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Assessment Of Public Services Using GIS Analysis

تقييم الخدمات العامة باستخدام تحليل نظم المعلومات الجغرافية

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ABSTRACT

Umm Durman City suffers from several problems and challenges, represented in randomization of public services and non compliance with planning standards in spatial distribution in line with the increase in population and urban expansion.

The main aim of this study is to provide an overview of the spatial patterns of public services distribution and to investigate the relationship between public services locations and population size of Umm Durman City. To achieve this aim was relied on data available in government institutions. The methodology of study had followed the descriptive and analytical approach based on the results of the census carried out by Sudanese National Bureau of statistics in 2008.

This study analyzes the spatial distribution of public services based on population density, the measuring level of availability of public services using population size indicator contributes to the debate of spatial equity in distribution of these services.

The services studied were (health facilities, petrol stations, markets sector), much attention had been given to health facilities, particularly governmental health centers, because health and access to health care services are important factors for economic development, on other hand the study of health centers is essential particularly in providing population with the basic health needs.

This study used spatial analysis based on various GIS techniques. the final result of this research reveals to an imbalance for the distribution of public services, these services are not uniformly distributed among all districts in the study area, spatial distribution do not fit the size of the population and there is a lack of public services, so this study suggested that a sufficient number of public services should be provided to serve areas where there is no adequate services.

المستخلص

تعاني مدينة أم درمان من عدة مشاكل تتمثل في التوزيع العشوائي للخدمات العامة وعدم الالتزام بالمعايير القياسية للتخطيط في التوزيع المكاني بما يتماشى مع الزيادة في عدد السكان والتوسع العمراني.

الهدف الرئيسي من هذه الدراسة هو تقديم لمحة عامة عن الأنماط المكانية لتوزيع الخدمات العامة والتحقق في العلاقة بين مواقع الخدمات العامة وحجم سكان مدينة أم درمان. ولتحقيق هذا الهدف تم الاعتماد على البيانات المتوفرة في المؤسسات الحكومية. وقد اتبعت منهجية الدراسة المنهج الوصفي والتحليلي استناداً إلى نتائج التعداد الذي أجراه المكتب الوطني للإحصاء في عام 2008.

تحلل هذه الدراسة التوزيع المكاني للخدمات العامة القائمة على الكثافة السكانية، حيث يساهم مستوى قياس توافر الخدمات العامة باستخدام مؤشر حجم السكان في مناقشة المساواة المكانية في توزيع هذه الخدمات.

الخدمات التي تمت دراستها هي (المرافق الصحية، محطات الوقود، قطاع الأسواق)، وقد تم ايلاء الكثير من الاهتمام لدراسة المراكز الصحية لا سيما المراكز الصحية الحكومية، لأن الصحة والحصول على خدمات الرعاية الصحية من العوامل الهامة للتنمية الاقتصادية، من ناحية أخرى المراكز الصحية ضرورية خاصة في تزويد السكان بالاحتياجات الصحية الأساسية.

استخدمت هذه الدراسة التحليل المكاني على أساس تقنيات **GIS** المختلفة، النتيجة النهائية لهذا البحث تكشف اختلال التوازن في توزيع الخدمات العامة، وأن هذه الخدمات ليست موزعة بشكل موحد بين جميع المناطق في منطقة الدراسة، والتوزيع المكاني لا يناسب حجم السكان وأن هناك نقص في الخدمات العامة، لذا اقترحت هذه الدراسة أنه ينبغي توفير عدد كاف من الخدمات العامة لخدمة المناطق التي لا توجد فيها خدمات كافية.

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CHAPTER ONE

INTRODUCTION

1.1 General Overview:

In any city, services and public facilities are considered as the beating heart of the body. Without these services and facilities, it is difficult for a human being to imagine that there is a suitable life called a civic life. The most important features and foundations of civic life are the availability of public services and facilities that facilitate the livelihoods of people in large communities and achieve their human.

The situation of public services and facilities are varies from one city to another according to several factors and according to this difference living in cities is classified as upscale or backward.

The status of public services and facilities vary in cities from one city to another and from one country to another there are cities where these services and facilities are available with a high degree of efficiency and there are cities where these services and facilities are available with a medium degree and are subject to many difficulties in many respects, and there are cities that suffer from a severe shortage and a significant underdevelopment in their services and public facilities this is the result of a number of reasons, which may be economic, technical or otherwise.

Public services is a service which is provided by government to people living within its jurisdiction, either directly (through the public sector) or by financing provision of services. such as institutions, authority, sectors and others. These services provide public services to all citizens in the country, providing for their needs, managing their affairs and taking care of their interests, In other words it can be said that the Public services are all that citizens benefit from continuously, regardless of income, physical ability or mental (so this services should be available to all).

Public services are an integral part of the physical structure of the territory, city, town or neighborhood. Therefore, the development of public services must be parallel to the

urban development of the area or city. The main task of these services is to meet the needs of the population in the form and type required.

Since public services are the basic foundation upon which people develop and advance, and it seek to solve the problems facing society whether educational, health, recreational, social or economic, etc. so must be planned parallel to population increase and urban development for the area. Public services should be carefully planned. so absence of proper planning of service areas might leads to deterioration in the living environment of the city.

Umm Durman City is a center for population growth (as a result of internal migrations), so the aim of the research is to conduct a study that illustrates the current distribution and spatial planning of some public services (health facilities, hospitals, petrol stations and markets) in a scientifically way by spatial analysis

GIS technology is a modern tool for scientific research, so it has been used in this study, This technique leads to the creation and creation of new and multiple patterns such as data output in the form of maps, graphs or high quantitative analysis, To take the scientific decision proper and appropriate. Furthermore GIS can be used for many different purposes in public services, especially in planning and management.

1.2 Problem Statements:

The study area suffers from a lack of public services in general and low efficiency of spatial distribution (random distribution), also suffers from not taking into account the Principles and standards of spatial and geographical planning of these services This is evident in its availability in areas more than others, In addition the planning for public services was not on High efficiency that meets the needs of the community, and this reflected in the imbalance of public services. Also It has been demonstrated that alot of areas are limited accessibility to public services.

1.3 Research Importance:

- The growing population growth and urban development witnessed by Umm_ Durman city community in recent years requires a study of the public services that must be provided to the population in a manner that should meets all their requirements and daily needs.

- Umm Durman City is Considering an important part of the state of Khartoum and a center of tremendous growth of the population, which forms the bulk of the state of Khartoum, the capital of the country.
- Umm Durman City is one of the urban centers and center of internal migration.
- The study deals with the most important sectors in which the progress of peoples is measured:
  - The health facilities sector, Health one of the major indicators of development.. Communities suffering from disease and epidemics can not progress much in the development process and it is also one of the basic demands in human development.
  - The importance of petrol station service as it is one of the most important transport services to provide Source of operation and movement of all types of vehicles.
  - The importance of markets Where it is considered Shopping is essential in our lives. Because we need something: food, clothes, shoes, something ... etc.

1.4 Research Objectives:

The main objective of this research is to:

- Study the current situation of distribution of health centers and comparison with the standards adopted by the Sudanese Ministry of Health.
- Identify the adequacy of health services in the study area and compare them with the population of the area.
- Examining the availability of hospitals and the areas covered by them.
- Identify the geographical distribution of petrol stations in the study area, and its relationship to population density in the region and the adequacy of these stations and whether there is a relationship between the increase in population and increase the number of petrol stations.
- Know and analyze the arrival of civil defense to petrol stations in the event of fire.
- Identify the geographic distribution of the markets, and then know how efficiency and ability the arrival of police In case something happens.

- Demonstrate the potential of GIS technology in the application of the spatial analysis methodology for service areas locations by using appropriate analysis tools (GIS plays an important technical role in spatial analysis).
- Develop appropriate proposals and recommendations for decision makers to take into consideration when establishing new service areas and to improve the current status of the study area.

1.5 Methodology Of The Research:

The study followed the descriptive approach in addition to the analytical method (which is concerned with data in terms of classification, classification and evaluation) by using geographic information system (GIS) based on the Population Census data (National Census 2008- National Bureau of statistics).

1.6 Previous Studies:

1.6.1 Gomaa M. Dawod and others (2013), the spatial fairness of public services is a major aspect in offering a healthy and cheerful living environment in a city. The Geographic Information System (GIS) technology has been applied to investigate the spatial distribution of some selected public services over the municipal election areas within Makkah city, Saudi Arabia. These services include education, health, security, religious, commercial, and sports services.

Results of GIS spatial analysis (particularly the Euclidian distance, the mean distance band to a neighbor, the standard distance, the directional distribution ellipse, and the average nearest neighbor ratio tools) have concluded that there is inequity in the services distribution over municipal election areas in Makkah City. Consequently, it is recommended that local planners and decision makers should take the obtained results into consideration to achieve fair and better distribution of public services in the city.

1.6.2 Nader Zali and others (2016), In this study a descriptive-analytical method was used. Geographical scope of the research was Tabriz city and the statistical population included all regions in the city. Main objective of this study is to investigate the distribution of services in ten regions of Tabriz and rank them based on accessibility to public services.

Objective of research was to Studying the distribution of services in different regions of Tabriz; and ranking different regions of Tabriz in terms of the distribution of public services considering the residents' idea, accessibility and population living in those regions and presenting strategies in order to achieve spatial equality in the distribution of public services.

The results indicated an inequality in the distribution of public services compared to the population (per capita land use) and the residents' accessibility and demands.

1.6.3 Shawky Mansour (2016), The main aim of this study is to provide an overview of the spatial patterns of health facility distribution and to investigate the relationship between health facility locations and population size of urban districts of Riyadh Governorate. Spatial analysis techniques within GIS environment provide analytical capabilities to explore health service delivery and examine whether there is a significant variation among districts in public health provision and accessibility.

GIS has a potential role in assessing the geographic distribution of health services, in particular evaluating the effectiveness of health facility coverage relevant to population density. Various GIS analytical tools have been used widely to recognize spatial patterns of distribution of existing health facility and find out new optimal location of facilities. the number of public or private health facilities per 10,000 population living in an administrative area is an important indicator for equity in health service supplies (WHO 2010). thus, this indicator can be used to identify areas with higher and lower coverage and allows for comparison between urban districts. In addition, this measurement has an effective role for planners and decision- makers to improve access to health services within the national health agenda.

The result was Inequalities in public health service across the governorate were measured using various GIS methods. this study has contributed significantly to the field of health facility distribution and provision and more importantly to inequalities of service availability according to population size and geographic distances. The findings of this study clearly revealed that there was a cluster pattern of public health facility distribution. Several districts were identified as underserved by public health facility and many districts were identified as lower density of public health provision.

1.7 Thesis Layout:

This thesis is organized into seven chapters:

Chapter One contains an introduction and explain the objectives and importance of the study. Chapter two reviews health facilities (the concept of availability and accessibility) and public services. Chapter three gives a detailed description of GIS (definition, role, functionality, components) and spatial analyses. Chapter four illustrate the study area, its climate, sources of data, in addition to methodology and work plan. Chapter five presents results and analysis. Conclusion and recommendations state in chapter six. Finally, the references in chapter seven.

CHAPTER TWO
Health Facilities And Public Services

2.1 Introduction:

Human life and development is based on the extent to which man can satisfy the basic needs such as food, clothing and shelter. In order to fulfill these and other needs, man requires access to certain facilities such as market, housing, water supply, electricity and adequate transportation (Adekunle et al, 2011).

Public services and facilities are essential for residents in any city all over the world in general, and in developing countries in particular. Governments start to rethink the delivery of public services in order to enhance their quality and quantity, to meet public's needs and expectations. Improving efficiency of basic public services for residents has been recognized as one of the major ways of promoting sound human settlements, good health, and appropriate and decent living conditions. Assessing efficiency of public services is multidimensional and includes several factors such as geographic and financial accessibility, availability, quantity, distribution, quality, and clients' satisfaction. However, spatial distribution is of great importance. Thus, spatial analysis of public services distribution gains an increasing attention in the last decades from both geographic and environmental per-spectives.

The spatial fairness of public services is a major aspect in offering a healthy and cheerful living environment in a city. Moreover, the issue of spatial equity of urban public facilities has proliferated recently from both planning and geographic points of view, trying to arrive to the so-called spatial justice, Diagnosing the current situation of a public service is quite essential in planning its new spatial locations in order to increase the service availability and accessibility to residents (Gomaa M. Dawod and others, 2013).

