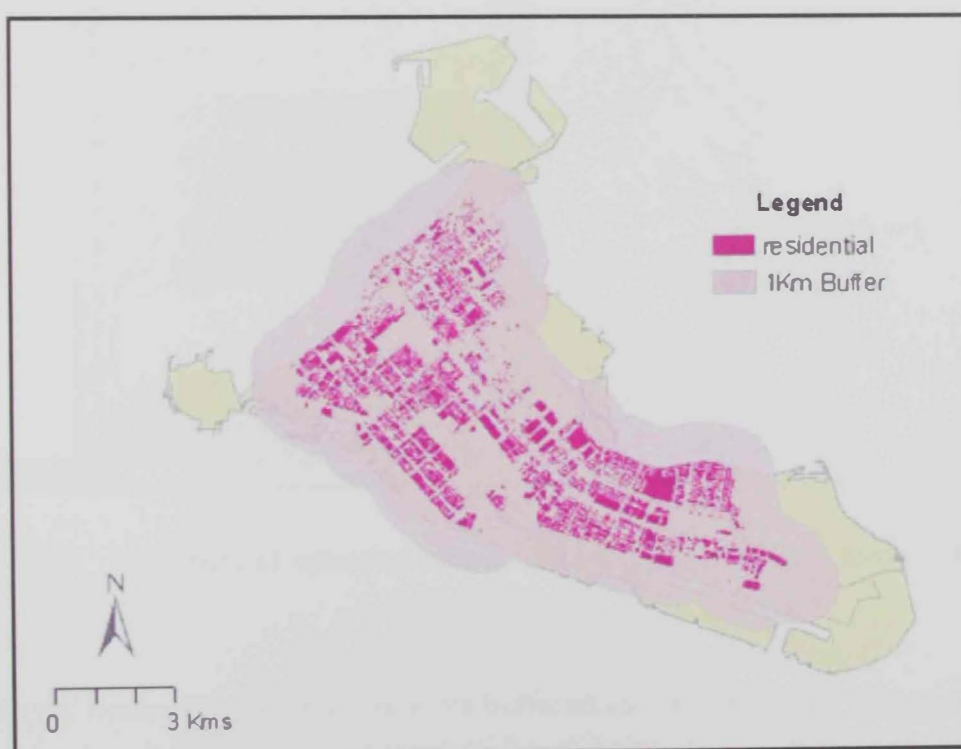
Figure 4.38: Residential areas with 1 Km buffer

Step- 5:

In this Analysis the target sites are for constructing new Upper primary schools so all the existing upper primary schools were selected by using select by attribute option. Following SQL statement was used to select the schools that satisfy a part of criteria number five (Figure 4 .39).

SQL statement

SELECT * from Schools WHERE GRADE = '6-9'
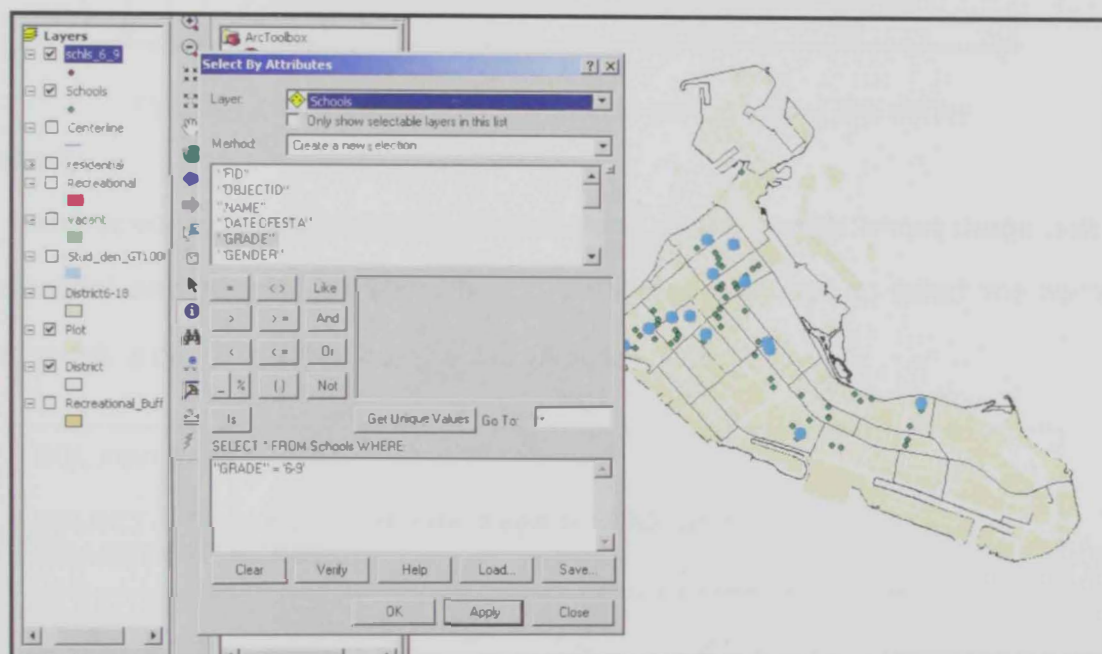
Figure 4.39: Procedure of selecting schools with 1 Km buffer from same grade existing schools

These selected Upper Primary Schools were buffered to 1 kilometer by using buffer tool in order fully satisfy the criteria 5 (Figure 4.40).
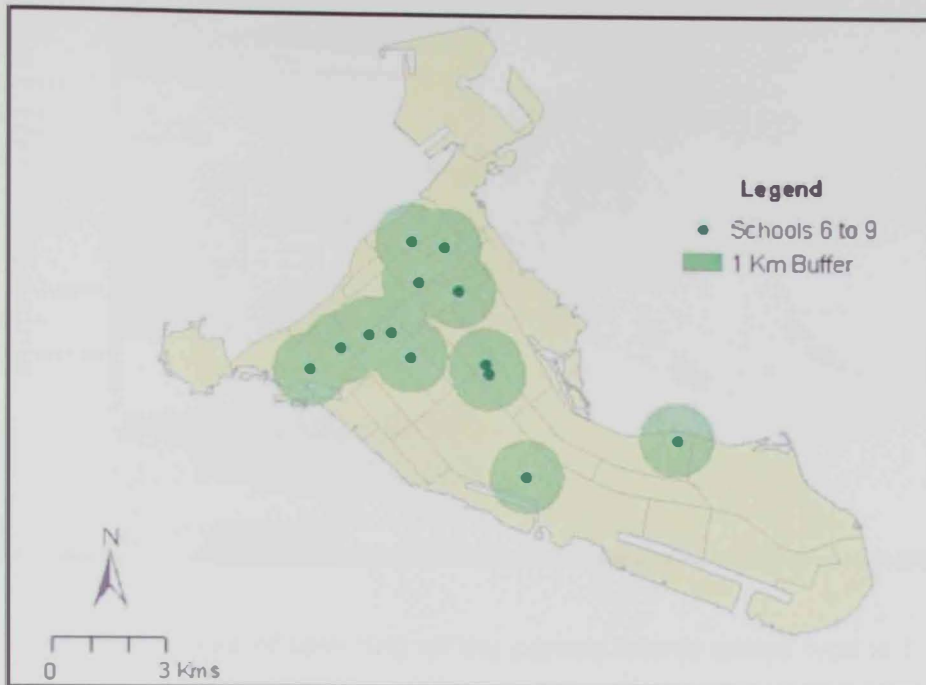
Figure 4.40: Existing Schools (same grade) with 1 km buffer

