الآيـــــــة

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

اقْرَأْ * خَلَقَ الإِنْسَانَ مِنْ عَلَقٍ * اقْرَأْ وَرَبُّكَ الأَكْرَمُ *
بِسْمِ رَبِّكَ الَّذِي
الَّذِي عَلَّمَ بِالْقَلَمِ * عَلَّمَ الإِنْسَانَ مَا لَمْ يَعْلَمْ

صدق الله العظيم

سورة العلق (الآيات 1-5)

Dedication

I dedicate this thesis

To my father, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time.

To all knowledge seekers and providers,

To all my teachers,

To all my colleagues,

And to my all friends and classmates.

Acknowledgement

I would first thank God for what we have reached and to complete this research. I would also like to thank my thesis supervisor Prof. Dieter Fritsch SUSTECH Visiting Professor, he was guidance me in the right direction.

I'd like to grasp this opportunity for most to express my greatest thanks to all who have helped me towards the successful completion of this research.

Last but not least, I have to confirm that my completion of this project could not have been accomplished without the support of my family, my friends, my colleagues at work and my classmates.

Abstract

The study aims at finding the optimal locations for new Automated Teller Machines (ATMs) for the banks in Khartoum area through the use of Geographic Information System (GIS) technology. It is well-known, that GIS plays an important role providing a platform for effective planning, organizing and decision-making. In this research we introduce the locations of existing and new ATMs to ensure access of banking services to all bank customers. The database created for the study area (Khartoum Locality) includes data about roads, existing ATMs and facilities available in the area. With the help of Esri's ArcGIS software through using the weighted overlay analysis tool we have identified suitable sites of new ATMs. One of the final results from this study is that the optimal area for building new ATMs amongst potential sites in terms of compatibility with the chosen criteria is in the area of International University of Africa.

المستخلص

تهدف الدراسة إلي إيجاد افضل موقع صراف آلي جديد للبنوك بمحلية الخرطوم عن طريق استخدام تقنيات نظم المعلومات الجغرافية ، حيث أن نظم المعلومات الجغرافية تلعب دورا هاما من خلال توفير بيئة للتخطيط والتنظيم وصنع القرار. في هذا البحث تطرقنا إلي تحديد مواقع الصرافات الآلية الحالية والجديدة لضمان وصول الخدمات المصرفية إلي كل عملاء البنوك. وتشمل قاعدة البيانات التي تم انشاؤها لمنطقة الدراسة بيانات الطرق و مراكز الصرافات الآلية الموجودة والمرافق المتاحة في المنطقة. وبمساعدة برنامج Esri's ArcGIS ومن خلال استخدام أداة التحليل Weighted Overlay حددنا أكثر من موقع مناسب لبناء صراف آلي جديد. واحده من النتائج النهائية لهذه الدراسة أوضحت أن أفضل موقع لبناء جهاز صراف آلي جديد من بين المواقع المحتملة من حيث التوافق مع المعايير المختارة هو في منطقة جامعة أفريقيا العالمية.

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Chapter 1

Introduction

1.1 Introduction

The banking industry in Sudan is changing at a very rapid pace especially in the recent years, which is also reflected in major developments. Significant advancements in communication and information technology accelerated and broadened the propagation of financial information and financial services.

Banking services represent an important economic activities in any country, and if we look at it, we find that economic activity involves many of the properties. There is no doubt that the availability of these features mean the need to keep abreast of banking activity to the requirements of development in all aspects of economic and social activity in any country, regardless of the nature of its economic system or political philosophy.

With an increasing population increased financial transactions are needed, in particular we need banking services near the people.

Due to these changes and open market policy of Sudan, the banking sector is facing fierce competitions. To overcome this race, many strategies are implemented. One of which is creating a vast network of financial and transaction centers (such as branches and ATM centers) at appropriate location so as to reach a maximum number of customers. One such facility is creating a formidable network of ATM centers for easy financial transaction for customers and reducing the pressure on branch banking. For opening new ATM centers banks always look for areas, which are easily accessible, and high in demand. Demand in any particular geographical region depends on the behavior, life style, earning power and spending pattern of the people. If the surrounding area is having high number of commercial establishments, then this could also be a valid ground for identifying new site.

ATM represents one of the important services provided by the banks to facilitate banking transactions for the customers at any time. In this research a new approach is proposed of solving the ATM location problem.

1.2 Research Problem

Facility location problems are classical optimization problems that have numerous applications, especially in the service industries. Examples of these applications include optimal location of gas stations, health care units, warehouses, police stations, and power plants. Automatic teller machines (ATMs) are among the most important service facilities in the banking industry.

Selecting the appropriate location of any facility is a common problem because it is affecting the expected outcomes; therefore it has to be choosing carefully.

Location convenience is an important factor when customers select a financial institution. A customer may find a bank convenient if it has a branch or an Automated Teller Machine (ATM) near his / her residence or workplace, say within 2/km.

To provide better services for the banks and it enables providing best facilities, flexibility and convenience of banking transactions for customers we have to find the best location for an ATM machines.

1.3 Aims and Objectives:

Aims: To design a model that works to choose the best site for a new ATM machine. This will provide better services to the banks, and it provides best facilitates of banking transactions for customers.

Objectives:

- To determine the appropriate site for a new ATM.

- To determine the best location from the appropriate sites for a new ATM.

1.4 Research Question and Hypothesis:

The major question that can be asked is: How to finding the best location for new ATMs?

From this question, the hypothesis for this study is that the Bank customers have difficulties using banking transactions, because the bank's branches or ATM sites are not covering all the places or it is found at inappropriate locations.

Chapter 2

Literature Review

2.1 Introduction

There are several previous studies using GIS software to determine the location for facilities. These existing literatures to determine the location for new facilities is quite helpful. But the purpose of this research is to design an own modeling approach finding the best location of new ATM machines by using GIS techniques.