Urban growth had a great impact on public service management and compelled managers to be increasingly agile atadopting practical solutions to unforeseen problems, such as residents inequality and lack of visual balance in different regions of a city (Nader Zali, 2016).

Developing countries are characterized by a lack of public services and poor spatial distribution which caused many populations deprived from some basic public services.
Assuring a high degree of accessibility to essential services (health care facilities, supply and services, cultural and educational, recreational, etc.) is very important especially for the metropolis with high territorial dynamics (Cristina Merciu and others, 2013).
However, for improving efficiently accessibility it is required to identify the obstacles in the urban environment and to evaluate the effect (Svensson, 2010).
This research deals with the importance of geographic information systems in assessing the current situation of some public services and spatial analysis to identify the areas benefiting from these services and accessibility. Also identifying areas that are underserved or at risk of being underserved.
GIS is useful in the analysis and evaluation of the performance of public services, and identify disadvantaged areas for the redistribution of services where it serves as compared to what is already planned and what is the reality. GIS technology offers great opportunities for the development of public services applications using maps. This technology integrates database operations such as query with the unique visualization of spatial analysis benefits. In addition GIS has been applied to identify Spatial and temporal gaps in public services.

2.2 Health Facilities:

2.2.1 General Overview:

The meaning of health has evolved over time. In keeping with the biomedical perspective, Health is defined according to the World Health Organization (WHO) is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. All health-related definitions do not come out of the scope of this concept, even if the words and expressions different.
Health has become one of the most important aspects of development, It is one of the most important factors contribute of the progress and preparation of nations and peoples. development can not be achieved without a healthy population, because health has a significant impact on growth and development in all aspects. So the States are keen to take care of the health of its citizens, and provide them with the reasons for prevention

before the disease, and post-disease treatment opportunities to ensure their health and safety.

Health services are conceder great deal of importance to the individual and society, as one of the basic demands such as eating, drinking and shelter. recent advances in the field of health system have greatly improved our understanding of the role played by geographic distribution of health services in population health maintenance.

The health services include all the services provided to prevent the dangers of diseases and the administrative, technical and medical requirements that contribute to the prevention of the disease, which is the responsibility of the various health institutions, such as health centers, private clinics and hospitals.

Health facilities are one of the most important services that societies seek to provide everywhere because of their importance. also access to health care is necessary to preserve or improve the health. also critical to prevent the onset of disease as well as to identify health problems early and prevent disease progression. So the competent authorities should be focus on increasing equitable distribution and access to health facilities. The health services system has become a fertile field for many researchers.

2.2.2 The Concept of Availability of Health Facilities and Accessibility:

Healthy populations and access to health care services are significant factors influencing economic development and prosperity. Since geographic access is an essential feature of an overall health system, it is important for health service researchers to develop accurate measures of physical access to health (Eda Unal ans others, 2014).

The main goal of health service delivery is to provide equitable utilization and access to health care services. An important factor in obtaining quality care is physical access to health care as lack of spatial access can result in delayed treatment and poor health outcomes. Fundamental to addressing the issues of equity and equitable access to health care is the issue of geographical distribution (Oliver and Mossialos 2004).

Availability of health care services directly affects all aspects of health. If services are available and there is an adequate supply of services, then the opportunity to obtain health care exists. it is vital for us to understand the existing geographical distribution of health services in relation to the populations they serve.

Availability of health facilities and accessibility are conceder the key factor to provide healthy environment and to minimize disease risk. Convergence of opinions agreed that lack of basic health care facilities have led to inefficiency in production, declining productivity, reduced life expectance and increased mortality rate. Therefore, providing public health service based on population location is essential.

According to the European Observatory glossary produced on Health Systems and Policies, availability of health care is defined by the World Health Organisation (WHO) in 1998 as "measuring the proportion of the population with the access to medical services" (Simion Mehedinți, 2016).

In addition to the availability of health facilities, spatial accessibility is a necessary albeit for healthcare services for all population segments of society, whether they reside in urban agglomerations or in peripheral rural areas. Spatial barriers most notably long travel distances to health care facilities are significant factors contributing to the exclusion from medical care. Where often lower proportion of patients tends to use services at closed distance from their dwellings.

The main goal of most public healthcare systems is to improve or achieve a healthier population. Physical Access to health services is one of the first steps in maintaining and improving population health (Eda Unal ans others, 2014).

Accessibility mainly depends on the availability and affordability of the services. Ensure that all the sectors of the society should have equal and adequate access to Primary healthcare, regardless of socio-economic and geographic factors. This is key factor to provide healthy environment and to minimize disease risk (Samson Mathew and others, 2017).

The optimum access to health care means a state of affairs characterized by the provision of care and timely intervention of medical staff or paramedical authorized in situations that require the presence of the provider of health services to the home or place in which the patient is (Simion Mehedinți, 2016).

Accessibility refers to the relative ease of access to a given location. As a general rule, previous studies have identified 2 criteria—availability of services and accessibility to services as the components of the overall spatial accessibility of people to services (S. Reshadat and others, 2015).

Many studies have shown that there is a relationship between the health level of the population and the distance from the sites of health services Therefore, the health level is improved through the geographical redistribution of the sites of these services so that they are closest to the sites of population density, and the establishment and opening of new health service centers to meet the needs of the population.

Inequalities in spatial accessibility to health care are pronounced in many emerging countries but also persist in developed countries where medically underserved areas are often encountered in rural areas (Joseph and Bantock, 1982, Fryer et al., 1999, Robst and Graham, 2004).

The use of GIS in health-care research has increased dramatically in recent years, Geographic Information System (GIS) plays an increasingly important role in understanding and analyzing accessibility to health care services. In particular, the ability of GIS to highlight the spatial dimensions of accessibility, also in assessing the geographic distribution of health services, in particular evaluating the health facility coverage relevant to population density.

Health facilities at any region can be divided into two main types that are known as primary health centers and hospitals.

The former provides basic health care services and the latter provides services for specialist health treatment. Health authorities have always aimed to provide health care for all residents using a fair access policy that is characterized as providing the right service at the right time in the right place (Murad, 2006).

2.2.3 Primary Health Care:

Primary health care is essential health care based on practical, scientifically sound and socially acceptable methods and technology made universally accessible to individuals and families in the community through their full participation and at a cost that the community and country can afford to maintain at every stage of their development in the spirit of selfreliance and self-determination. It forms an integral part both of the country's health system, of which it is the central function and main focus, and of the overall social and economic development of the community. It is the first level of contact of individuals, the family and community with the national health system

bringing health care as close as possible to where people live and work, and constitutes the first element of a continuing health care process (Declaration of Alma-Ata, 1978).

Primary health care (PHC) is an imperative strategy to providing "health for all" and is widely acknowledged as a universal solution for improving population well-being in the world (World Health Organization and UNICEF 1978). PHC is crucial as it is a very cost-effective method of health care (more affordable and easier to deliver than specialty or inpatient care). Therefore if PHC is equitably distributed it can play important role in preventing diseases and decreasing health inequality on a large scale in society (Guagliardo, 2004).

The ease of access to primary healthcare services and availability of primary health care providers are important aspects of the healthcare delivery system (Aday and Anderson, 1981).

In the context of accessibility of PHC, WHO's rule is universal access regardless of where the people live or work (World Health Organization and UNICEF 1978). However, there are some unofficial guidelines from the WHO, for example, one General practitioner for every 1000 people (Nasser Bagheri and others, 2005).

One of the major problems confronted by health-care managers, especially in underdeveloped countries, is the uneven distribution of healthcare centres in urban regions. This imbalanced geographical distribution can lead to inefficiency in the offered services and inequalities in access to services, since the necessity to travel long distances to reach health-care services inhibits patients' use of the services and leads to increases in inequalities in health (S. Reshadat and others, 2015).

2.3 Petrol Stations:

Despite the importance of oil as a supplier of energy and driving forces, it is a direct source of pollution and a threat to the safety of citizens, This requires efforts and coordination among all parties to consolidate the concept and importance of safety and environmental protection.

During the last decade of the twentieth century, Sudan witnessed major developments in the development process, especially in the oil industry, followed by a significant increase in the work of oil companies in all stages of the industry (exploration, production, distribution and marketing). Thus, there was a significant change in the fuel service

stations, Which requires to know the methods That used to achieve security and safety of these stations, especially as these stations are a major danger within residential areas.

Transport is one of the most prominent phenomena of the movement from one place to another, the movement is the lifeline, so the role played by transport becomes more important with the spatial expansion and population growth, and petrol stations are a vital part of land uses for transportation, it is one of the most important transport services to provide Source of operation and movement of various types of vehicles So it should be available in most parts of the area As they provide an appropriate amount of smooth movement and ease of moving from one place to another, petrol stations are a major source of the movement of cars in the streets by supplied from it, so its importance stems from spatial considerations in terms of geographical distribution and spatial location.

A petrol station, petrol station, fueling station, or service station is a facility which sells fuel and lubricants for motor vehicles are refueled, lubricated, serviced, and sometimes repaired. Petrol stations should be located not only where they are in fact accessible but where they can be easily located by strangers and that, in details, they should be placed where they will be little danger and congestion as possible. Most petrol stations sell petrol or diesel, some carry specialty fuels such as liquefied petroleum gas (LPG), natural gas, hydrogen, biodiesel, kerosene, or butane while the rest add shops to their primary business, and convenience stores {Ayodele, 2011; Abdul Hamid et al., 2009).

The increase in urban population and the growth of the number of cars and other vehicles generate various kinds of demands, one of which is fuel. A considerable amount of cars fuel is wasted due to the long urban paths and unnecessary trips. Increase in vehicles triggered increasing demands for fuel and by extension fuel station, since engines are made to use petroleum products and Petrol station are the places where fuel is sold (Odeh Jameel El Faleet, 2017).

2.4 Markets Sector:

A market is a location where buyers and sellers come into contact to exchange goods or services (place of trade and shopping). Markets can exist in various forms depending on various factors, in the past there was one market in the town, but it became everywhere with the development of people and their needs, and it is the second built in the city after the mosque for its importance in people's lives.

Markets are suffer in the rich, medium and poor countries of the world From some negative phenomena such as theft (both from stores or citizens) and Clashes between people. markets and shops annually suffer large losses as a result of the theft of many goods.

Recently there has been a serious phenomenon of thefts in markets (especially in Eid) by people of different nationalities in the theft of mobile phones, bags, etc. on the public market premises or from cars in a frightening manner. so the purpose of the market sector study is to check the security of the market, in other words to find out how quickly the police arrive if something happens

There is no doubt that we all need to live in security and stability, the person in his life needs to security on himself, and his money. Security is a human need and a human necessity. Therefore the availability of security helps citizens in the state to carry out human activities with ease, and with high efficiency, fear hinders both of activity, creativity and work.

Security needs is one of the basics for human survival; indeed it is second to food and closing. According to Abraham Maslow's theory of hierarchy of human needs security is the second need. Police departments are on the duty of protecting the citizen's safety and taking safety measures to reduce the risk of breaking the law. (M. Ahmed and others, 2013).

Police are law enforcing agents whose main function is to provide security and mention law and order in the societies, states and nations. Security in the country is one of the greatest blessings enjoyed by the population

CHAPTER THREE
GIS AND SPATIAL ANALYSIS

3.1 Geographic Information System:

3.1.1 GIS Overview:

A GIS is a digital computer application designed for the capture, storage, manipulation, analysis and display of geographic information. Geographic location is the element that distinguishes geographic information from all other types of information. Without location, data are termed to be non-spatial and would have little value within a GIS. Location is, thus the basis for many benefits of GIS: the ability to map, the ability to measure distances and the ability to tie different kinds of information together because they refer to the same place (Longley et al. 2001).

"Every object present on the Earth can be geo-referenced", is the fundamental key of associating any database to GIS. Here, term 'database' is a collection of information about things and their relationship to each other, and 'geo-referencing' refers to the location of a layer or coverage in space defined by the coordinate referencing system.

The basic concept of geographic information systems is to arrive at the right decision based on the processing and analysis of geographically defined spatial data, where GIS is characterized by the rest of the information systems strongly analyzing the data associated with the correct geographical location and spatial relations between them. and has the ability to link high spatial data Of the phenomenon with its descriptive data and the treatment and analysis.