Step- 6:

By Using select by attribute option, model selects all the parcels whose usage type is **Industrial and Airports**. Following SQL statement was used to select the parcels that satisfy a part of criteria number Six (Figure 4.41).

SQL statement

SELECT * from PLOT WHERE Type = 'IND' and USAGETYPE = 'Airport'
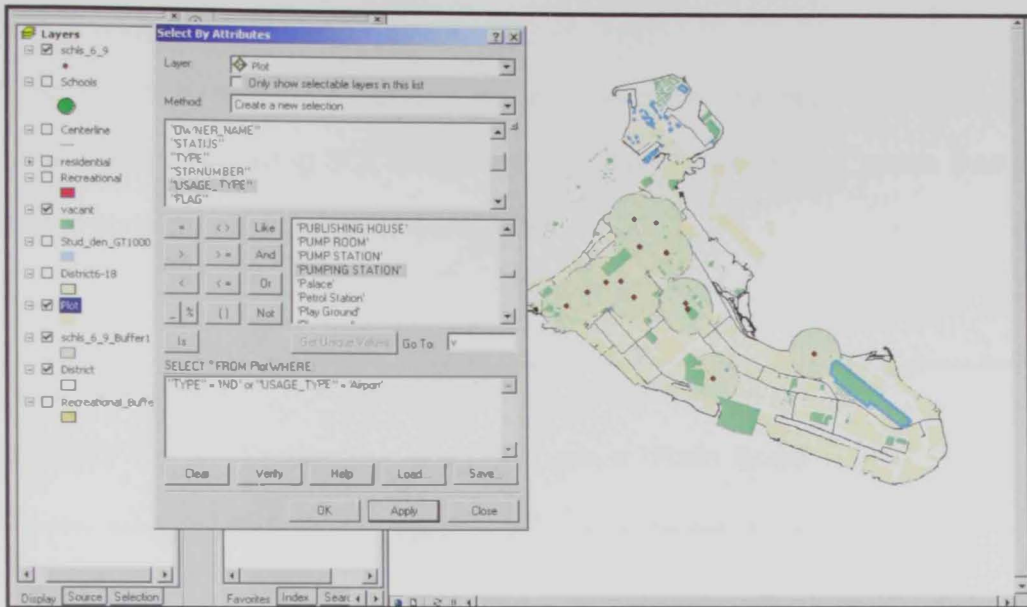
Figure 4.41: Procedure of selecting all the parcels whose usage type is Industrial and Airports

These selected areas were buffered to 2 kilometer by using buffer tool in order fully satisfy the criteria 6 (Figure 4.42).
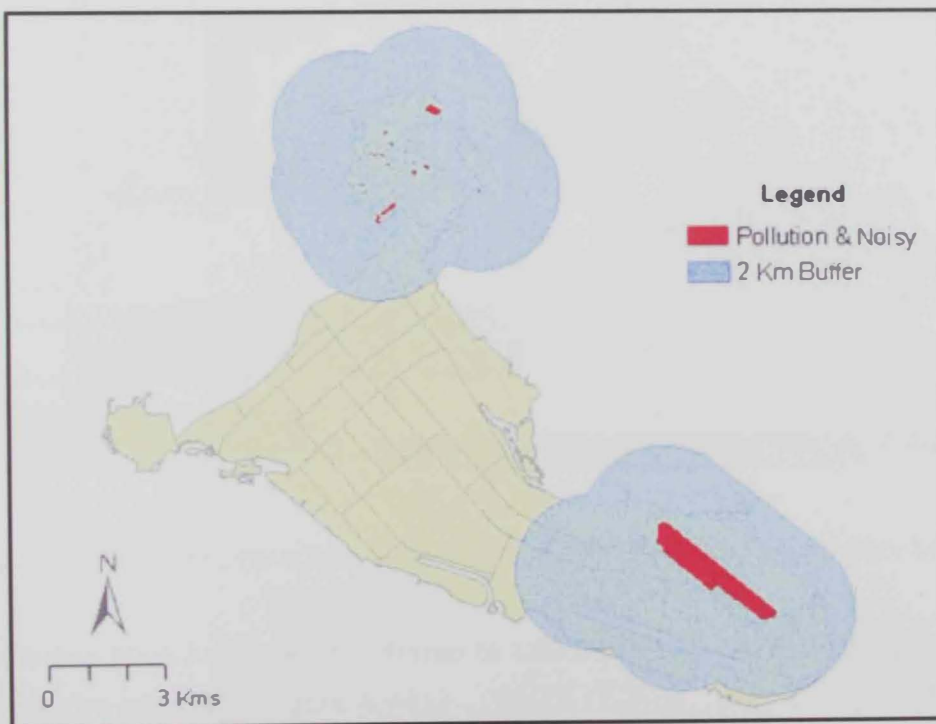
Figure 4.42: Polluted and noisy areas

Step- 7:

By Using select by attribute option, model selects all the Main Roads from Road Center line layer. Following SQL statement was used to select the Roads that satisfy a part of criteria number Seven (Figure 4.40).

```
SQL statement

SELECT * from Centerline WHERE Type = 'Main Road'
```
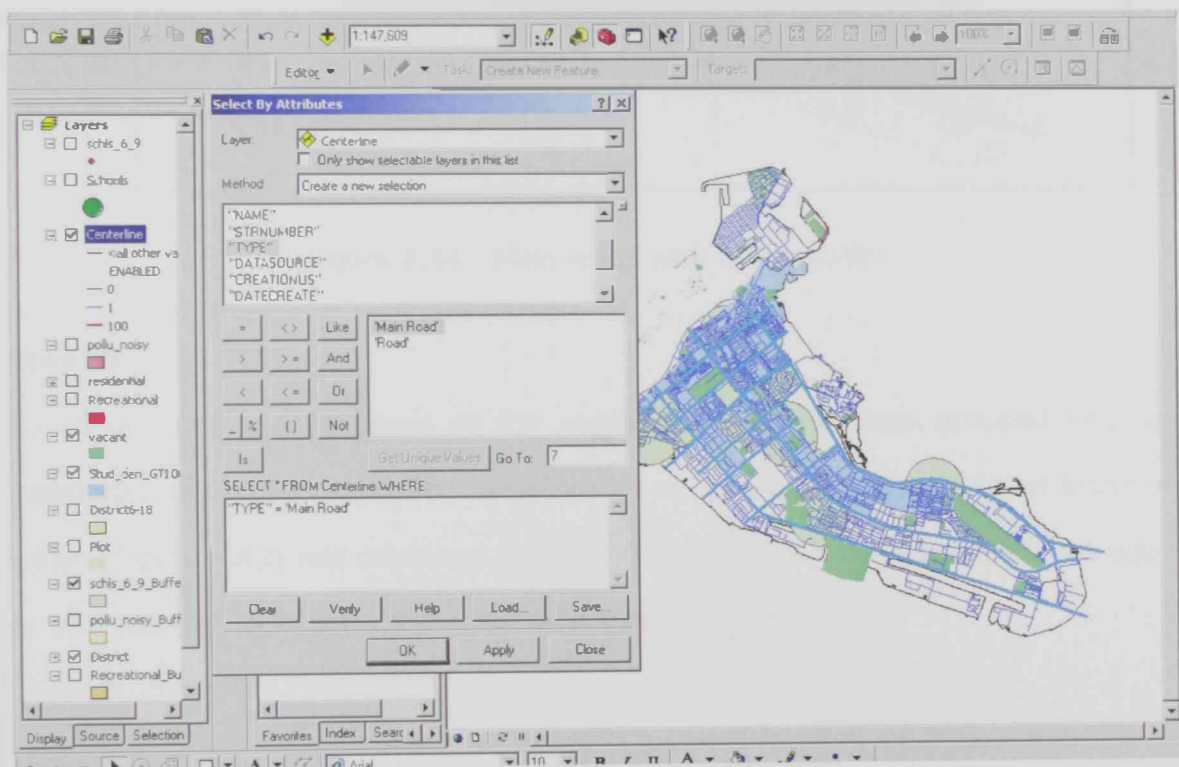

Figure 4.43: The procedure of selecting roads centerline with 100m buffer

These selected Main Roads were buffered to 100 meters by using buffer tool in order fully satisfy the criteria 7 (Figure 4.44).
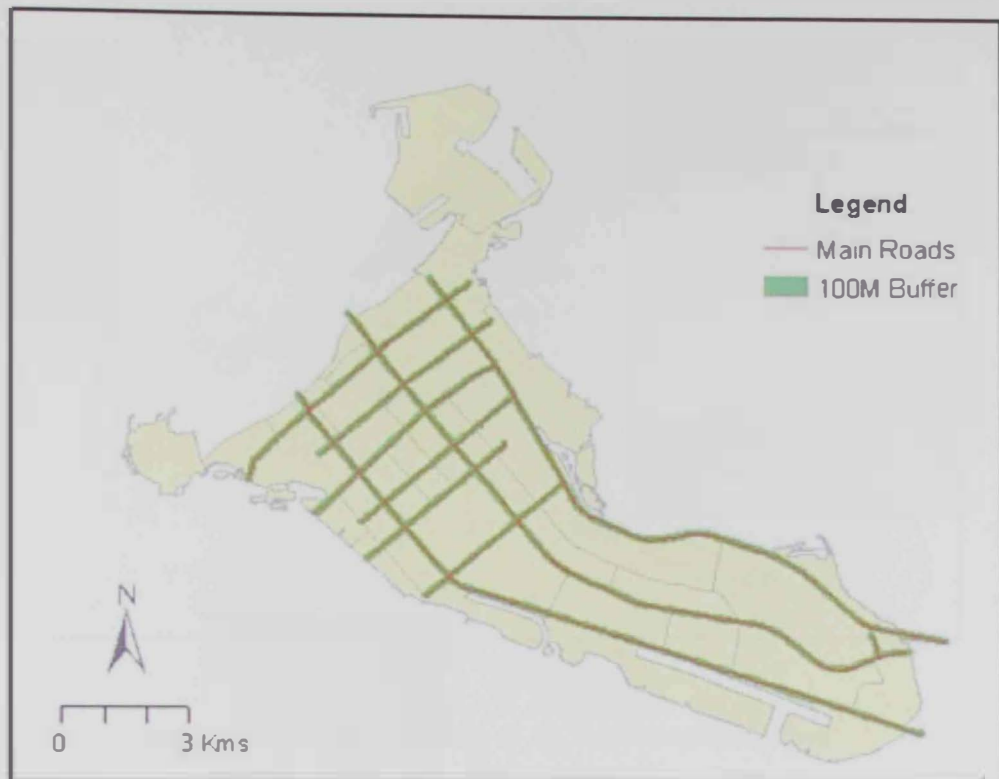
Figure 4.44: Main roads with 100m buffer

Step- 8:

Based on criteria descriptions all the resulted areas have been grouped into two categories as accepted zones and unaccepted zones. Then all the layers of accepted zones (Figure 4.42) are combined together by giving each layer same Weight equal to 1. Union tool has been used to combine the all layers.
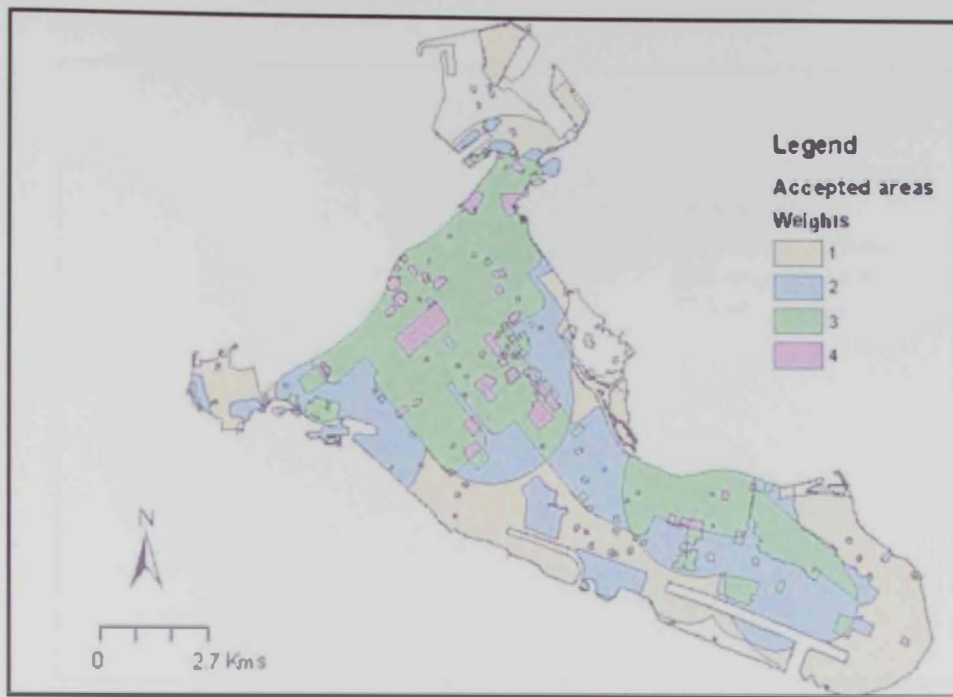
Figure 4.45: Total weights of all the accepted areas

Step- 9:

Similarly all the unaccepted layers (Figure 4.46) viz. Existing Schools buffer, Main Roads Buffers and Pollution and Noisy areas buffer, were combined together into single layer by using union tool
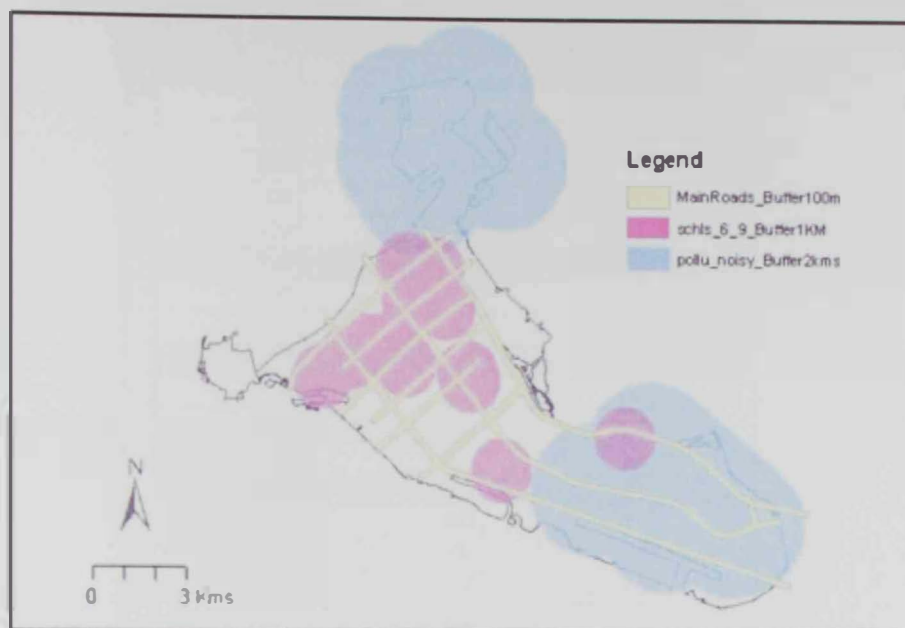
Figure 4.46: Union of all unaccepted areas for new schools

Step- 10:

In this final step the two layers, one is accepted areas and second is unaccepted areas (Table 4.16) were combined together using Union tool. Before these two layers were combined each layer was given a unique ID as shown below.

S.NO	Layer	Unique-ID
1	Accepted Areas	100
2	Unaccepted areas	200

Table 4.16: Accepted and Un accepted areas

After the union of the two layers the resultant layer will have the two unique IDs with three maximum combinations as shown in the following table (Table 4.17).

Accep_ID	UnAcc_ID	Acc_Total	FID_|
100	0	1	
100	0	2	
100	0	2	
100	0	2	
100	0	3	
100	0	3	
100	0	3	
100	0	4	
0	200	0	
0	200	0	
100	200	1	
100	200	1	
100	200	1	
100	200	1	
100	200	1	
100	200	1	
100	200	2	

Table 4.17: Attribute of accepted and un accepted areas

The areas which are fully in the accepted zones (Accep_ID = 100) but not in the unaccepted zone (UnAcc_ID = 0) were selected using the select by attribute tool.

Following SQL Statement was used to select he final prospective areas for new schools (Figure 4.47).