2.2 Review of prior studies

2.2.1 Case 1: General Studies

- **Title of Study:** Location of Banking Automatic Teller Machines Based on Convolution
- **Name of Researcher:** Mansour A. Aldajani and Hesham K. Alfares
- **Study Objectives:** To minimize the total number of ATMs to cover all customer demands within a given geographical area.
- **Methodology and Planning:** First, a mathematical model of this optimization problem is formulated. A novel heuristic algorithm with unique features is then developed to efficiently solve this problem. Finally, simulation results show the effectiveness of this algorithm in solving the ATM placement problem.
- **Conclusion:** This study proposed a new approach for the placement of automatic teller machines (ATMs). The approach computes the minimum number of machines as well as their locations that satisfy the service level coverage requirements. It does so by implementing a new heuristic solution that is based on the 2-dimensional convolution. The proposed approach provides a flexible means for choosing arbitrary service models and demand patterns, making it suitable for real applications. Experiments with the new algorithm show its efficiency and flexibility in solving ATM placement problems near-optimally.

2.2.2 Case 2: Studies used GIS Techniques

- **Title of Study:** Urban Road Network Accessibility Evaluation Method Based on GIS Spatial Analysis Techniques
- **Name of researcher:** Hu Weiping
- **Study Objectives:** The urban road network plays a key role in the urban spatial structure. It is the main city social-economy activities and transportation carrier. One of the most important problems is how to evaluate the accessibility of a road network.
- **Methodology and Planning:** First, road accessibility concept and some appraisal methods are discussed. Then, the spatial analysis method on road network assessment has been established based on GIS spatial analysis, some urban road network accessibility evaluation models are built up. The models use ESRI Corporation's ArcGIS Engine components and Microsoft Corporation .Net Framework, and focus on the road network connectivity, the shortest travel time and the weighted average travel time. The paper presented three main road network accessibility evaluating indicators, introduced the theory of the model construction in detail, and the model construction process. Taking Foshan city (City in China) as an example, the models were tested using the urban road network data. Finally, further urban road network accessibility evaluation models are discussed.

- **Conclusion:** Based on GIS spatial analysis methods, using ESRI's ArcGIS Engine components and Microsoft's .Net Framework, they built a weighted and normalized index to value the accessibility of road nodes. In the sample test of Foshan city, the results show that the index can explain the existing situation of road network's accessibility.

2.2.3 Case 3: Studies determining the optimal location

- **Title of Study:** Facility Location Modeling: Decentralization of Saskatoon Homecare Agency
- **Name of researcher:** Pegah Abbasi (2012)

- **Study Objectives:** The purpose of this research is to model their facility location problem using a quantitative method, with the objective of determining the optimal set of sites that leads to minimizing overall costs. In addition to identifying the best locations, the size of each facility in terms of required staff is also determined.
- **Methodology and Planning:** In this thesis, two quantitative methods are employed to find the best locations for new facilities. In the first method, they use the Center of Gravity which is only suitable for single facility location problems. This approach finds the best location based on minimized demand weighted average distances between the center of each neighborhood and the homecare site. In the second method, they use the P-median model which is suitable for both single and multiple facility location problems. This approach attempts to minimize the total annual cost subject to a set of constraints. As opposed to the Center of Gravity model, in which the new location can be anywhere in the 2D plane - the P-median model - there should be a set of potential locations to choose the best site from. Based on Health Region suggestions, the other five proposed locations were Market Mall, Lawson Heights Mall, Confederation Mall, Avenue H South, and University Heights Square. The P-median model also defines the number of staff that should be sent from each open location to each neighborhood.
- **Conclusion:**

  Saskatoon Health Region (SHR) is encountering a facility location problem for its one and the only homecare agency which is located on Idylwyld Drive. The main motivation for SHR for decentralization is that on average, there are only 50% hands on time which is even getting worse due to expansions of the city, population growth and increase in traffic. Moreover, their current expenditures are exceeding the assigned budget. Dealing with lack of parking stalls due to 25th Street extension, covering the increasing demand and staff dissatisfaction of excessive and unorganized travels around the city are other motivations for decentralization.

2.2.4 Case 4: Studies determining the optimal location using GIS Techniques

- **Title of Study 1:** Determining An Optimal Retail Location By Using GIS
- **Name of researcher:** N. Trubint et al. (2005)
- **Study Objectives:** How to achieve positive business results under high costs, but at the same time maintain the attained service quality. The aim of this paper is to present the modern approach to solving this multidisciplinary problem which relies on the support of a Geographical Information System (GIS).
- **Methodology and Planning:** Analysis of retail outlet locations is supported by MapInfo software package for Desktop Mapping. They also use vector maps of the urban parts (towns) of Serbia. The required databases are as follows: demographic data, business demography, portions of urban infrastructure databases as well as databases of existing retail outlets.
- **Conclusion:**

  Location theory is a transportation discipline that has recently undergone rapid growth. The basic today's approach to these problems becomes more and more multidisciplinary-oriented. It often proves insufficient to solve a location problem in the sense of solving one of the theoretical models – a variety of other factors have to be included as well, depending on the problem formulated. This is why location models for urban environments have recently been developed. For the problem addressed in this paper, finding optimal retail outlet locations, criteria to be considered include: profitability, quality of service, urban construction criteria. Geographic Information Systems provide valuable support in this regard. GIS tools will certainly not provide exact results, but will allow to include a variety of factors into consideration without increasing considerably data processing time. By analyzing and combining the layers formed, they reached helpful conclusions not only in finding an optimal location but also in retail network management.

- **Title of Study 2:** A GIS-Based Approach for Evaluating ATM Partnership Opportunities
- **Name of researcher:** B. Farhan , B. (2007)
- **Study Objectives**: This paper develops a GIS-based approach for evaluating ATM partnership opportunities.
- **Methodology and Planning**:

  In this research, it is logical to employ the maximal covering location problem (MCLP) to select/evaluate potential ATM partners. MCLP will be employed to address the two issues mentioned: comparing a potential partner to an ideal partner, and considering budget constraints (i.e. number of ATMs allowed). The procedure for evaluating potential ATM partners is given as follows:

  1. Consider a study area (e.g. city or urban area).
  2. Identify the demand to be covered in the study area.
  3. Identify potential ATM sites in the study area.