Work on GIS began in late 1950s, but first GIS software came only in late 1970s from the lab of the ESRI. Canada was the pioneer in the development of GIS as a result of innovations dating back to early 1960s. Much of the credit for the early development of GIS goes to Roger Tomilson. Evolution of GIS has transformed and revolutionized the ways in which planners, engineers, managers etc. conduct the database management and analysis.

GIS is very important in every day emergencies circumstance such as emergency health care provision, monitoring demands and intervention over time (Moore). It can determine the "response times" needed for individual stations to service their areas within target timescales or may be analyzing data from road traffic accidents to find the hot spots where more control is needed (Balqies Sadoun and Samih Al-Rawashdeh, 2009).

The global Internet and GIS can work jointly to provide access to distributed data (spatial & nonspatial) located at geographically isolated locations and shared dynamically for better decision making nationally or internationally in all times (Ghosh and Samaddar).

3.1.2 Definition Of GIS And Scope:

A Geographic Information System (GIS) is a computer-based information system for input, management, analysis, and output of geographic data and information. It deals with collection, storage, retrieval, manipulation, analysis, and display of spatially related information. GIS systems are important tools for managing natural and other resources at all scales ranging from local to global. GIS capabilities include the overlay of information provided by different thematic maps according to user-specified logic as well as derivative map outputs.

Although GIS has been around since the 1960s, applications have expanded in the 1990s. Many software systems have now been developed to cover a wide range of fields such as earth and environmental sciences, natural resource management, terrain modeling, agriculture, forestry, construction engineering, land use policy and development control, population distribution, settlement, transport, education, and health planning. The expanded use of GIS in many areas of resource development has also necessitated the need for modern systems that incorporate analytical models with integrated powerful query languages to provide solutions to many spatial problems.

Due to the multiplicity and diversity of applications, task-specific systems have been developed. They include systems for engineering, property-based information, generalized thematic, statistical and land-parcel mapping, environmental planning systems, and image processing systems associated with Landsat and other remotely sensed data (Ondieki, C. M., and S. Murimi, 2009).

A geographic information system is therefore a system dealing with geographic information about a particular space with a defined boundary. It combines technical and

human resources with a set of organizing procedures to produce information in support of decision making, as shown in Fig (3.1).

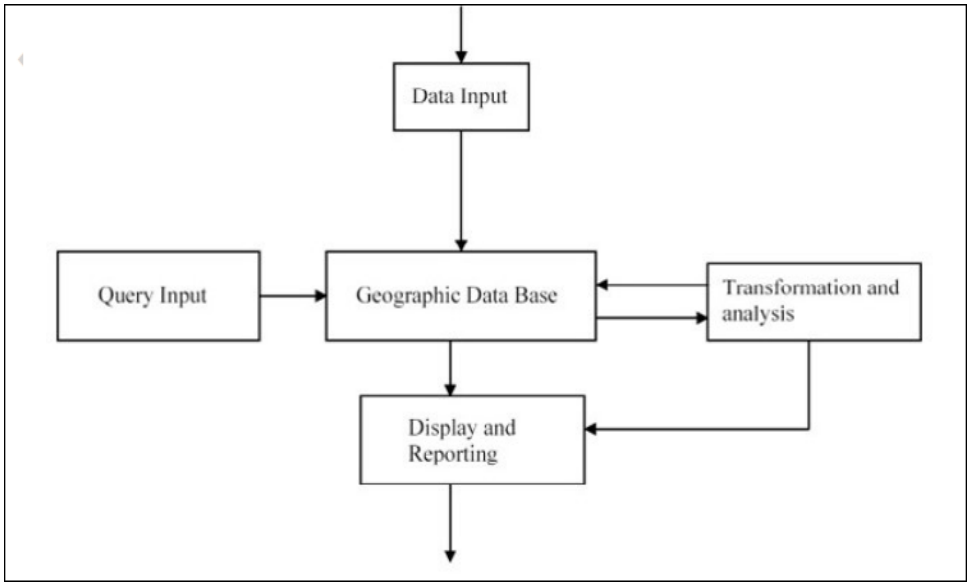


Fig (3.1) Components Of Computer-Based GIS

GIS operates on two data elements: spatial and attribute data. Spatial or geographical data refers to a known location on the Earth's surface. Usually this is expressed as a grid coordinate or in degrees of latitude and longitude. Most organizations make use of implicit geographical references as place names, addresses, postcodes, road numbers and so on; implicit spatial references can usually be geocoded into explicit spatial references. Technological advance, particularly in software and hardware, has resulted in the development of systems which provide a range of searching, querying, presentation and analytical functions in a more user-friendly manner (Verka Jovanović, 2008).

3.1.3 The Role Of GIS:

The role of a GIS is to enable the capture, storage, and manipulation of data in a structured form, therefore allowing the use of analytical techniques on the spatial dimensions of problems. With a GIS, analysis and depiction of spatially referenced information as well as dissemination of results of analysis using thematic maps is possible. Environmental science and other disciplines have generated enormous amounts of data of many different types, and this is bound to increase in future.

A GIS is needed to store, display, and bring together data sets for improved data extraction and integration (see *Monitoring at Various Spatial and Temporal Scales*). research can benefit from GIS-based data for modeling and simulation (Ondieki, C. M., and S. Murimi, 2009).

3.1.4 Functionality of GIS:

GIS functionality refers to the set of functions that a GIS can perform. The GIS provides the following set of capabilities for spatially referenced land related data and information: data input, data storage and retrieval, data manipulation and analysis, and data output and reporting.

3.1.4.1 Data Input:

This function involves the identification and collection of data necessary for processing in the GIS as obtained from the various sources. These data are entered and verified using scanners, digitizers, and graphic displays driven by appropriate software. Part of the data input may also include format conversion, error detection, and topology construction.

(1) Keyboard: Attributes data are commonly entered by keyboard during manual digitizing or as a separate operation in which the attributes are entered with a code to indicate the spatial element they describe. The attribute file is subsequently linked to the spatial data. manual digitizing is the most widely used method for entering spatial data from maps.

(2) Manual Digitizing: In manual digitizing, the map is affixed to a digitizing table and a pointing device is used to trace the map features. To digitize, data are registered on the digitizing table, then input into the GIS, transformed to standardized world coordinates, and finally, the various features are assigned attributes. The steps followed are:

a) Preparing the map sheets. The features to include are marked in pencil.
b) Digitize the coverage by moving the digitizer as accurately as possible along features.
c) Identifying and correcting errors in digitizing.
d) Define features and build topology by ensuring no overlap in features.
e) Assign attributes to coverage features such as river names, vegetation types, and location information.

(3) Scanning: A scan of a digital image of the map is produced by moving an electronic detector across the map surface.

(4) Import of Existing Digital Files: This involves converting information using a computer text editor to create flat files that list a series of data coordinates. To produce a land use map, for example, classified remotely sensed imagery is used together with digitized topographic detail and point data from a flat file. Import of digital files allows one to combine classified data for a particular geographical area with other geographic referenced data sets for the same area.

3.1.4.2 Data Storage and Retrieval:

The purpose of data storage and retrieval is to organize the data in a topographically structured form so that it can easily be retrieved for subsequent manipulation, analysis, and display. In addition to supporting multiple users and databases, security and data integrity are ensured.

3.1.4.3 Data Manipulation and Analysis:

This functional component performs a number of tasks, mainly geometric calculations, map-overlay computations, network analysis, and production of estimates of parameters for transfer to external analytical models; all through user-defined rules (see *Analysis and Utility of Monitoring Data*). Through various operations, this function enables the use of spatial and non spatial data contained in the GIS database to answer questions about the real world.

Stored map layers in the database need to be updated, edited, and manipulated for desired results. Analysis may involve overlaying several map layers, and selecting, retrieving, and extracting certain measurements from the data. These functions are performed by GIS system software commands.

By conducting a series of GIS processing operations, it becomes possible to answer queries for a GIS system. For example, the areas most prone to erosion when changes in vegetation cover are made within a watershed can be identified, and how much agricultural land or forest area will be lost when building a road by selecting alternative routes can be quantified. These queries and their answers form the basis for geographical data modeling in a GIS.

3.1.4.4 Data Output and Reporting:

Output for all or selected portions of the spatial database are displayed using standard or cartographic formats (see *Regional and Global Geoinformation Systems*). Various hardware devices, such as plotters, displays, and printers, may be used for output presentation of maps, tables, and figures. Information is thus presented in a form suitable to the user, usually in either hard copy, "softcopy," or using electronic files or format.

Hardcopy outputs are permanent means of display. The information is printed on paper, photographic film, or similar material. Maps and tables are commonly output in this format. "Softcopy" output refers to viewing on a computer monitor. It may be text or graphic and in monochrome or color. Softcopy outputs are used to preview data before final hardcopy output.

Output in electronic formats consists of computer-compatible files used to transfer data among computer systems either for additional analysis or to produce a hardcopy output at a remote location. It is generally accepted that the output function of GIS must include dissemination of output information to users. Users must understand the GIS application tools and relationships between the available data and the required information. The user, the system, and the experts who advise on models and data involved in problem solutions constitute the GIS applications (Ondieki, C. M., and S. Murimi, 2009).

3.1.5 Components of GIS:

Geographic Information System (GIS) have five Components:

1. Hardware.
2. Software.
3. Data.
4. People.
5. Methods.

3.1.6 What A GIS Can Do?

There are five basic questions which a complete GIS must answer these are:

1. **What exists at a particular location?** Given a geographic reference (eg lat,long) for a location, the GIS must describe the features of that location

2. **Where can specific features be found?** This is the converse of the first question. For example, where are the districts with rainfall greater than 500mm and less than less than 750mm?
3. **Trends or What has changed over time?** This involves answering both questions above. For example, at what locations are the crop yields showing declining trends?
4. **What spatial patterns exist?** if occurrence of a pest is associated with a hypothesized set of conditions of temperature, precipitation, humidity, where do those conditions exist?
5. **Modelling or What if …?** This is a higher level application of GIS and answers questions like what would be the nitrate distribution in groundwater over the area if fertilizer use is doubled? (www.esriuk.com).

3.1.7 Advantages of GIS:

The Geographic Information System has been an effective tool for implementation and monitoring of municipal infrastructure. The use of GIS has been in vogue primarily due to the advantage mentioned below:

- Planning of project.
- Make better decisions.
- Visual Analysis.
- Improve Organizational Integration.

Planning Of Project: Advantage of GIS is often found in detailed planning of project having a large spatial component, where analysis of the problem is a pre requisite at the start of the project. Thematic maps generation is possible on one or more than one base maps, example: the generation of a land use map on the basis of a soil composition, vegetation and topography. The unique combination of certain features facilitates the creation of such thematic maps. With the various modules within GIS it is possible to calculate surface, length, width and distance.

Making Decisions: The adage "better information leads to better decisions" is as true for GIS as it is for other information systems. A GIS, however, is not an automated decision making system but a tool to query, analyze, and map data in support of the decision making process. GIS technology has been used to assist in tasks such as presenting

information at planning inquiries, helping resolve territorial disputes, and siting pylons in such a way as to minimize visual intrusion.

Visual Analysis: Digital Terrain Modeling (DTM) is an important utility of GIS. Using DTM/3D modeling, landscape can be better visualized, leading to a better understanding of certain relations in the landscape. Many relevant calculations, such as (potential) lakes and water volumes, soil erosion volume (Example: landslides), quantities of earth to be moved (channels, dams, roads, embankments, land leveling) and hydrological modeling becomes easier. Not only in the previously mentioned fields but also in the social sciences GIS can prove extremely useful. Besides the process of formulating scenarios for an Environmental Impact Assessment, GIS can be a valuable tool for sociologists to analyze administrative data such as population distribution, market localization and other related features.

Improving Organizational Integration: Many organizations that have implemented a GIS have found that one of its main benefits is improved management of their own organization and resources. Because GIS has the ability to link data sets together by geography, it facilitates interdepartmental information sharing and communication. By creating a shared database one department can benefit from the work of another--data can be collected once and used many times. As communication increases among individuals and departments, redundancy is reduced, productivity is enhanced, and overall organizational efficiency is improved. Thus, in a utility company the customer and infrastructure databases can be integrated so that when there is planned maintenance, affected people can be informed by computer-generated letters.