SQL statement

SELECT * from Accp_Unaccp_union WHERE Accep_ID = 100 and UnAcc_ID = 0
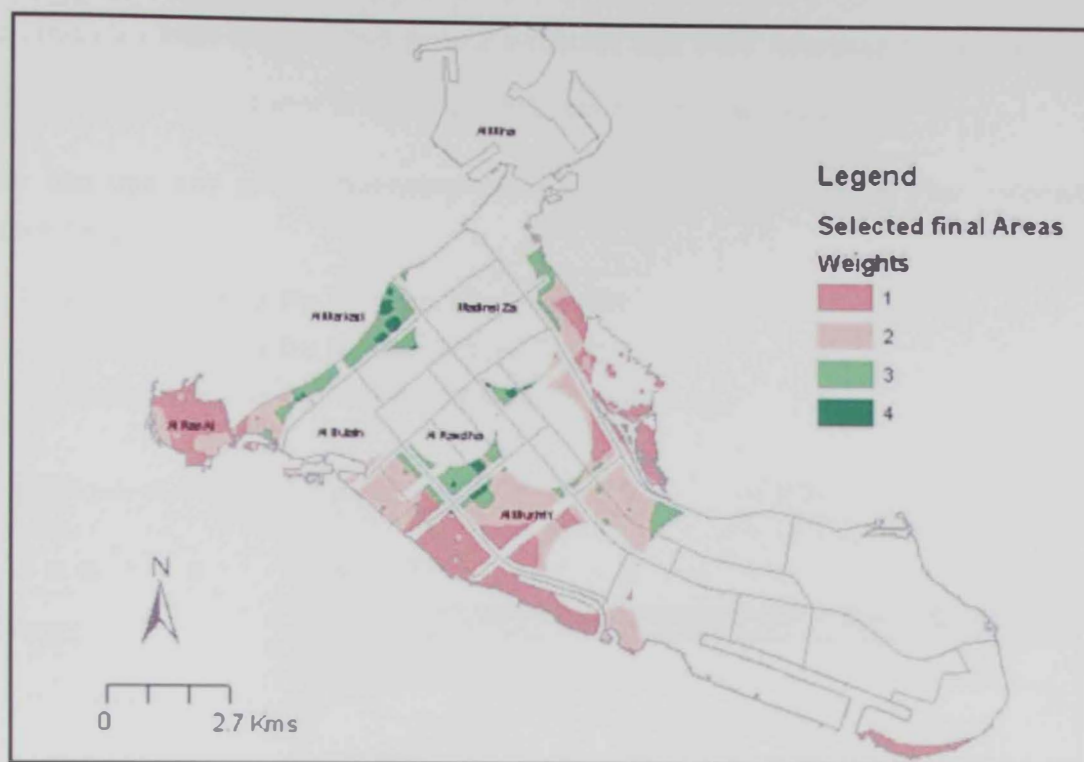
Figure 4.47: Final Sites for New Schools.

The final sites were ranked into four categories based on their weights ranging from 1 to 4. More Weightage indicates more favourable conditions for opening new school. Parcels with Weightage equal to 4 can be strongly considered for opening new Upper primary Schools than other parcels.

4.8   Development of an Interactive GIS based School Finder Tool

The main objective of this tool development is to make the School database easily available for every body. With very little knowledge of computers one can easily search and analyze the entire school database by using this tool. This tool has been developed by using the Visual basic for Application (VBA) in **ArcGIS** software. This

tool gives an easy way to find School locations and their database for administrates or Parents, for that mater or for any stakeholder of the schools.

User can use any of the following criteria to find the schools of their interest as shown below.

1. **Finds schools by District** (Figure 4.48)
2. **Finds schools by Grade** (Figure 4.48)
3. **Finds Schools by 'School Name'** (Figure 4.48)
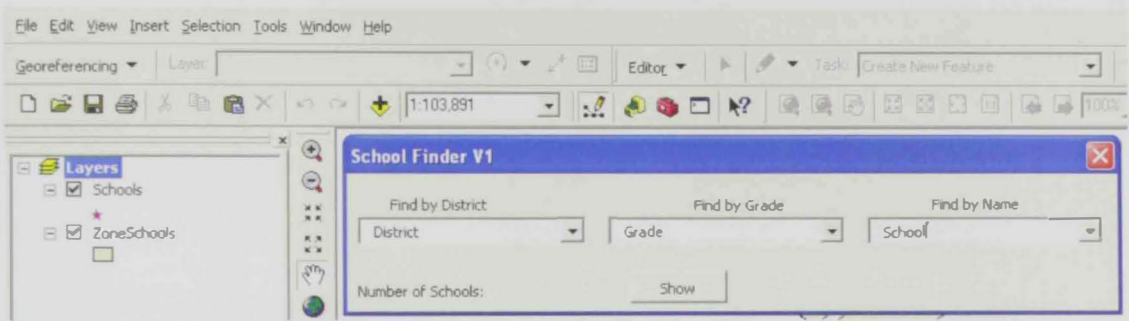
Figure 4.48: Find schools by district, grade or school name

Finds schools by District

In This option, the District combo-box pulls all the districts names from the schools attribute table and list in the box. User can use the mouse to select any district where he wants to find the Schools (Figure 4.49).
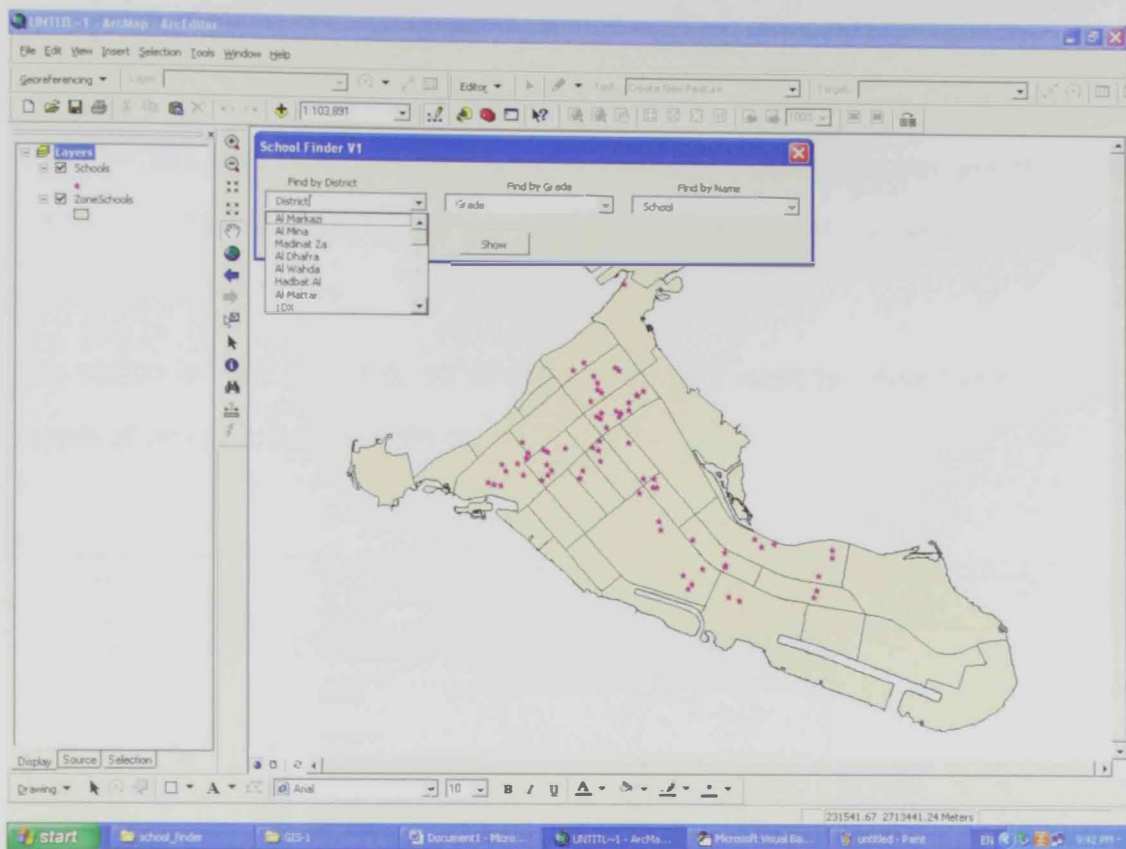
Figure 4.49: Find schools by district