  A) Identify potential sites for an "ideal" partner. This is important for comparison purposes with potential partners. It is an ideal case because it considers every possible location in the study area.

  B) Identify potential sites for the partner in consideration. Unlike the previous case, the potential sites here are the actual locations the potential partner has. Depending on the budget, part or all of these locations would be selected.

  4. Given the demand, the potential ATM sites (as defined by A and B above) and the number of allowed ATMs to locate (according to budget), solve the MCLP problem to find the optimal locations for the two cases above: A and B.
  5. Compare between the selected locations resulting from A and B above based on the coverage criterion (amount of customers covered by ATMs in each case), and recommend the best course of action.

- **Conclusion**:

  Banks expand their ATM networks basically to keep existing customers and to acquire new ones. Expanding an ATM network can be done essentially in two ways: building new locations (organic growth) or by partnering with a retailer. The first option is likely to be costly and can take a long time, so the latter may be a better option. Choosing the "right" partner is not an easy decision to make. This paper developed a GIS-based approach that could be used to help make such a decision. It takes into consideration issues that were not accounted for in previous approaches: comparing potential partners to an ideal partner and budget limitations. As shown in the paper, the developed approach was used for evaluating one or more partners so that the best option is chosen. The decision that should be made is which partner to select, or not to select any partner if they are not good enough. Additionally, this approach reduces inefficiencies by determining the appropriate number of ATMs needed to cover demand. GIS was instrumental throughout this research. As was shown in this paper, GIS was used for representing spatial data (e.g. demand represented using grid cell centroids), processing spatial data (e.g. performing spatial queries and buffers to determine uncovered demand), preparing the data for the spatial optimization model (i.e. writing a computer code in Avenue to be solved by the optimization software), validation (i.e. showing the solutions of the optimization model on the map to assure that the model is applied properly) and display purposes (i.e. mapping).

Chapter 3

Methodology

3.1 Study Area

3.1.1 Overview

Khartoum is the capital and second largest city of Sudan and the African continent. It is located at the confluence of the White Nile, flowing north from Lake Victoria, and the Blue Nile, flowing west from Ethiopia. Khartoum is a tripartite metropolis with an estimated overall population of over five million people, consisting of Khartoum Proper, and linked by bridges to Khartoum North (al-Khartoum Bahri) and Omdurman to the west.

Khartoum Proper is a city or a locality in Khartoum state and the seat of the Sudanese government and is the largest of the three cities. The older part of the city lies beside the White Nile while the newer parts, such as Al-Amarat and Khartoum Two, spread out to the south, across the railway line and the ring road, and around the airport runway. The city, both the old part and its newer extensions, is laid out mostly in a grid.

Khartoum has the highest concentration of economic activity in the country. Khartoum is the main location for most of Sudan's top educational bodies, its home to the largest airport in Sudan and rail lines. Our cosmopolitan city's range, that is historic attractions, museums, free annual events, and tourist services is unrivalled by any other Sudanese city.

3.1.2 Location

Khartoum city lies along the left bank of the Blue Nile, and forms a huge triangle. Its vertex at the confluence of the two Niles, the White Nile on its west side and the Blue Nile on its east and the base bordering Gezira State some 30Km southward. It is situated on latitude 15° 33 N, and longitude 32° 31 E.

Khartoum is located in the middle of the populated areas in Sudan and the almost northeast center of the country between 16 degrees latitude north and 15 degrees latitude south and longitude 21 degrees west and 24 degrees longitude east, and covers an area amounting to 20,736km (12884 Mile) square between the West Bank of the River Nile, from North Khartoum Bahri, Shendi, River Nile State, from both the East Kassala, Kassala State, Port Sudan, Red Sea State and North East Blue Nile, from the

West White Nile, Omdurman, North Kordofan and Northwest Omdurman, Northern State, from South Wad Madani, Al Jazirah (state) and Southwest Ed Dueim, White Nile State. As shown in the following figure:

Figure (3-1): Khartoum Location

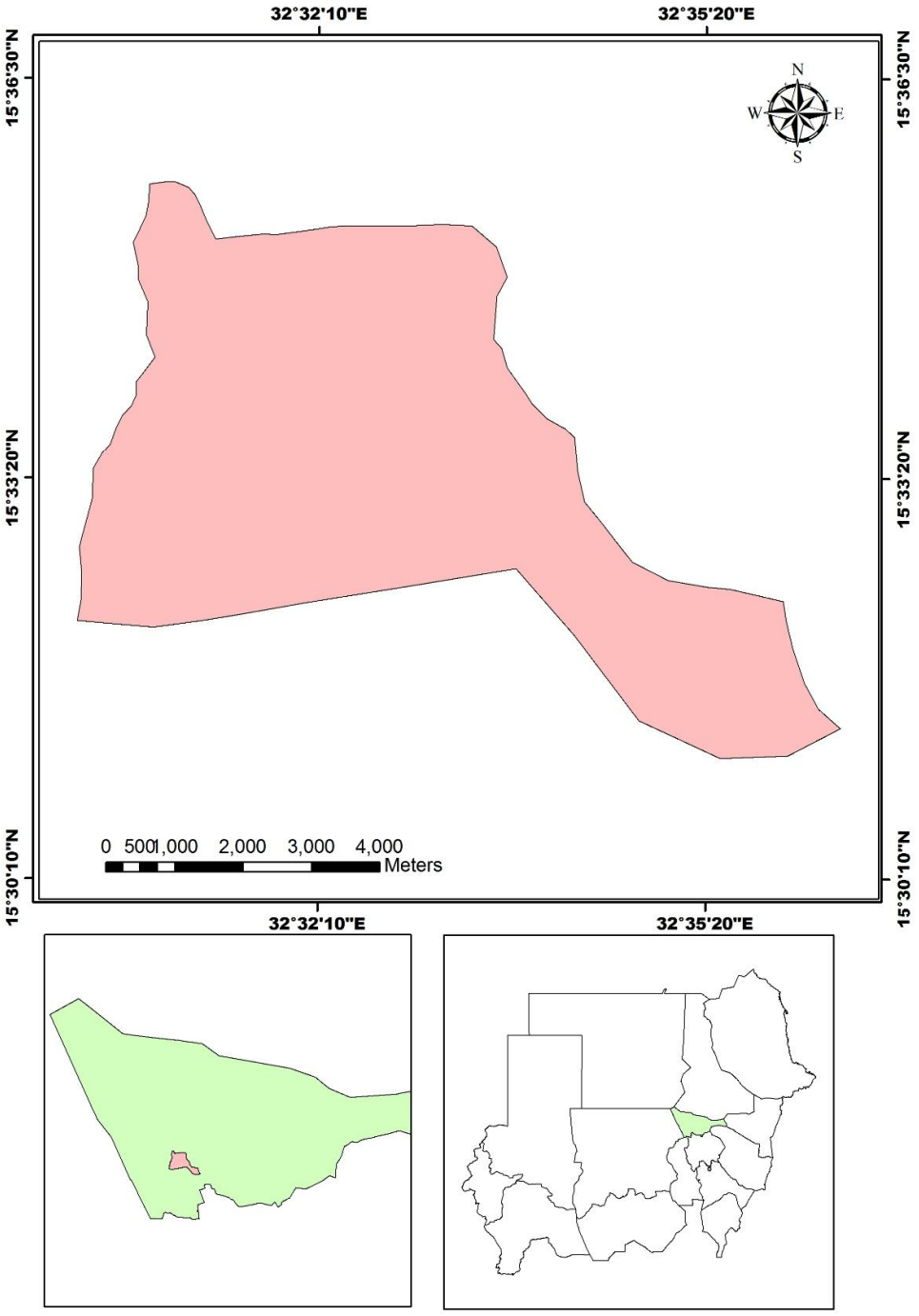


Figure (3-2): Study Area (Khartoum Locality)

3.1.3 Topography

Khartoum is located at an altitude of 382 meters (1,253,28 feet) above sea level, above the plain flat ground surface with a slight slope towards the River Nile punctuated by hills and rocky protrusions and sand dunes scattered - it is giving the image of a flat terrain with minor ripples. The two Niles (blue and white) are the most important natural phenomenon of Khartoum, where they meet at almogran point.

3.1.4 Population

Khartoum population has grown to over 5 million people. Khartoum locality is considered as a dense populated area, where the population is approximately 639,598 according to the 2008 census.

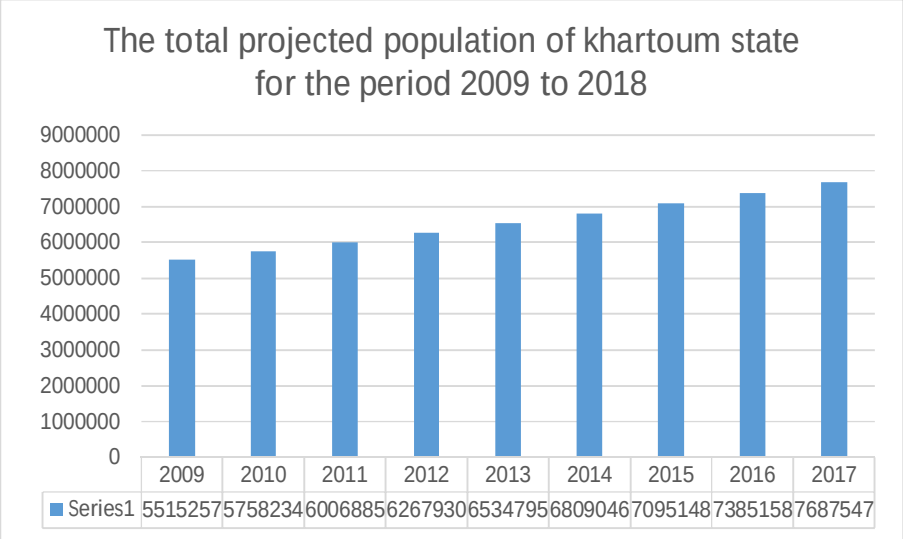


Figure (3-3): The total projected population of Khartoum state for the period 2009 to 2018

Khartoum has the highest concentration of economic activity in the country. Khartoum is the main location for most of Sudan's top educational bodies, it is home to the largest airport in Sudan and railway lines.

The population in the study area are from different Sudanese tribes which include Batahen, Magarba, Hasania, Ahamda, Mahs, Abdalab, Gaaleen, fadnia, Maslamia, Kawahla, Shokria, Ashraf and others.

3.2 Software and Tools

3.2.1 QGIS (v 2.14)

QGIS (Quantum GIS) is a cross-platform free and open source desktop geographic information system (GIS) application that provides data viewing, editing, and analysis.

Similar to other software GIS systems, QGIS allows users to create maps with many layers using different map projections. Maps can be assembled in different formats and for different uses. QGIS allows maps to be composed of raster or vector layers. Typical for this kind of software, the vector data is stored as either point, line, or polygon-feature. Different kinds of raster images are supported, and the software can georeference images.

QGIS supports dxf, shape files, coverage's, and personal geodatabases such as MapInfo, PostGIS, and a number of other formats. Web services, including Web Map Service and Web Feature Service, are also supported to allow the use of data from external sources.

3.2.2 Global Mapper (v 17)

Global Mapper is an affordable and easy-to-use GIS application that offers access to an unparalleled variety of spatial datasets and provides just the right level of functionality to satisfy both experienced GIS professionals and beginning users. Equally well suited as a standalone spatial data management tool and as an integral component of an enterprise-wide GIS, Global Mapper is a must-have for anyone who works with maps or spatial data.

Global Mapper is more than just a utility; it offers a surprisingly extensive collection of analysis and data processing tools in a truly affordable package. Providing support for virtually every known spatial file format as well as direct access to common spatial databases, this remarkable application can read, write, and analyze all of your current data.

3.2.3 Google Earth (v 7.1.5.1557)

Google Earth is a virtual globe, map and geographical information program that was originally called Earth Viewer 3D created by Keyhole, Inc, a Central Intelligence Agency (CIA) funded company acquired by Google in 2004 (see In-Q-Tel). It maps the Earth by the superimposition of images obtained from satellite imagery, aerial photography and geographic information system (GIS) onto a 3D globe.