3.1.8 GIS in Everyday Life:

Making GIS data work for you, In today's global community, the more information you have at your fingertips, the easier it is to make an informed decision. In today's high-tech world, information comes in many different ways, from company reports and statistics from down the hall to digital photos and multimedia from across the world.

Information can be overwhelming and the need for timely decisions calls not only for innovative ways to access accurate, up-to-the minute information, but also tools to help present the information in useful ways.

A geographic information system or GIS allows you to bring all types of data together based on the geographic and locational component of the data.

But unlike a static paper map, GIS can display many layers of information that is useful to you. You will be able to integrate, visualize, manage, solve, and present the information in a new way. Relationships between the data will become more apparent and your data will become more valuable.

GIS will give you the power to create maps, integrate information, visualize scenarios, solve complicated problems, present powerful ideas, and develop effective solutions like never before. GIS is a tool used by individuals and organizations, schools, governments, and businesses seeking innovative ways to solve their problems.

3.2 Spatial Analysis:

3.2.1 Definition Of Spatial Analysis And Scope:

The heart of GIS is the analytical capabilities of the system. What distinguish the GIS system from other information system are its spatial analysis functions. Spatial Analysis helps in identifying trends on the data, creating new relationships from the data, viewing complex relationships between data sets, and making better decisions. Although the data input is, in general, the most time consuming part, it is for the data analysis that GIS is used. The analysis functions use the spatial and non-spatial attributes in the database to answer questions about the real world. Geographic analysis facilitates the study of real-world processes by developing and applying models. Such models illuminate the underlying trends in geographic data and thus make new information available (Verka Jovanović, 2008).

Through spatial analysis you can interact with a GIS to answer questions, support decisions, and reveal patterns. Spatial analysis is in many ways the crux of a GIS, because it includes all of the transformations, manipulations, and methods that can be applied to geographic data to turn them into useful information (Longley et al, 2001).

There are many definitions of the term "Spatial Analysis" and we will mention some of them:

- Spatial analysis is the process of extracting or creating new information about a set of geographic features to perform routine examination, assessment, evaluation, analysis or modeling of data in a geographic area based on pre-established and

computerized criteria and standards. Spatial analysis is a process of modeling, examining, and interpreting model results useful for evaluating suitability and capability, for estimating and predicting, and for interpreting and understanding (Data West Research Agency definition).

- Spatial analysis is often referred to as modeling, It refers to the analysis of phenomena distributed in space and having physical dimensions (the location of, proximity to, or orientation of objects with respect to one another; relating to an area of a map as in spatial information and spatial analysis; referenced or relating to a specific location on the Earth's surface).
- Spatial analysis refers to a process that relies upon both exploratory and confirmatory techniques to answer important questions and enhance decision making with spatial data. This includes approaches to identify patterns and processes, detect outliers and anomalies, test hypotheses and theories, and generate spatial data and knowledge.
- A general ability to manipulate spatial data into different forms and extract additional meaning as a result (Bailey, 1994).
- In broad terms one might define spatial analysis as the quantitative study of phenomena that are located in space (Bailey et al. , 1995).
- Spatial analysis is a process in which you model problems geographically, derive results by computer processing, and then explore and examine those results. This type of analysis has proven to be highly effective for evaluating the geographic suitability of certain locations for specific purposes, estimating and predicting outcomes, interpreting and understanding change, detecting important patterns hidden in your information, and much more.
- Spatial analysis involves spatial modeling, which includes models of location-allocation, spatial interaction, spatial choice and search, spatial optimization, and space-time (M.M. Fischer, 2001).

Methods of spatial analysis are often used to produce new information from geographic data. There are several spatial analysis techniques available, ranging from simple to complex (methods of spatial analysis can be very sophisticated, they can also be very simple).

In GIS there are four traditional types of spatial analysis: (spatial overlay and contiguity analysis, surface analysis, linear analysis, and raster analysis). It includes such GIS functions as topological overlay, buffer generation, and spatial or network modeling.
Classification of the techniques of spatial analysis is difficult because of the large number of different fields of research involved, the different fundamental approaches which can be chosen, and the many forms the data can take.

3.2.2 The Spatial Analysis Process:

The spatial analysis is composed by a set of chained procedures whose aim is to choose an inferential model that explicitly considers the spatial relationship present in the phenomenon. The initial procedures of analysis include the set of generic methods of exploratory analysis and the visualization of data, in general through maps. These techniques permit the description of the distribution of the variables of study, the identification of observations that are outliers not only in relation to the type of distribution but also in relation to its neighbors, and to look for the existence of patterns in the spatial distribution. Through these procedures it is possible to propose hypothesis about the observations, in a way of selecting the best inferential model supported by the data.
The spatial inferential models are usually presented in three great groups:
Continuous variation, discrete variation, and the point processes. the resolution of a spatial problem may involve the utilization of one of them or the interaction of some or even all of them (Gilberto Câmara and others, 2004). The different types and problems of Spatial Analysis of Geographic Data are summarized in Table (3.2).

Table (3.2) Types of Data and Problems In Spatial Analysi

	Data Types	Example	Typical problems
Analysis of point patterns	Localized events	Disease incidence	Determination of Patterns and Aggregations
Surface analysis	Samples of fields and matrixes	Mineral deposits	Interpolation and uncertainty measures
Areal analysis	Polygons and attributes	Census data	Regression and joint distributions

A key benefit of GIS is the ability to apply spatial operators to GIS data to derive new information. This ability forms the foundation for spatial modelling and geoprocessing. Working with Spatial Analysis tools it is possible to (Vassilis PappaS, 2013):

- Derive new information.
- Identify spatial relationships.
- Find suitable locations.
- Calculate travel cost.
- and much more.

3.2.2.1 Spatial Analysis Functions In GIS:

Three different types are illustrated:

1. Attribute query
2. Spatial query
3. Derive new data from existing data

Note that only some of these operations generate new data. The first two functions mentioned are simple queries, and the result consists of a selection of objects from the databases (Chou, 1997).

3.2.2.2 The Six Categories Of Spatial Analysis

The taxonomy of spatial analysis includes six high-level categories that classify and group related analytical questions (ESRI).

1. Understanding where.
2. Measuring size, shape, and distribution.
3. Determining how places are related.
4. Finding the best locations and paths.
5. Detecting and quantifying patterns.
6. Making predictions.

With the taxonomy of spatial analysis, we now have a language for communication. However, the individual questions in the taxonomy are just the building blocks that make up our vocabulary. How we choose to put these building blocks together is a function of the real-world problem that we're trying to solve. Combining these questions takes us from learning the language of spatial analysis to understanding the process of spatial analysis.

Successful spatial analysis requires a seven step approach that begins with asking the questions and ends with making a decision. It is important to emphasize that spatial analysis is not just running a tool, or a model, but rather is a workflow and an approach to problem solving.

(1) Ask questions: Formulate hypotheses and spatial questions.
(2) Explore the data: Examine the data quality, completeness, and measurement limitations (scale and resolution) to determine the level of analysis and interpretation that can be supported.
(3) Analyze and model: Break the problem down into solvable components that can be modeled. Quantify and evaluate the spatial questions.
(4) Interpret the results: Evaluate and analyze the results in the context of the question posed, data limitations, accuracy, and other implications.
(5) Repeat as necessary: Spatial analysis is a continuous and iterative process that often leads to further questions and refinements.
(6) Present the results: The best information and analysis becomes increasingly valuable when it can be effectively presented and shared with a larger audience.
(7) Make a decision: Spatial analysis and GIS are used to support the decision-making process. A successful spatial analysis process often leads to the understanding necessary to drive decisions and action.

Some difficulties of Geographic Analysis are: plenty of data; spatial relationships are important but difficult to measure; inherent uncertainty due to scale; difficult to make data sources compatible; difficult mathematics; quantity vs. quality questions; multiple objectives etc.

Before commencing geographic analysis, one needs to assess the problem and establish an objective. The analysis requires step-by-step procedures to arrive to conclusions. The range of geographical analysis procedures can be subdivided into the following categories (Verka Jovanović, 2008):

a. Database Query.
b. Overlay.
c. Proximity Analysis.
d. Network Analysis.

e. Digital Terrain Model.

f. Statistical and Tabular Analysis.

3.2.3 Types of Spatial Analysis:

Types of spatial analysis vary from simple to sophisticated. In this course, spatial analysis will be divided into six categories: queries and reasoning, measurements, transformations, descriptive summaries, optimization, and hypothesis testing.

1. Queries and reasoning: are the most basic of analysis operations, in which the GIS is used to answer simple questions posed by the user. No changes occur in the database and no new data are produced.

2. Measurements: are simple numerical values that describe aspects of geographic data. They include measurement of simple properties of objects, such as length, area, or shape, and of the relationships between pairs of objects, such as distance or direction.

3. Transformations: are simple methods of spatial analysis that change data sets by combining them or comparing them to obtain new data sets and eventually new insights. Transformations use simple geometric, arithmetic, or logical rules, and they include operations that convert raster data to vector data or vice versa. They may also create fields from collections of objects or detect collections of objects in fields.

4. Descriptive summaries: attempt to capture the essence of a data set in one or two numbers. They are the spatial equivalent of the descriptive statistics commonly used in statistical analysis, including the mean and standard deviation.

5. Optimization techniques: are normative in nature, designed to select ideal locations for objects given certain well-defined criteria. They are widely used in market research, in the package delivery industry, and in a host of other applications.

6. Hypothesis: testing focuses on the process of reasoning from the results of a limited sample to make generalizations about an entire population. It allows us, for example, to determine whether a pattern of points could have arisen by chance based on the information from a sample. Hypothesis testing is the basis of inferential statistics and forms the core of statistical analysis, but its use with spatial data can be problematic (Longley et al, 2001).

3.2.4 The Benefits Of Spatial Analysis:

As we formulate spatial analysis solutions, it is important to keep in mind not only the goals that need to be achieved, but also the benefits that result from successful spatial analysis. Regardless of the domain or industry (government, commercial retail, petroleum, utilities, and so on), the purpose of spatial analysis is to use our data and increased understanding to make better decisions. Each problem may have a different objective, but the focus should always be on solving the underlying real-world problem (ESRI).

- Achieve objectives.
- Improve program outcomes.
- Reduce costs.
- Avoid costs.
- Increase efficiency and productivity.
- Increase revenue.
- Assure revenue.
- Protect staff and citizens (health and safety).
- Support regulatory compliance
- Improve customer service.
- Enhance customer satisfaction.
- Enhance competitive advantage.

CHAPTER FOUR

METHODOLOGY

4.1 Study Area:

Umm Durman AlKubra is one of the Sudanese cities founded in 1691, located in the state of Khartoum, occupying the northwestern of the locality of Khartoum, the capital of Sudan, which is part of the so-called triangular capital, (which consists of Khartoum, Khartoum Bahri and Umm Durman), and It stretches along the West Bank of both the Nile and the White Nile opposite Khartoum and west of Khartoum Bahri, with a population about 2758401 people (2008), an area of about 237.4 square miles. And it is divided administratively into three localities (Karary – Umm Badda – Umm Durman), And It is administratively subordinate to the Khartoum state. Locality of Umm Badda is one of the largest localities in the Sudan, and this geographical spread made it one of the most densely populated localities, and making it the top of the list of localities in all the recent population censuses.

The city of Umm Durman is the historical capital of the Sudan as it was associated with The Mahadia Government, founded by Mohammed Ahmed Al Mahadi in the mid-nineteenth century, It also contains several important buildings such as (The official studios for both Radio and Television of Sudan, The National Theater, AL Morada Club, And the largest sports clubs includes (AL marikh Stadium and Al Hilal Stadium), The New Khartoum International Airport is under construction, Military Hospital).

Umm Durman has the most famous tourist and historical landmarks such as (The Dome Of The Mahadi, Al Tabiya,The Museum Of The Khalifa House, Abd Algayyum Gate and The Mosque Of The Nilain).

4.1.1 Geography Of Umm Durman:

Locality of Umm Durman is located between latitudes (15˚ 11.5¯) and (16˚ 39.5¯) North and (31˚ 37¯) and longitudes (32˚ 36.5¯) East, located in the north-west of Khartoum state specifically on the West Bank of the White Nile and the Nile River off Khartoum city.