Once the user selects the desired districts from the dropdown list of Districts, automatically all the Schools which are falling under that district boundary will be selected and counted (Figure 4.50). These counted numbers will be reported on the tool bar as **number of schools** in the district.
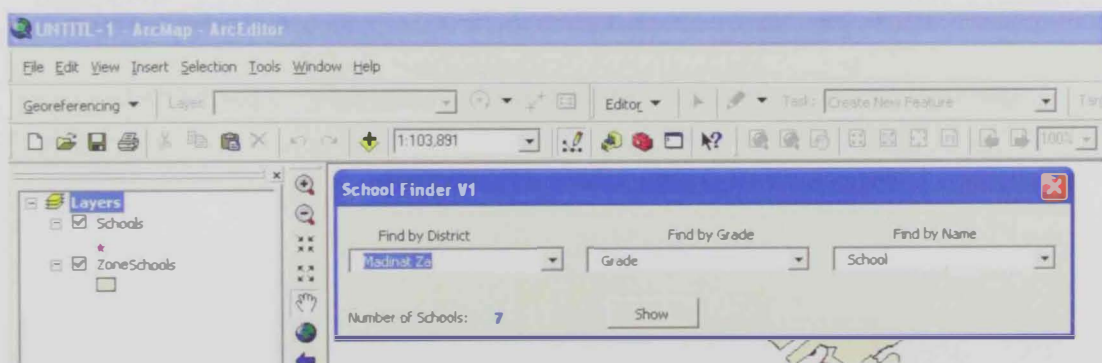
Figure 4.50: The result reported on the toolbar as number of schools

The selected district boundary will be highlighted with light blue color (Figure 4.51). Then user can click on the **Show** button to zoom to the selected District boundary (Figure 4.52). Then the tool Zooms to the selected District and displays the name of the District. All the schools that are inside this selected district will also be displayed with their School names.

This option is very useful to all of the people who want to know the locations and details of all schools in any district.
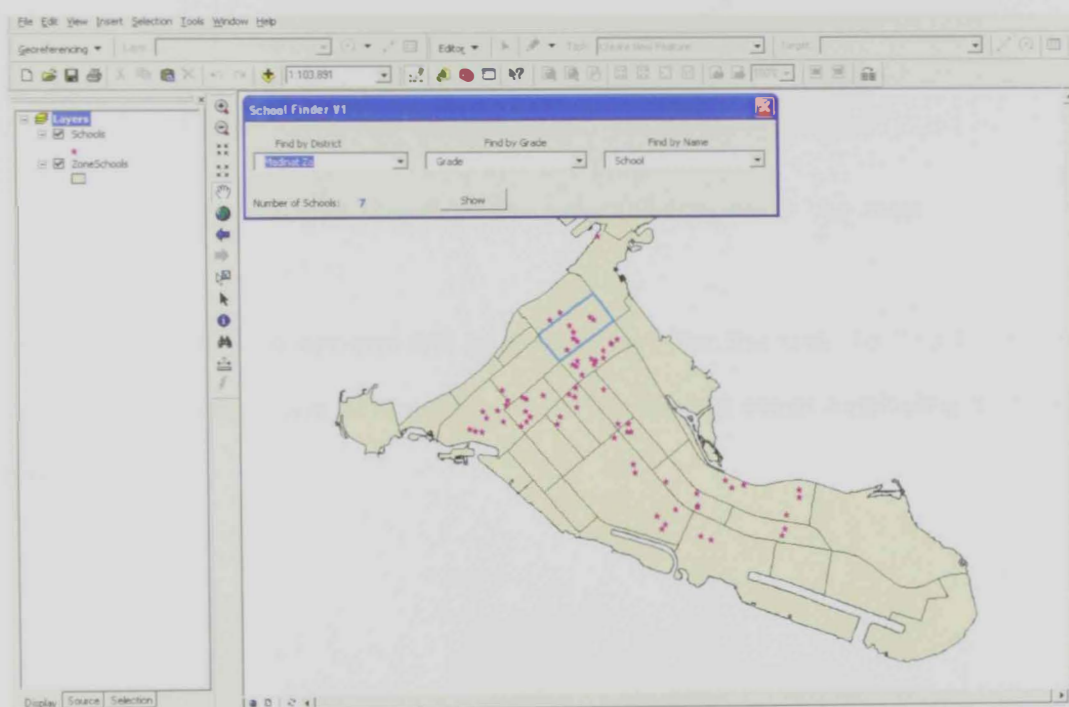
Figure 4.51: The result of the selected schools shown in the map
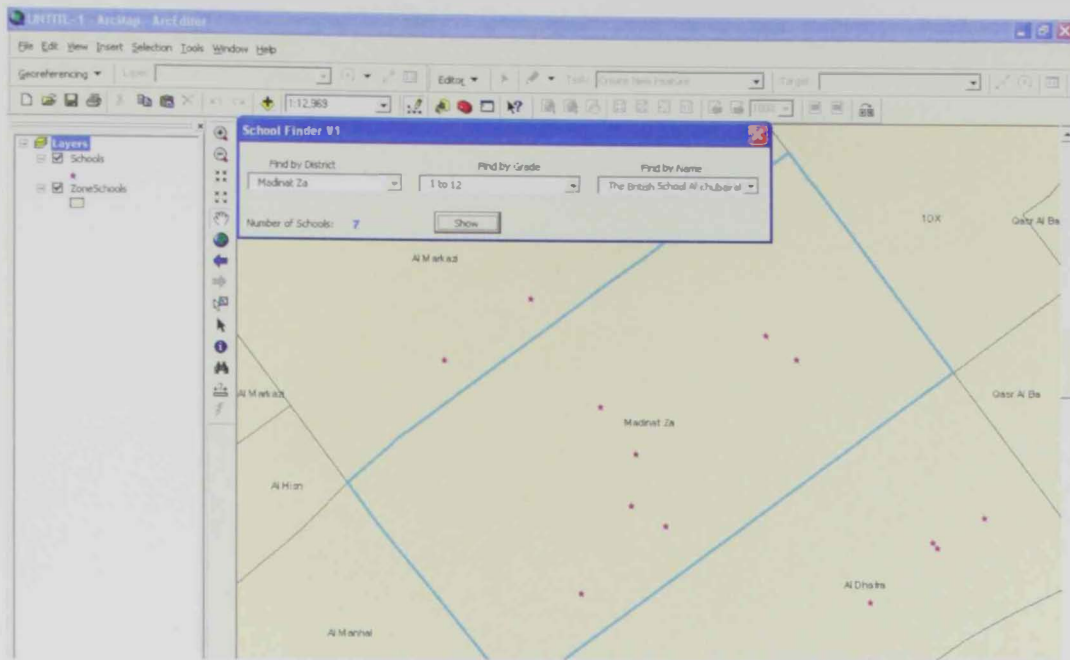
Figure 4.52: Zoom to the selected schools in the map