Google Earth displays satellite images of varying resolution of the Earth's surface, allowing users to see things like cities and houses looking perpendicularly down or at an oblique angle.

Google Earth can provide a lot of information about a location, and if you were to view it all at once, it would just be confusing.

3.2.4 ArcGIS (v 9.3)

ArcGIS is a Geographic Information System (GIS) for working with maps and geographic information. It is used for creating and using maps; compiling geographic data; analyzing mapped information; sharing and discovering geographic information; using maps and geographic information in a range of applications; and managing geographic information in a database.

The ArcGIS 9.3 includes a Geoprocessing environment that allows execution of traditional GIS processing tools (such as clipping, overlay, and spatial analysis) interactively or from any scripting language that supports COM standards.

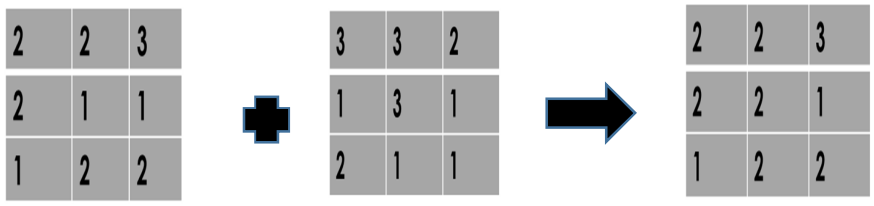
The ESRI version is called Model Builder and it allows users to graphically link Geoprocessing tools into new tools called models (similar to ERDAS IMAGINE software). These models can be executed directly or exported to scripting languages, which can then be executed in batch mode (launched from a command line), or they can undergo further editing to add branching or looping.

3.2.5 Weighted Overlay Analysis (Tools)

Weighted Overlay is a technique for applying a common measurement scale of values to diverse and dissimilar inputs to create an integrated analysis.

Weighted overlay analysis allows you to combine, weight and rank several different types of information and visualize it so you can evaluate multiple factors at once. By identifying and rating areas based on criteria, you can discover opportunities, risks, and constraints in an area. Weighted overlay analysis produces suitability models. Suitability models help answer questions like "Where are the greatest risks for insect damage?" or "Where are optimal locations for a commercial development?" The answers to these types of questions depend on your input data and the criteria you define from that data.

Illustration:



InRas1 (Influence 75%) | InRas2 (Influence 25%) | OutRas

In the illustration, the two input raster's have been reclassified to a common measurement scale of 1 to 3. Each raster is assigned a percentage influence. The cell values are multiplied by their percentage influence, and the results are added together to create the output raster. For example, consider the upper left cell. The values for the two inputs become (2 * 0.75) = 1.5 and (3 * 0.25) = 0.75. The sum of 1.5 and 0.75 is 2.25. Because the output raster from Weighted Overlay is integer, the final value is rounded to 2.

3.3 Data

The main source of information is the available maps, data collected from EBS Co. Ltd, Google earth and Open street map as show below:

#	Dataset	Description	Main Source
1	ATM Map	Feature class representing point locations of exiting ATMs.	EBS Co. Ltd 2015
2	Facilities Map	Feature class representing point locations of facilities buildings.	Google Earth 2015
3	Road Map	Feature class representing the linear roads of Khartoum locality.	openstreetmap.org 2016

Table (3-1): Dataset information

3.4 Methodology

In this research an approach has been designed to study the usability of GIS in a search of suitable sites for new ATMs in Khartoum city. For this research images were re-projected into UTM_WGS 1984_Zone 36) using QGIS software.

The workflow of methodology is given in the figure below (Figure 3.4). Different features like ATM data and facilities captured from Google earth in KML format are used, after converting into the shape file format. Furthermore, road features captured from Open Street Map in OSM format are used as well, also in shape file format. Topology was created for all layers.

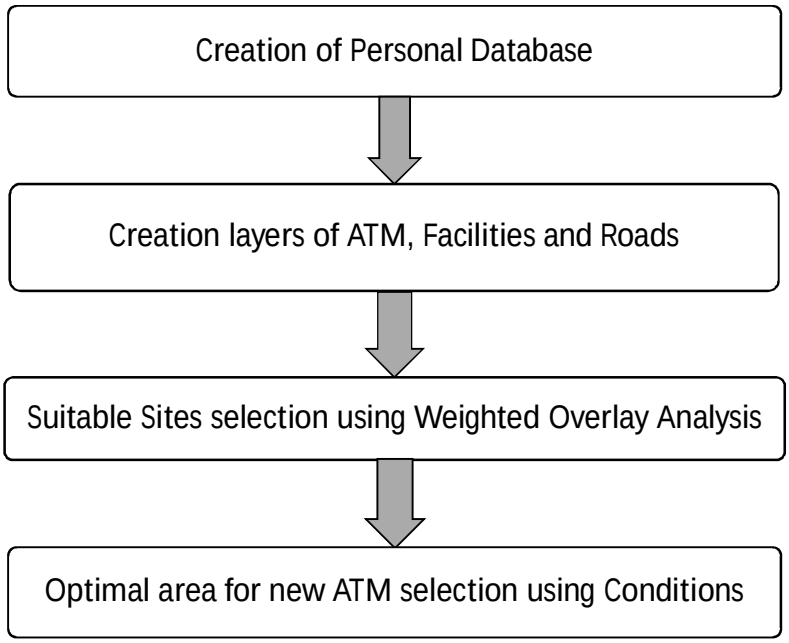


Figure (3-4): Methodology Schematics

3.4.1 Data Analysis

The objective of the Bank is to provide ATM at the nearest site for the target customer segments. The criteria which play an important role in the selection of a bank by customers are proximity to their residence or facility buildings, easy accessibility and convenience to save extra costs, energy and time for doing their banking transactions. These aspects were kept in mind for our analysis.