It has many valleys and pits such as Wadi Saydna, Khor Abu Anja, and many mountains such as Karary and Marrkhiyat Mountains.

The geological composition of the city consists of:

- **The Basic Rocks:** located in the north and west of the city, and It includes several types of rock such as fire rock, Shast rocks and Granite.
- **Nubian Sandstone Formation:** covering a large area of the city, and was formed as a result of vertical movements at the beginning of the second geological time.
- **Modern Sedimentary Rocks:** which are formed in the clay plain located in the vicinity of the Nile River, and fertilized through thin deposits, flooding which comes from Blue Nile.

4.1.2 Surface and Topography:

The surface of the Sudan is generally characterized by monotony in its topography, and also end of the water draining in general in the Nile River, Umm Durman takes this trait as its surface is characterized by an extroversion and leveling, and the land tends to rise from the northwest side, where it reaches its highest peak in the mountains of Karary.

It has some valleys and pits where rainwater collects during autumn And then moving in a flat land sloping towards the Nile. The most important valleys are Khor Abu Anja and Wadi Saydna.

4.1.3 The Climate:

Umm DurmanCity is prevails by desert climate almost all months of the year, except in July and August, which are experiencing some rainfall at a lower rate than Khartoum which lies east on the other side of the river directly.

Comparing the average annual temperature with other cities, Umm Durmanis one of the hottest cities where the temperature exceeds 53 ° C (127 ° F) in the summer.

The annual average temperature is 37 ° C (99 ° F). with six months a year Its average monthly temperature is not less than 38 ° C (100 ° F).

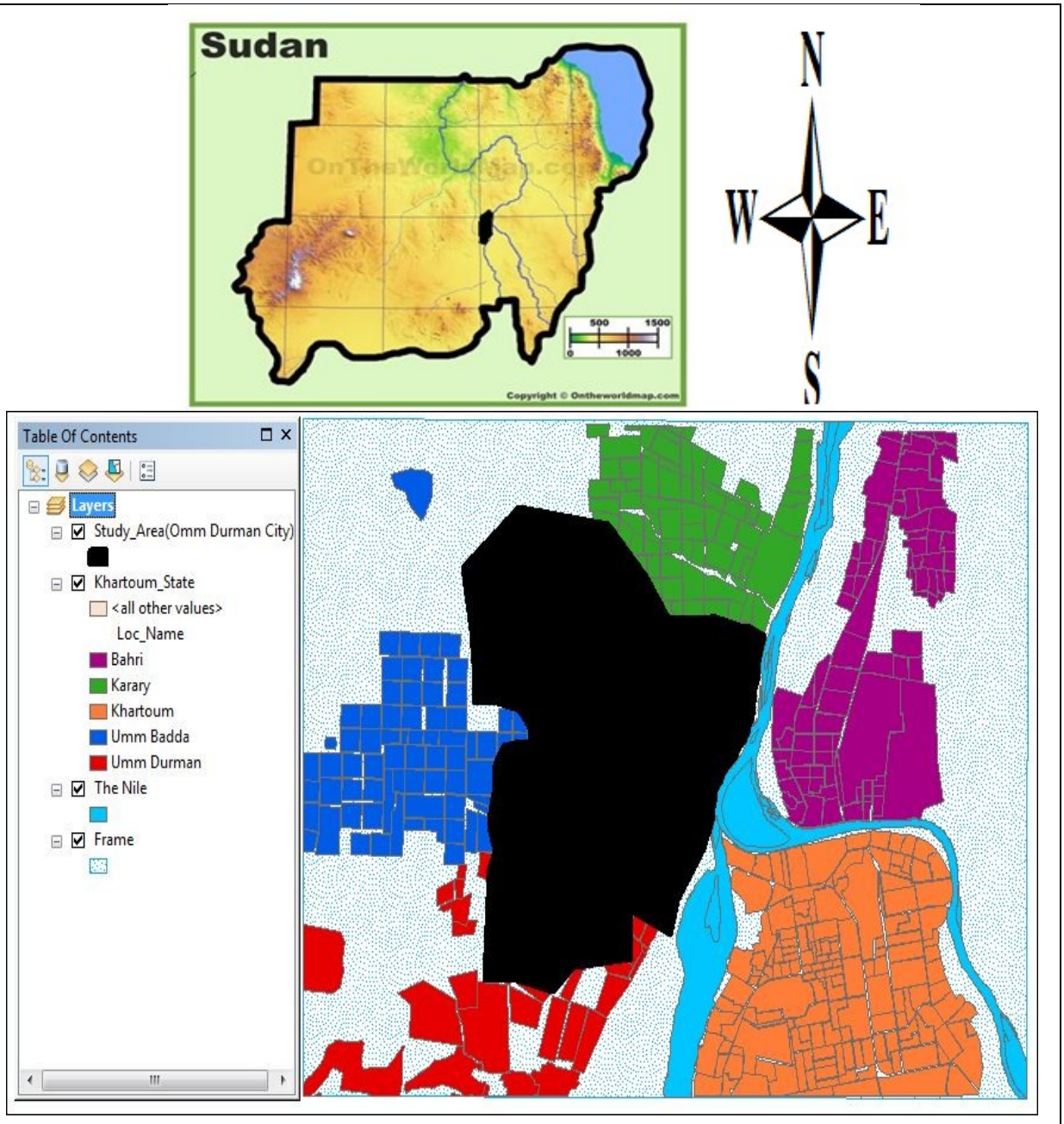


Fig (4.1) Study Area With Boundaries

4.2 Software Used:

Geographic Information System (GIS) Specifically (ArcGIS 10.3) Software was use for geo-referencing map. Were applied to the data for analysis of data and visualization of results.

4.3 Sources of Data:

Shape files had been obtained from many sources, data types and data sources are shown in table (4.1).

Table (4.1) Sources of Data

No	Data Name	Type Of Layer	Source Of Data
1	Blocks	Polygon	Sudanese Federal Ministry of Health
2	Nile	Polygon	Sudanese Federal Ministry of Health
3	Health Centers and Hospitals	Point	Sudanese Federal Ministry of Health
4	Police Centers	Point	Sudan National Survey Authority
5	Fire Stations	Point	Sudan National Survey Authority
6	Petrol Stations	Point	Sudan National Survey Authority
7	Markets	Point	Sudan National Survey Authority
8	Roads	Line	Ministry of Infrastructures and Transportation of Khartoum State

4.4 Work Plan:

The procedures used for each layer in the study area are outlined as follow:

4.4.1 Health Centers:

Shape files had been input to ArcGIS Software (ArcGIS 10.3), and then descriptive statistics and basic spatial statistical methods were applied to the data for analysis of data and visualization of final results.

The population census data (2017) were joined to attribute table of districts of study area layer based on the population 2008.

Five layers (shape files) had been input to ArcGIS Software (Fig 4.2):

1. Blocks.
2. Family Health Centers.
3. Reference Family Health Centers.
4. The Nile.
5. Umm Durman Locality Boundaries.

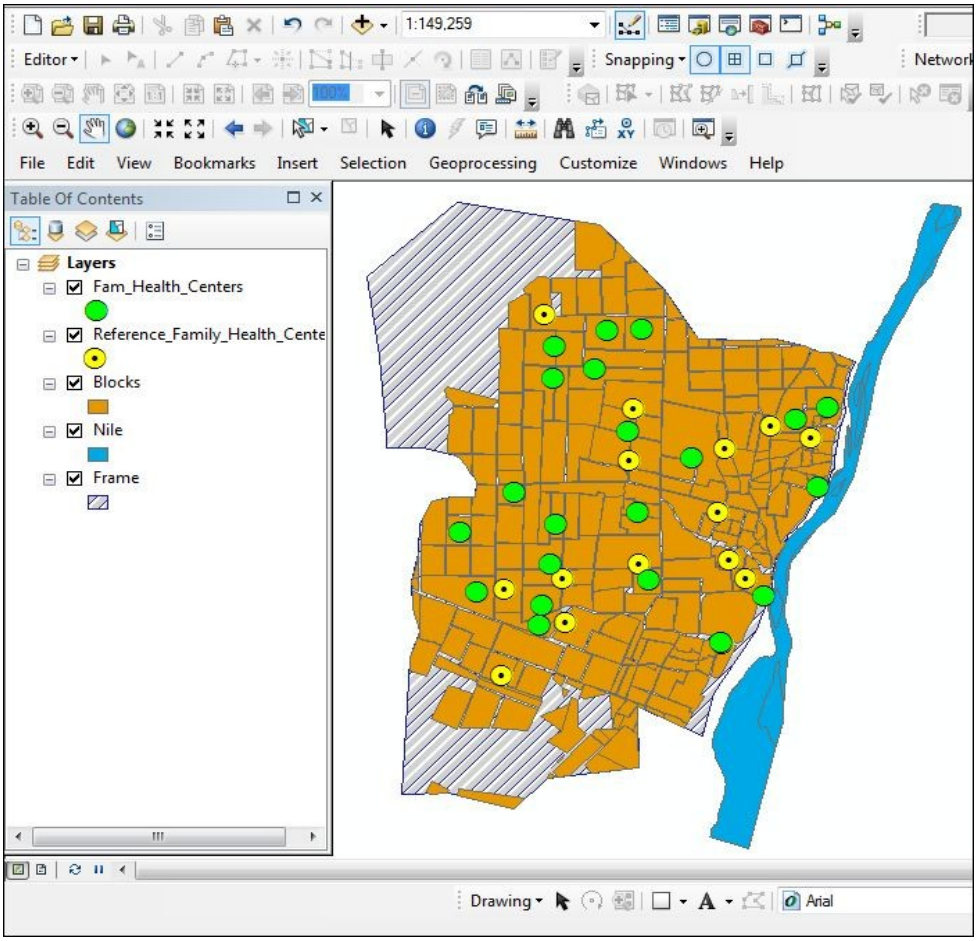


Fig (4.2) Family Health Centers and Reference Family Health Centers

4.4.1.1 Distance Criteria:

There are two types of governmental health centers, according to the classification of the Sudanese Federal Ministry of Health: the first one is family health centers and the second is the Reference family health centers.

- Distance criteria of thousand meters (according to the Sudanese Federal Ministry Of Health Standards) for each Family health center for radius from the health center to the far house using a buffer tool in GIS (Arc Toolbox Menu–Analysis tools-proximity-buffer) Fig (4.3).
- Distance criteria of Two thousand and five hundred meters (according to the Sudanese Federal Ministry Of Health Standards) for each Reference Family

Health center for radius from the health center to the far house using a buffer tool in GIS Fig (4.4).

4.1.1.2 Distance And Population Criterion:

Were used buffer tool procedure (buffer zones of all governmental health centers) with the standard population:

1. The capacity of family health center is 10000 people.
2. The capacity of the reference family health center is up to 60000 people.

To delineate residents who the center can delivery service them.