Similarly the other two options will give easy way for the user to find locations and details all the seventy one Schools based on the **Grade level available** and by their **School names**.

Chapter 5

Summary and Conclusion

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5.1   Summary

Geographic Information Systems (GIS) had seen wide applications in schools. This ranges from its use in their management to its inclusion in the curriculum. For example, GIS had been used in enrolment, school facility management, finding the fastest route between schools and houses, spatial distribution of schools, site selection for new schools, and hot spot analysis.

After setting the main objectives and the methodology of the thesis, the author made a profile across GIS education and applications in UAE. In the educational part, the thesis highlighted the introduction of GIS in the undergraduate and graduate studies at the UAE University and reviewed in depth the GIS concepts impeded in geography text books for grade 4 to 10. The work also included a survey to Geography teachers to check their readiness, perception, and availability of IT infrastructure that will support introduction of GIS at school level. In the application part, the thesis gave an overview about GIS implementation in some governmental departments as "examples" such as in Abu Dhabi Department of Municipalities and Agriculture, Dubai Municipality, and Sharjah Municipality. The objective of reviewing GIS education and applications is to show that there are good steps taken in the UAE at the University level and in the governmental departments in implementation of GIS. Now it is a suitable time to transfer the experience to school level.

The author took Abu Dhabi Island as a study case and elaborated and showed in a vivid way how GIS can be utilized to help school administrators to mange their schools.

5.2   Conclusion

A comprehensive GIS database was developed for the schools of Abu Dhabi Island. The database consists of four feature datasets and each feature dataset contains relevant feature classes (schools, population, roads, districts). The data had been edited and organized to a common format.   Information about the schools included attribute such as name of the school, grade, gender, number of students, telephone, and fax numbers. The dataset for population contained detailed attribute for all the 33 sub districts of Abu Dhabi Island such as age groups (0 to 5 years, 6 to 18, 19 to 25, 25 to 40, 45 years and above), gender, etc. Network database that will help in finding out the shortest route between schools and houses and may result in saving time and money was also developed.

Spatial Data and attribute information were collected from various organizations such as Abu Dhabi Water and Electricity Authority (ADWEA), Abu Dhabi Educational Zone, and Department of Planning and Economy. Although of the lengthy time spent and the problems faced in building the GIS database for Abu Dhabi schools, it is considered a milestone and a foundation for any future work related to the use of GIS for schools.

GIS analysis showed that majority of the population is concentrated mainly in North-Eastren districts of the Abu Dhabi Island at the Central Business Districts (CBD). Similarly, the population in age group 6 to 18 years that is considered as prospective students group is also concentrated mostly in same districts. The reason for this

concentration may be the availability of apartments in the high rise buildings that have less rent than villas out side the CBD, traveling cost is less near work, and accessibility to the facilities at the city center like shopping malls, hospitals, etc.

Schools are found randomly distributed in different districts of Abu Dhabi Island and clustered in Al Dhafra, Al Butain, and Madinat Zayed. By analyzing the Number of students in each school and number of schools in each district it was found out that there is positive correlations between the numbers of students in each district with its population. A direct positive correlation has been observed also between the school density and student density. This can be justified as the numbers of schools are increasing in each district the student number is also increasing. This may not be true in all cases. As only one school can have highest number of students where as other schools may have very less number of students.

A negative correlation has been observed between the population (6-18 years) density and school density. This can happen, because the population is mostly concentrated in high rise buildings and highly dense housing areas where as schools location is generally in open and calm areas and every body prefer to start a school in a place which is free from all types of disturbances. This is why most of the schools are located out the dense populated areas in Abu Dhabi Island. A similar negative correlation has been observed between the population (6-18 years) density and student density.

It is expected that more number of students will come to schools from the nearest districts (short traveling distance), however, analysis for Abu Dhabi shows this is not always true. It may be because of different reasons such as, reputation of the

school, school curriculum (American or British or others), school fees and facilities, and finally the location of the school.

Hot spot analysis which gives an idea about whether schools with high number of students or schools with low number of students tend to cluster or not, showed that schools with high positive Z score (> 2) are concentrated out side the CBD.

School managers are sometimes faced with the problem of locating new schools. The GIS analysis was used to find out prospective sites for opening new schools considering the current and future demand. Following the standards adopted by Abu Dhabi Municipality and criteria that put into account factors such as population, proximity to roads, residential areas, parks, noisy areas, and GIS modeling capabilities, 3 Kindergarten and 4 primary new sites had been identified.

It is not strange that many school administrators are not professional in the use of computers and GIS. Therefore, a system that minimizes and simplifies the use of GIS will help a lot. A school finder system had been developed using Visual basic for Application (VBA) in ArcGIS software. With very little knowledge of computers one can easily search and analyze the entire school database by using this tool. This tool gives an easy way to find school locations and their database for administrators, parents, or any other stakeholders of the schools.

155.3 Significance of the Study

- Schools are foundation of educational system and the use of GIS for their management will save time and money. Operations that need weeks and months if done manually such as location of new schools can be done within hours using GIS.

- Once the benefits of GIS are realized by school administrators this will help in convincing them to introduce it in the school curriculum.

- The use of GIS by school administrators is an indication of IT reforms that is needed to meet the 21st century challenges.