The Criteria for selection of optimal sites for ATMs are as follows:

- The site should be near to facilities.
- Area surrounding the site should be as far as possible from existing ATMs.
- It should be in close proximity to major roads, considering customer's safety and convenience.

For carrying out an actual analysis following the hypothesis 'Finding the best location for new ATMs' a model was built in Arc GIS to do some geoprocessing. Geoprocessing is a method that allows to chain together a sequence of tools, feeding output of one tool to another. Alternatively, it can be defined as a process to automate the workflow (Figure 3-4).

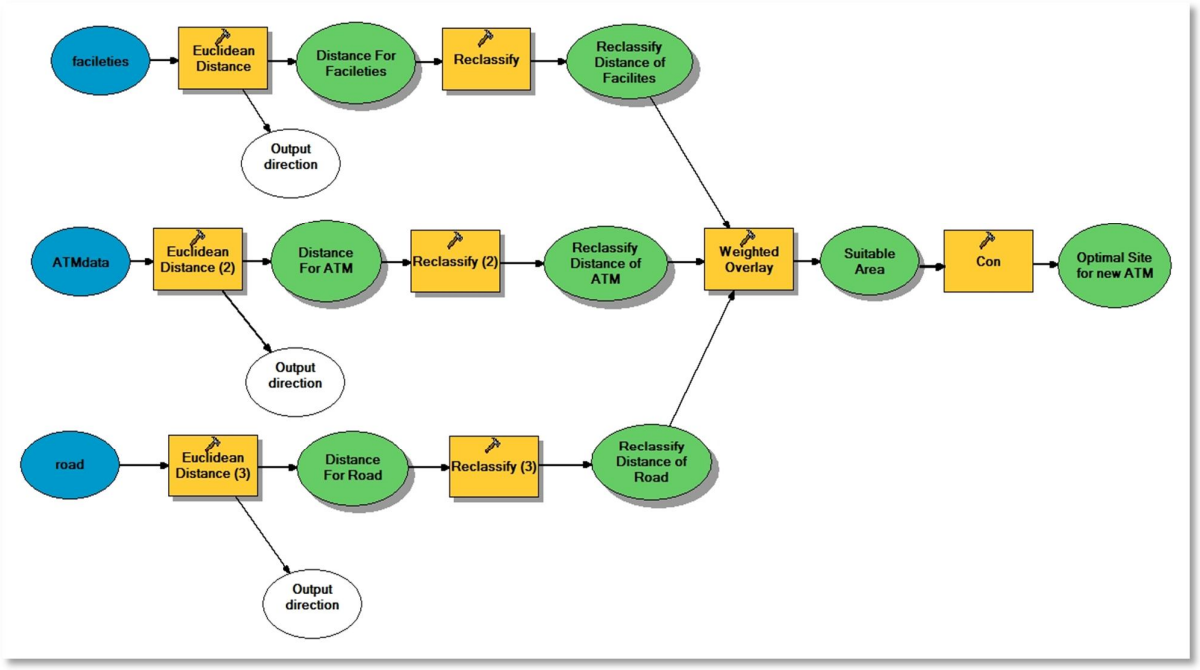


Figure (3-5): Model Builder (Finding the best Location for new ATMs) used for a Weighted Overlay Analysis

3.4.1.1 Phase I

As a first step, a map was created which was giving information about a present scenario of the Khartoum Locality (Study Area) like roads, facilities points and existing ATM of the Banks. Figure (4-1).

3.4.1.2 Phase II

As a next step, the existing ATMs were calculated in Euclidean distance. The Facilities layer was also taken into consideration which is one of the very important criteria in this analysis.

Then all output data is reclassified to bring them to the same scale which is an essential and required input for the weighted overlay analysis.

3.4.1.3 Phase III

Weighted overlay analysis is used for locating the potential sites for new ATMs. This technique is used to compare three diverse factors on a common scale and weight them according to their importance. In this analysis the facility points is given a highest weight, because the location of ATM should be near to facilities. Furthermore the convenience of customers, who are spending money in the market places, hospitals, restaurants and colleges, are taken into account. The existing ATMs are assigned the minimum weights and it is considered to locate new ATMs far from existing ATMs.

Then a conditional tool is used for reducing the number of optimal sites. Sites located by the weighted overlay are having suitability values (as shown in Table 3-2). The attribute value is assigned to be from 1 to 10 - 1 is the worst and 10 is the best suitable area (Figure 4-2). In the conditional expression, all areas with a value of 10 will retain their original value 10. Areas with a value of less than 10 will be changed to No Data (Figure 4-3).

Raster	Influence (%)	Attribute Table	Scale
Facilities	50%	1	1
		:	:
		10	10
Roads	30%	1	1
		:	:
		10	10
ATM data	20%	1	1
		:	:
		10	10

Table (3-2): Showing values assign to each layer to perform Weighted Overlay

Chapter 4

Results and Discussion

The results of this research study is the ability of a GIS to be a very efficient decision making tool for the banking sector mainly in finding the suitable sites for locating new ATMs. GIS can form a decision support system with the help of models that has been generated by using permutations and combinations of different criteria.

In this chapter we present the results of each phase and discuss it.

4.1 Phase I

Figure (4-1) shows a present scenario of Khartoum Locality (Study Area). It contains three layers of facility buildings, existing ATMs and roads of Khartoum locality. These layers are representing the important data for this research.