Then the number of people benefiting from the service provided by each center was calculated separately table (5.2 and 5.4) by using buffer of the health centers through the clip tool to determining the parts of districts covered by health service, then calculate the population by establishment a new field and using field calculator tool, and It was inputted the following mathematical equation:

Population Covered by Health Service =

$$\frac{\Sigma \text{ (New District Area km2(part of clip area))*(Pop of the District2017)}}{\text{Shape area of all districts}}$$

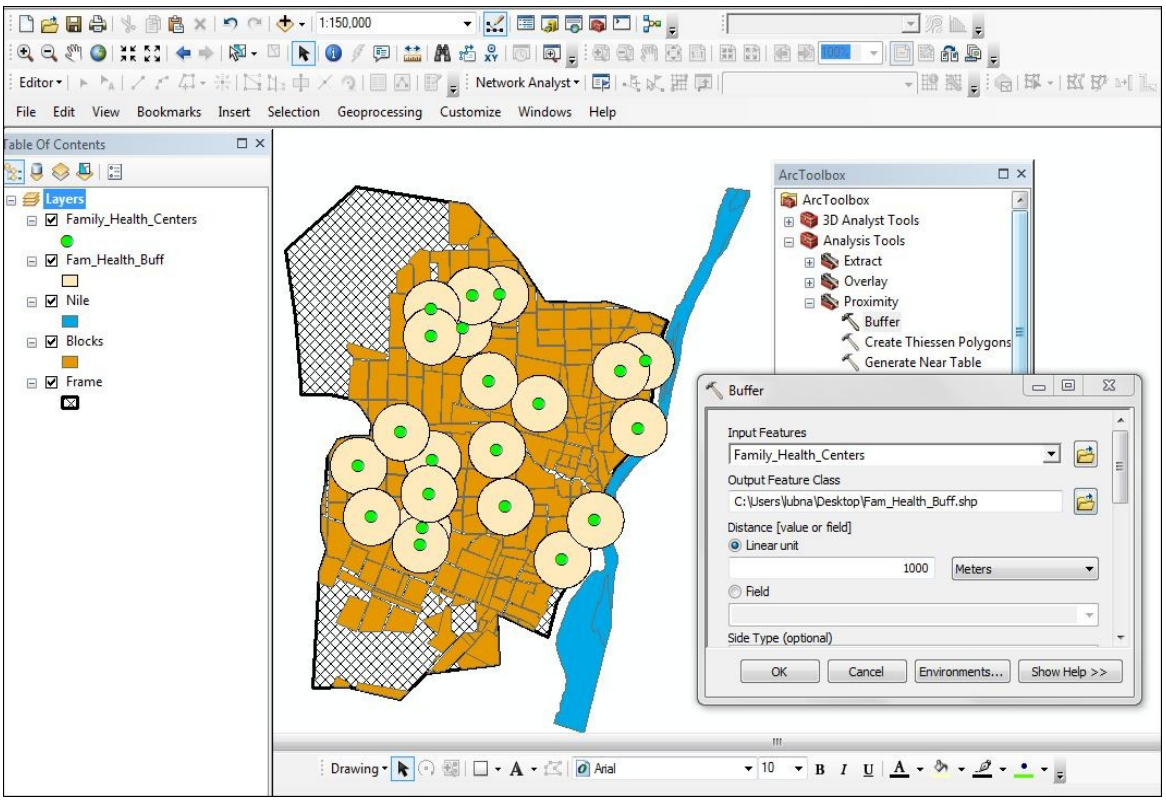


Fig (4.3) Buffer Zones of Family Health Centers (1000 Meters)

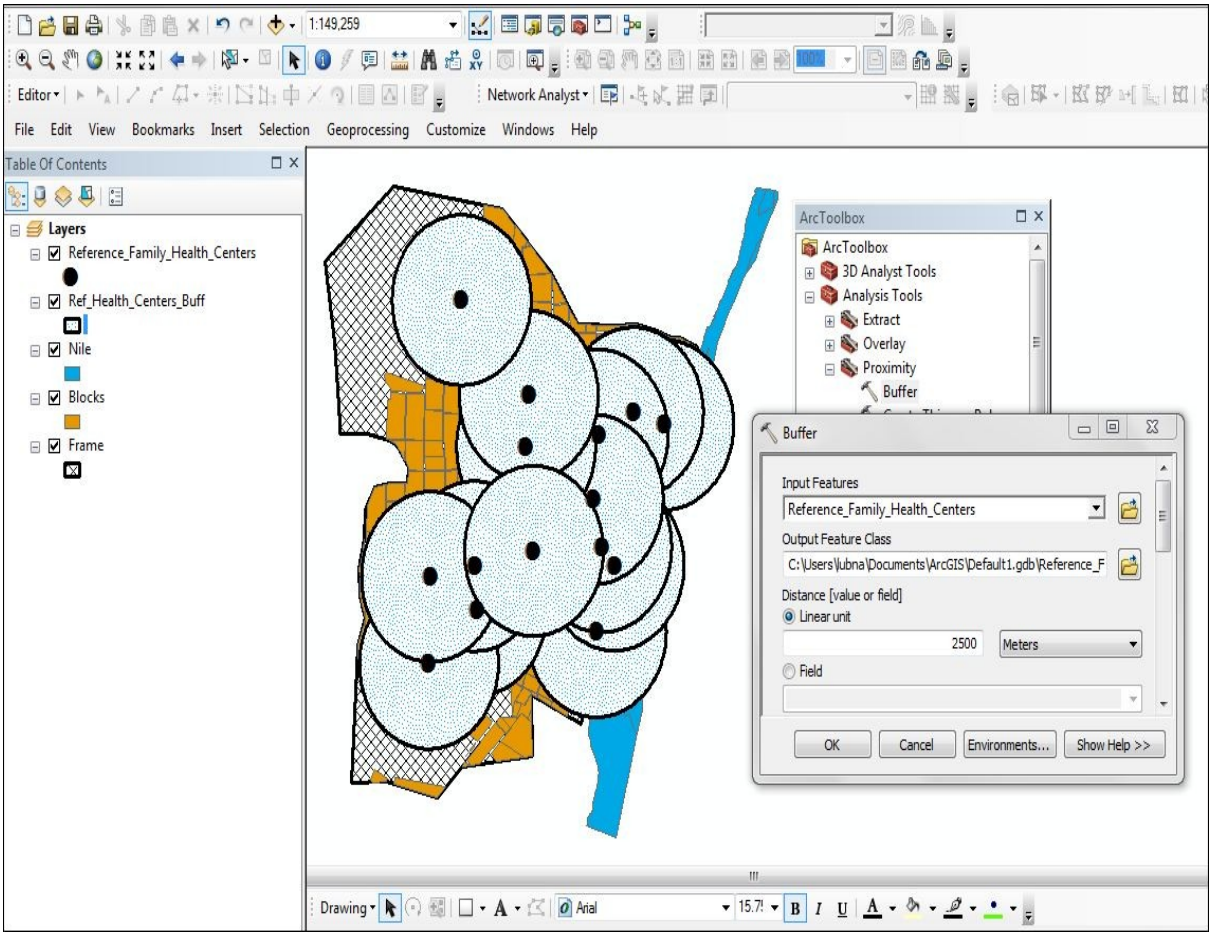


Fig (4.4) Buffer Zones of Reference Family Health Centers (2500 Meters)

4.4.2 Hospitals:

Had been extracted any locality boundaries (Karary – Umm Badda – Umm Durman), which are located within the boundaries of all study area, by using (Data)–(export data) from the menu of shape file of Umm Durman City Fig (4.5).

After that the shape files had been input to ArcGIS Software Fig (4.6), there are 10 hospitals in the study area:

1. Hospitals.
2. (Karary – Umm Badda – Umm Durman) locality.
3. Roads.
4. Nile.

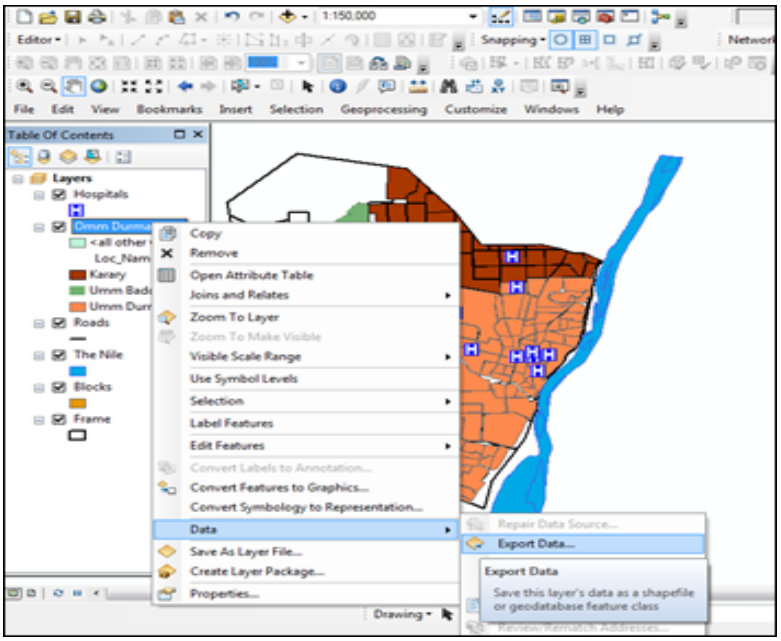


Fig (4.5) Extract Locality Boundaries

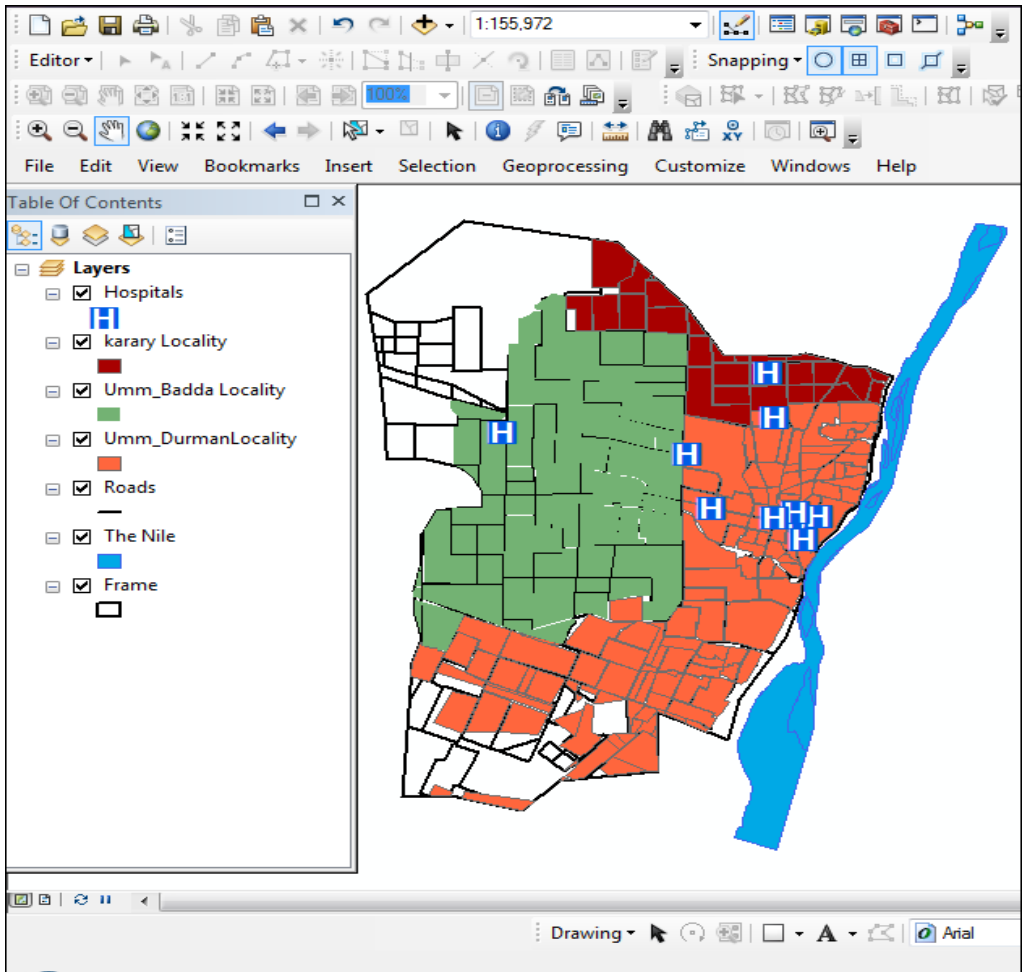


Fig (4.6) Distribution of Hospitals in the Study Area

4.4.3 Petrol Stations:

The layers (shape files) had been input to ArcGIS Software, There are thirty-two petrol stations and three fire stations in the study area Fig (4.7):

1. Petrol Stations.
2. Fire Station.
3. Umm Durman City.
4. Roads.

The following steps had been conducted to process the data:

- Use four thousand meters for radius from the fire stations by using a buffer tool procedure from (Arc Toolbox Menu–Analysis tools-proximity-buffer in GIS), taken 4000 meters as a parameter for each fire station in the study area, Fig (4.8).
- After the buffer tool procedure, the intersect tool (from Arc Toolbox Menu–Analysis tools-overlay-intersect in GIS) had been used to know petrol stations that are covered or not covered by fire stations Fig (4.9).