- Parents, police, and many other parties that have business with schools can benefit from the database developed in this study for various applications.

5.4   Recommendation

Based on the results obtained, the following recommendations are made:

1. GIS should be fully utilized for schools management issues such as distribution of population, schools, students, their enrollment, and determination of optimum routes between school and homes.

2. This study started with building GIS database for Abu Dhabi Island schools, it is strongly recommended to build a comprehensive schools database for all UAE. The database will help the Ministry of education as end user to manage and plan for future schools.

3. Development of tools/systems/user interfaces that simplify the GIS operations to end users is essential. The tool developed in this study should be expanded to help in interactive running of various scenarios and finally be made available online.

4. Short courses in the use of GIS for school administrators should be organized to train them on how to get use of its capabilities.

5. Incorporation of GIS in school curriculum is highly recommended.

6. Cooperation between data providers, software vendors, and school administrations will help in promotion of GIS for schools.

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UAE University
Master of GIS & RS

Questionnaire for Geography teachers in secondary schools

1. Sex: M □   F □

2. Name of School: ---------------------------------------

3. How many years have you been using a Computer?
   □1-2 years   □2-3 years   □3-5 years   □more   □none

4. How many hours a day do you use a computer?
   □1-2 hours   □2-3 hours   □3-5 hours   □more   □none

5. How many hours per week you spend using Internet?
   □2-3 hours   □4-8 hours   □8-12 hours   □more   □none

6. Which software are you familiar with?
   □Microsoft word   □PowerPoint   □Excel   □more, specify: ----------------------

7. Which of those is Input device?
   □Keyboard   □CPU   □Printer   □CD

8. Which of those is Processing device?
   □Keyboard   □CPU   □Printer   □CD

9. Which of those is Storage device?
   □Keyboard   □CPU   □Printer   □CD

10. Which of those is Output device?
    □Keyboard   □CPU   □Printer   □CD

Answer the below questions using the attached map:-

11. What is the name of the city on the map? ----------------------------

12. How many schools on the map? ------------------------

13. How many hospitals on the map? ----------------------

14. How many hotels on the map? ----------------------

15. When this map was produced? ------------------------

16. Which direction you will use if you want to move from Abu Dhabi Mall to Marina Mall? ----------------------------------

17. Find the distance between Emirates Palace Hotel and Sheraton Hotel? ---------------------------------

18. What is the satellite data used in the map? ------------------------

19. Locate the LULU Island on the map

---

20. Have you ever use Google earth? □Yes   □No

21. Did you study GIS in your Bachelor? □Yes   □No

22. If No, did you take a short course in GIS? □Yes   □No

23. Did you study Remote Sensing in your Bachelor? □Yes   □No

24. If No, did you take a short course in Remote Sensing? □Yes   □No

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25. Do you think that GIS will enhance Spatial thinking of the students?
□ Strongly agree   □ Agree   □Disagree   □Strongly disagree

26. Do you think that GIS will enhance Problem Solving of the students?
□ Strongly agree   □ Agree   □Disagree   □Strongly disagree

---

27. Do you have computer lab in your school? □Yes   □No

28. If no, why you don't have? --

29. How many computers your lab includes?
□Less than 5   □Less than 20   □around 30   □more

30. What kind of computer do you have in your lab?
□PII   □PIII   □PIV   □others ------------------------

31. Is your administration supporting new technology? □Yes   □No

32. Any comments about how to introduce GIS in Schools---------------------
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تحليل نظم معلومات جغرافية لمدارس أبوظبي

خلاصة

أداة لا يمكن الاستغناء عنها في (GIS)أصبحت نظم المعلومات الجغرافية كثير من حقول الدراسات والبحوث، إذ أن هذه النظم مفيدة عندما تمس الحاجة لاختيار موقع، أو اختيار أو تحديد قطاع لقيام سوق، وعند التخطيط لمرافق بنية تحتية وفي الاستجابة للطوارئ. ويستخدم نظام المعلومات الجغرافية عالمياً للقطاع التعليمي وفي أكثر من جانب مثل التخطيط لتخصيص أماكن للمدارس أو إدارة موارد إمدادات تعليمية. هذه الرسالة (الدراسة / الأطروحة) وقعت في أماكن توزيع المدارس في أبوظبي مع النظر إلى الكثافة السكانية ومناطق الخدمات مما نتج عنها تحديد أماكن مستقبلية لإنشاء مدارس جديدة بناءً على الطلب الحالي والمستقبلي مستخدمة في ذلك معايير متعددة مع تشييد شبكة طرق تساعد في إيجاد أقصر وأفضل الطرق بين منازل الطلاب والمدرسين والمدارس، وأوجدت نظام معلومات جغرافي تفاعلي كأداة للتعرف على المدارس، وفي خلال هذا البحث أو الدراسة تم تطوير نظام شامل لحفظ البيانات لكل مدارس أبوظبي الواحدة والسبعين (الموجودة بجزيرة أبوظبي) واستخدمت كافة وأدواتها مستعملة في ذلك برامج الكمبيوتر (GIS)تحليلات نظم المعلومات الجغرافية ESRI's ARCGIS.9.2.

إضافة إلى ذلك فإن هذا البحث أو الدراسة قد قدمت نظرة فاحصة لدور لنظم (في البرامج الدراسية للمدارس، تشمل التخطيط والإدارة (GISالمعلومات الجغرافية لتعطي المدرسين فرصة للتعلم والتعرف على نظم المعلومات الجغرافية وتطبيقها في التدريس.

وكشفت الدراسة أن أنشطة نظم المعلومات الجغرافية لم تستخدم بدرجة كبيرة في مدارس أبوظبي ولكن مع مبادرة نظم المعلومات الجغرافية، وحكومة أبوظبي والمعاهد العليا وغيرها تشير إلى رغبة في زيادة الطلب على استخدام هذه النظم بواسطة المدارس، وأن الحاجة تمس لبرامج تخصصية من نظم المعلومات (GIS) الجغرافية تصمم خصيصاً للتدريس وأغراض التعليم.

جامعة الإمارات العربية المتحدة
عمادة الدراسات العليا

تحليل نظم معلومات جغرافية لمدارس أبوظبي

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عمــــادة الدراســـــات العليــــــا
جامعة الإمارات العربية المتحدة

لاستكمال متطلبات الحصول على درجة الماجستير في علوم الاستشعار عن بعد
ونظم المعلومات الجغرافية

ديسمبر 2007