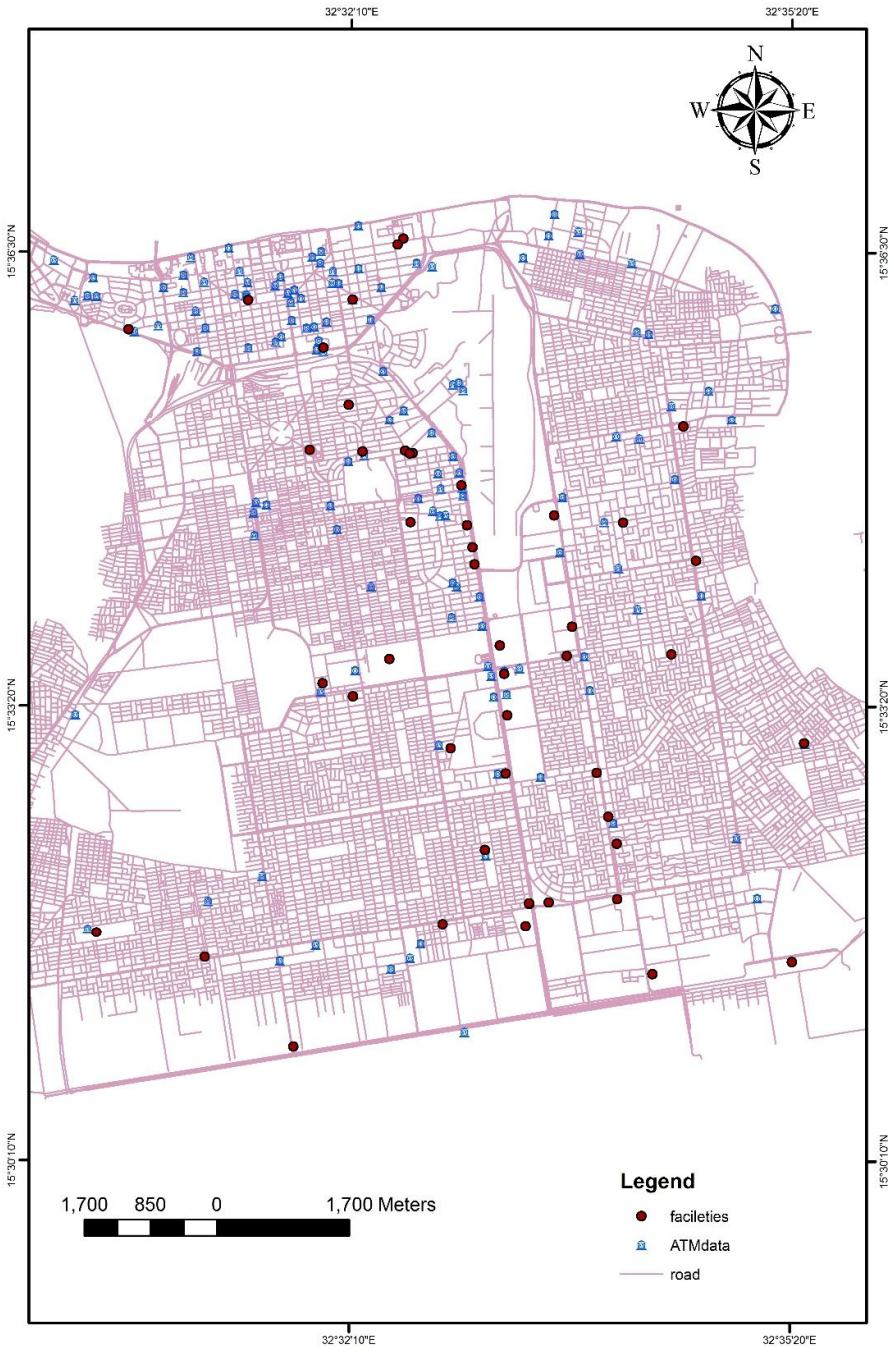


Figure (4-1): Present Scenario of Khartoum Locality (Study Area).

4.2 Phase II and III

Figure (4-2) shows the suitable area for the locations of new ATMs after applying the Euclidean Distance and Classification on the layers of ATMs, Facilities and Roads. After considering all layers in a Weighted Overlay Analysis we can select the suitable area for ATMs locations. Sites selected by a weighted overlay are having suitability values. The attribute value is assigned from 1 to 10 - 1 is the worst and 10 is the best suitable area.

Finally, after performing a multi-criteria analysis using the weighted overlay tool sixteen optimal sites for locating ATMs centers were identified in the extension of the study area (Figure 4-3). Obviously the optimal of these suitable sits for locating ATMs is in the area of International University of Africa, because it compatibility with the chosen criteria and it in educational area.