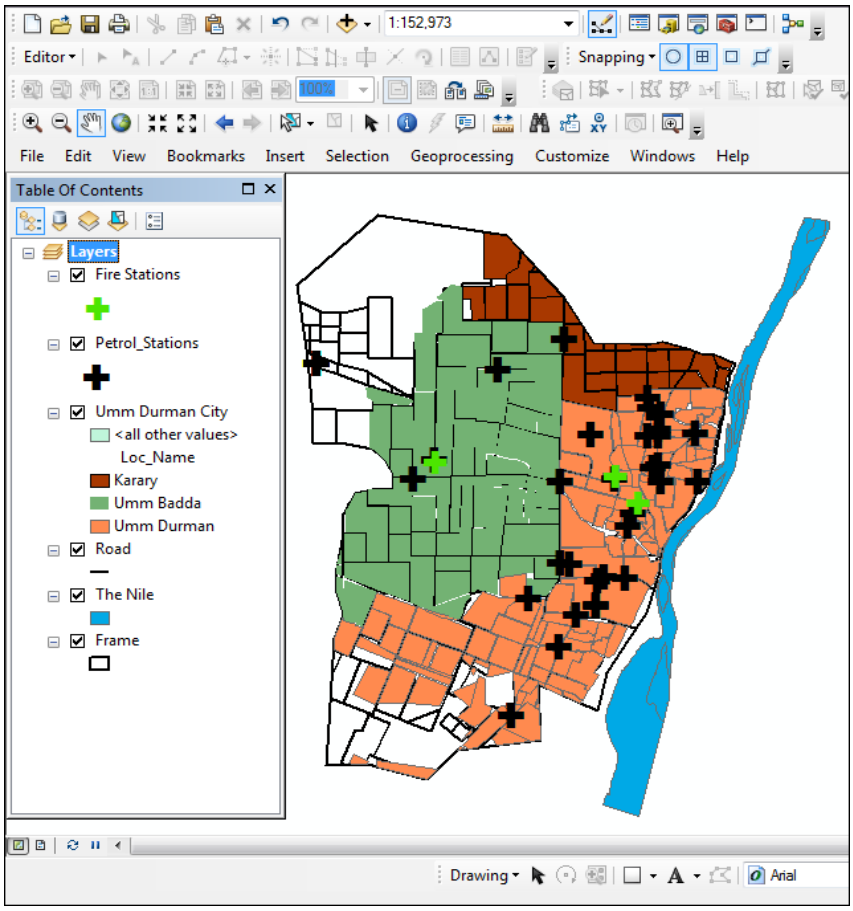


Fig (4.7) Distribution of Petrol Stations and Fire Stations in the Study Area

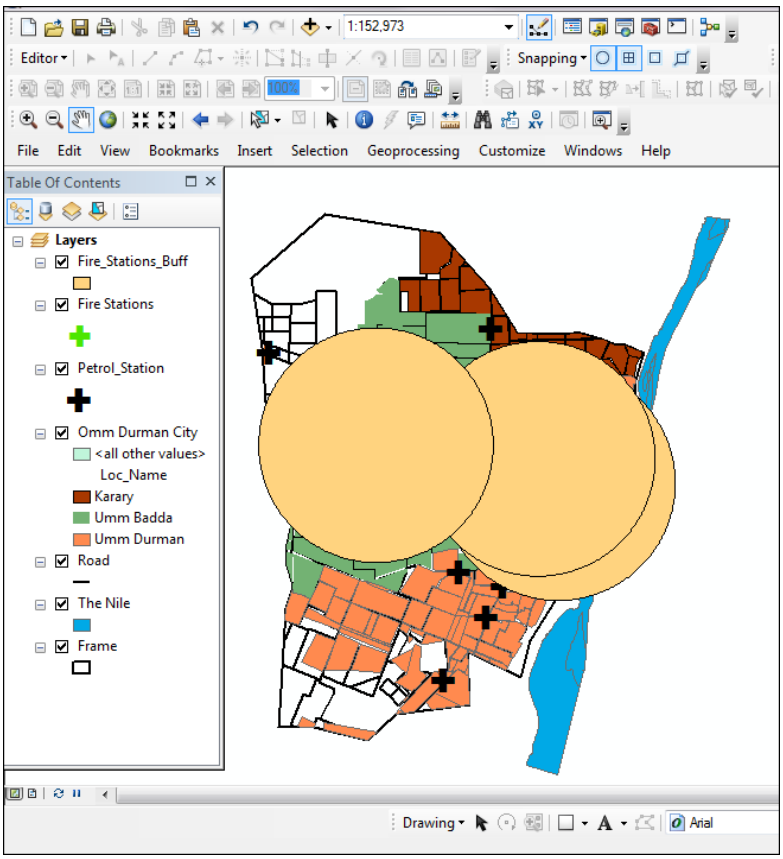


Fig (4.8) Buffer Zones of Fire Stations (4000 Meters)

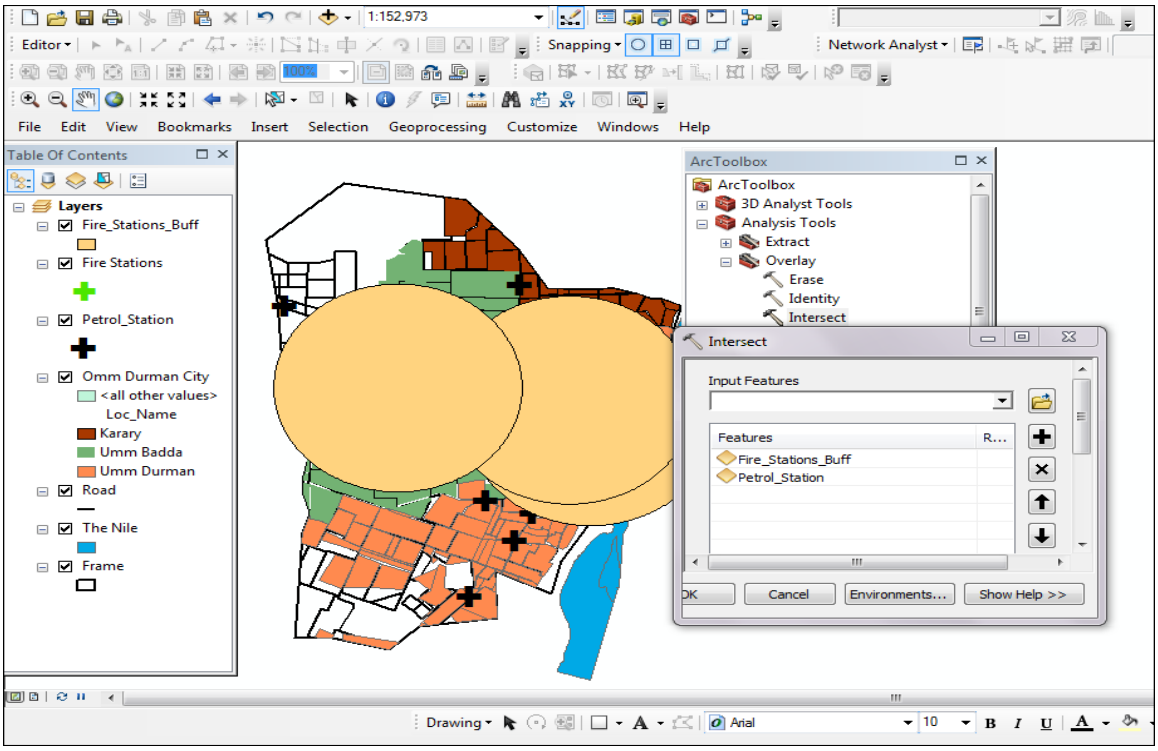


Fig (4.9) Intersect zone of Petrol Stations By Fire Stations Buffer

4.4.4 Markets Sector:

The layers (shape files) had been input to ArcGIS Software Fig (4.10). The study area contains thirty-six markets and sixty-seven police stations:

1. Markets.
2. Police Stations.
3. Blocks.
4. Roads.

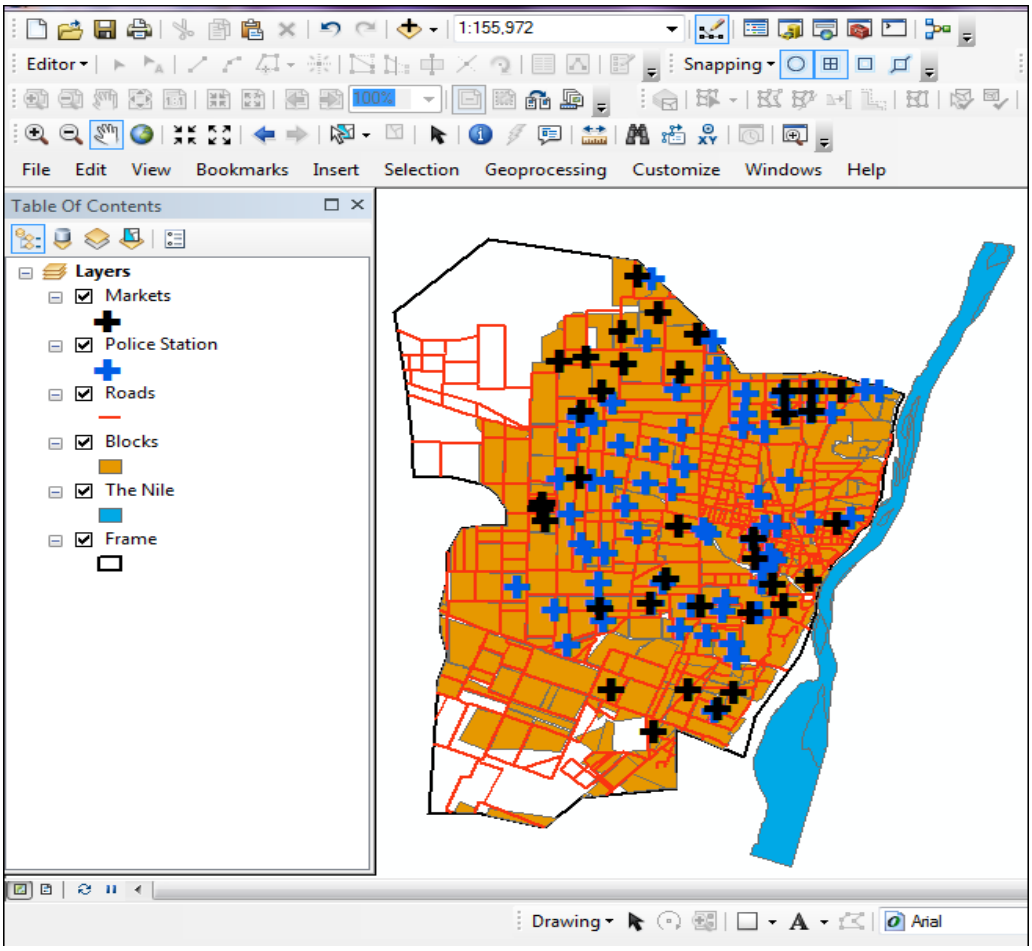


Fig (4.10) Distribution of Markets and Police Stations in the Study Area

The following steps had been conducted to process the data:

- Use thousand meters for radius from the police stations by using a buffer tool from (Arc Toolbox Menu–Analysis tools-proximity-buffer in GIS), taken 1000 meters as a parameter for each police station in the study area, Fig (4.11).

- After the process (buffer) the intersect tool (from Arc Toolbox Menu–Analysis tools-overlay-intersect in GIS) had been used to know the markets that are covered or not covered by police stations Fig (4.12).