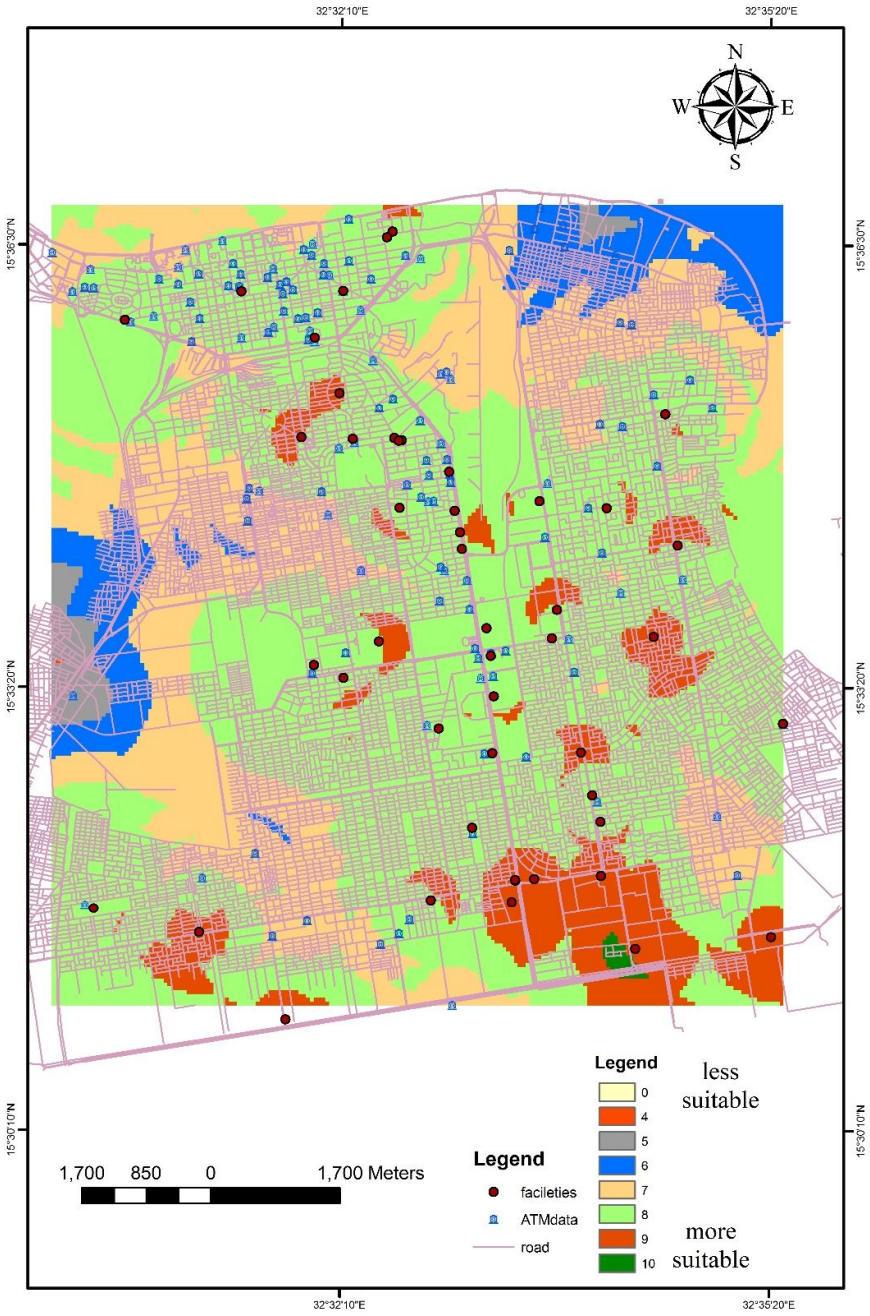


Figure (4-2): Shows the best suitable area for the locations of new ATMs.

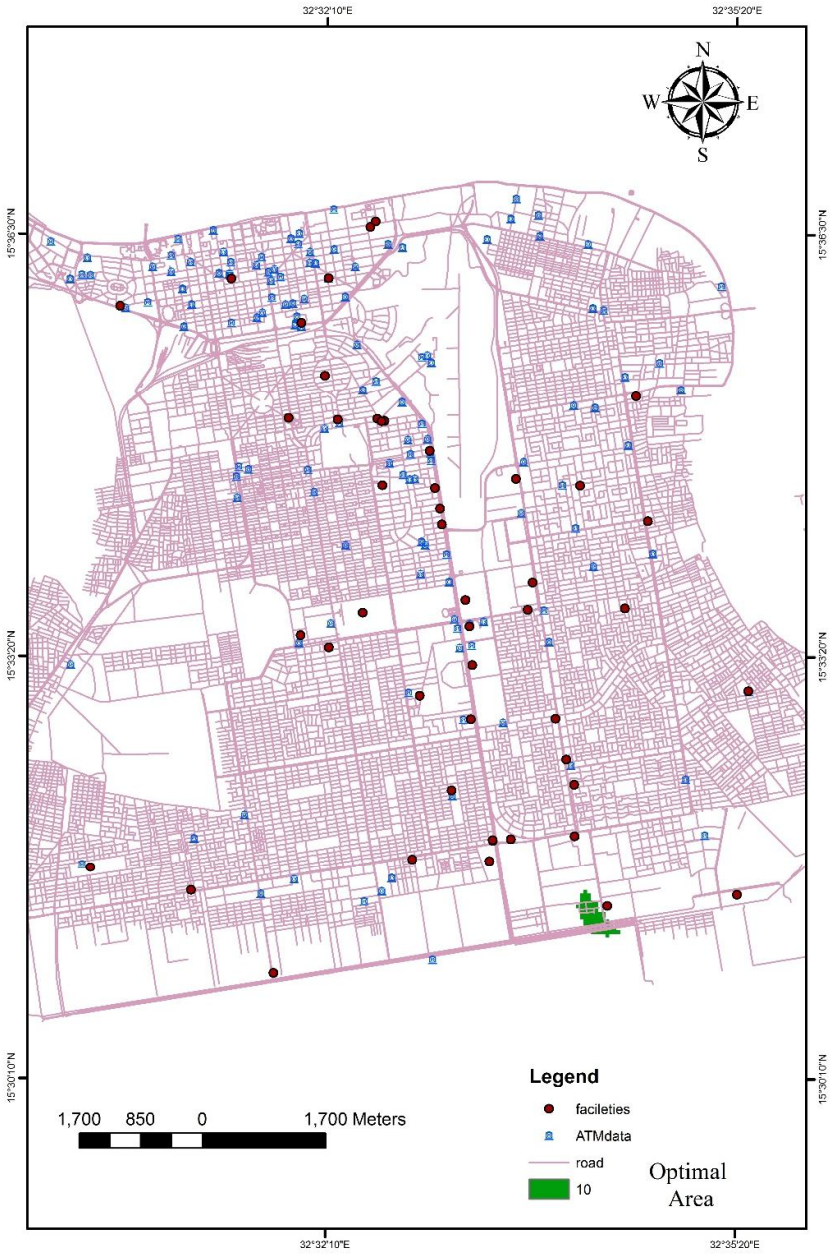


Figure (4-3): Shows the optimal area for the locations of new ATMs.

Chapter 5

Conclusions and Recommendations

5.1 Conclusions

From the study we learned about the role of Geographic Information System and their advantages, when used in finding the best location for new ATMs. This task has been achieved successfully by considering the customer as a center of activity, then the facilities offering money and other services, as this the most important means of bank services and ultimately for the benefit of a bank.

ATM location modeling give us an advantage and put a decision maker in a good position to decide about the best location, when he needs to build new ATMs. We have demonstrated by simulations that we can predict the potential ATM areas, which means that we can take a decision before ATM location is finally built.

The study shows the roads and facilities affect the location of new ATMs in the study area, where the best location for new ATMs is the presence of the main roads and facilities near to the site.

5.2 Recommendations

This is a kind of pilot project, which can be taken and directly implemented on smaller areas. It can also be implemented on larger areas by refining the criteria that has been considered for locations. A stand-alone user interface can also be made to help customers to locate the nearest ATM from the ATM centers.

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