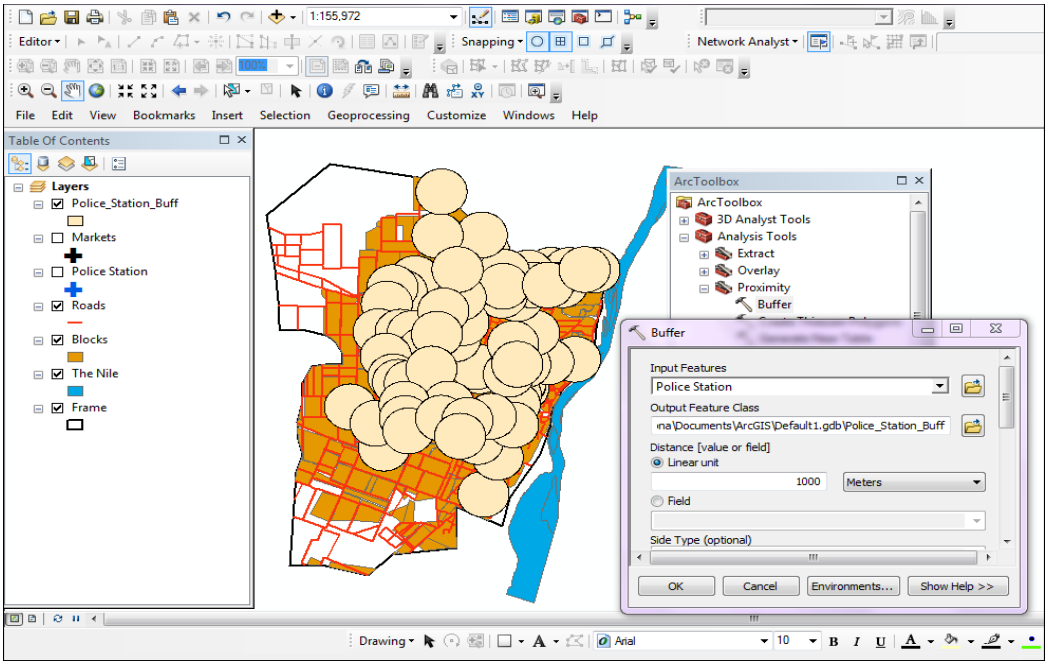


Fig (4.11) Buffer Zones of Police Stations (1000 Meters)

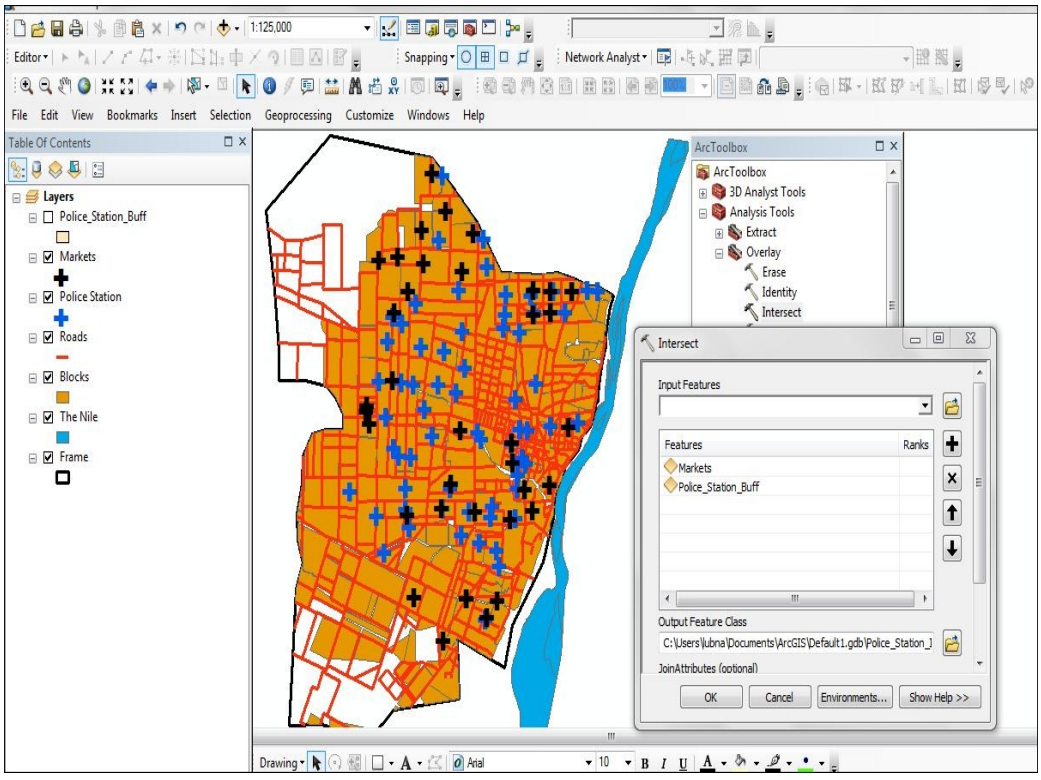


Fig (4.12) Intersect Zone of Markets By Police Stations Buffer

CHAPTER FIVE

RESULTS AND ANALYSIS

5.1 Family Health Centers:

5.1.1 Coverage Of Family Health Centers:

The study area contains twenty-one governmental family health centers fig (4.2), and by using the buffer (1000m), we find that there are some family health centers the services cover an intermediate area containing non-residential areas, including four family health centers fig (5.1), and these centers are: Al Qamaeer Family Health Center, Bait Al Mal Family Health Center, National Council Family Health Center, and Abu Seed 14 Family Health Center.

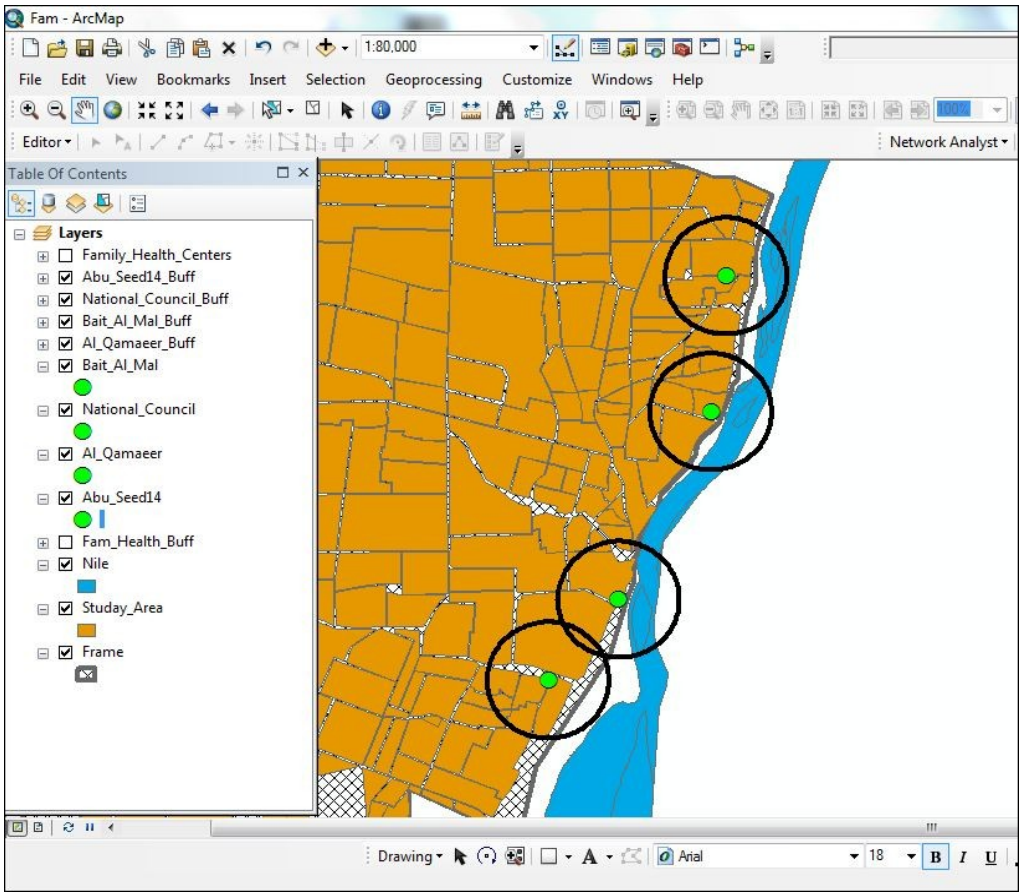


Fig (5.1) Residential Areas & Non Residential Areas Covered by Four Family Health Centers

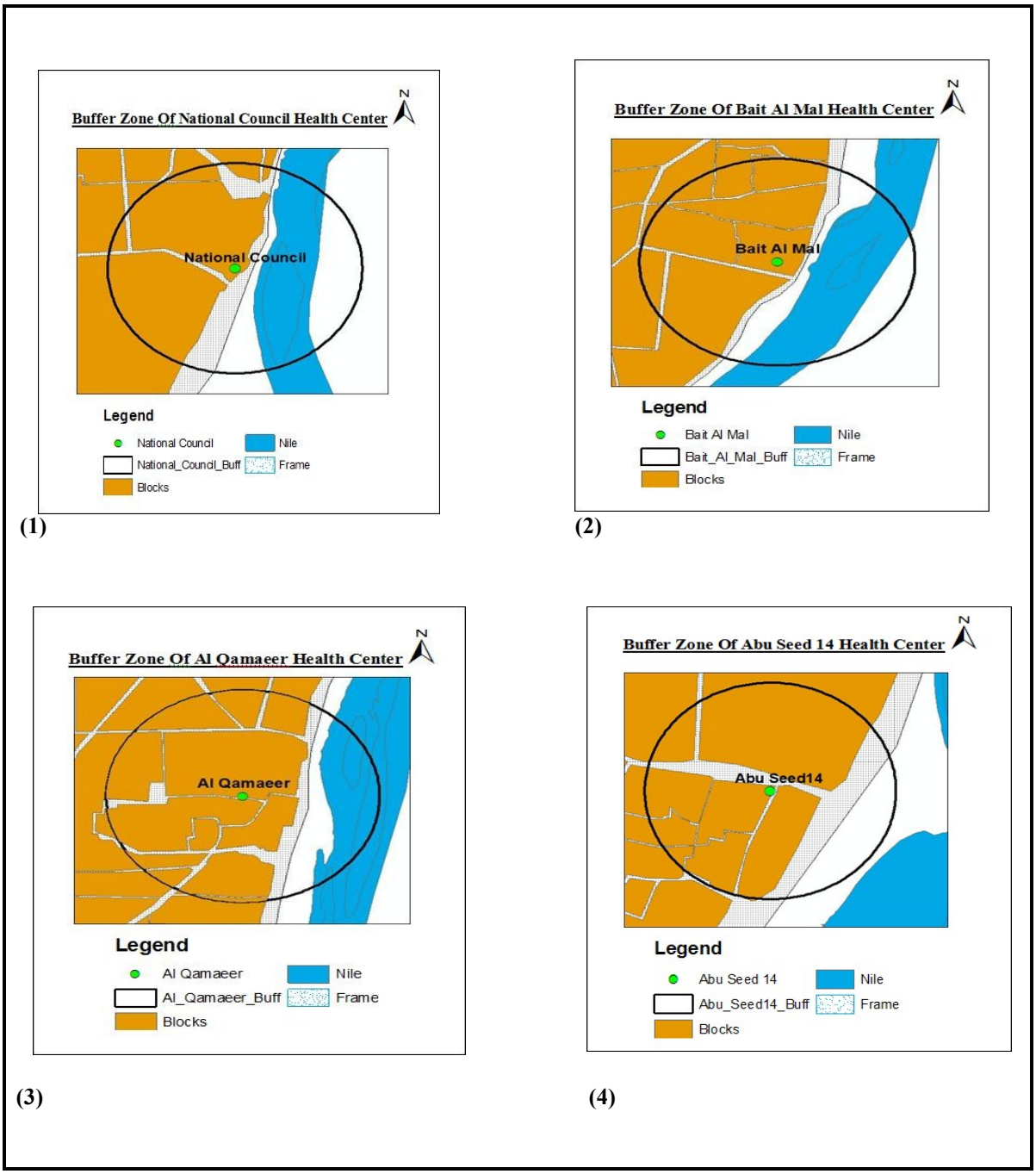


Fig (5.2(1,2,3,4)) Buffer Zones of Four Family Health Centers Show On Study Area

From the results table (5.1) there are:

1. One governmental family health centers‘ health services covering a wide area is non-residential more than 50% including National Council Family Health Center.
2. There are three governmental family health centers health services covering a wide area is non-residential more than 25% and less than 50% including Al Qamaeer Family Health Center, Bait Al Mal Family Health Center and Abu Seed14 Family Health Center.

Table (5.1) The Residential Area & Non Residential Area Covered by Health Service of Family Health Centers

Name of health center	**The total area of the covering health service(km²)**	**The Residential Area Covering by health Centers(Km²**	**Non Residential Area covering by health centers(Km²)**	**Non Residential Area percentage (%)**
Al Qamaeer Health Center	3.141	2.057	1.084	34.511
Bait Al Mal Health Center	3.141	1.595	1.546	49.219
National Council Health Center	3.141	1.442	1.699	54.091
Abu Seed14 Health Center	3.141	2.182	0.959	30.531
Total	12.564	7.276	5.288	**Average of percentage = 42.089**

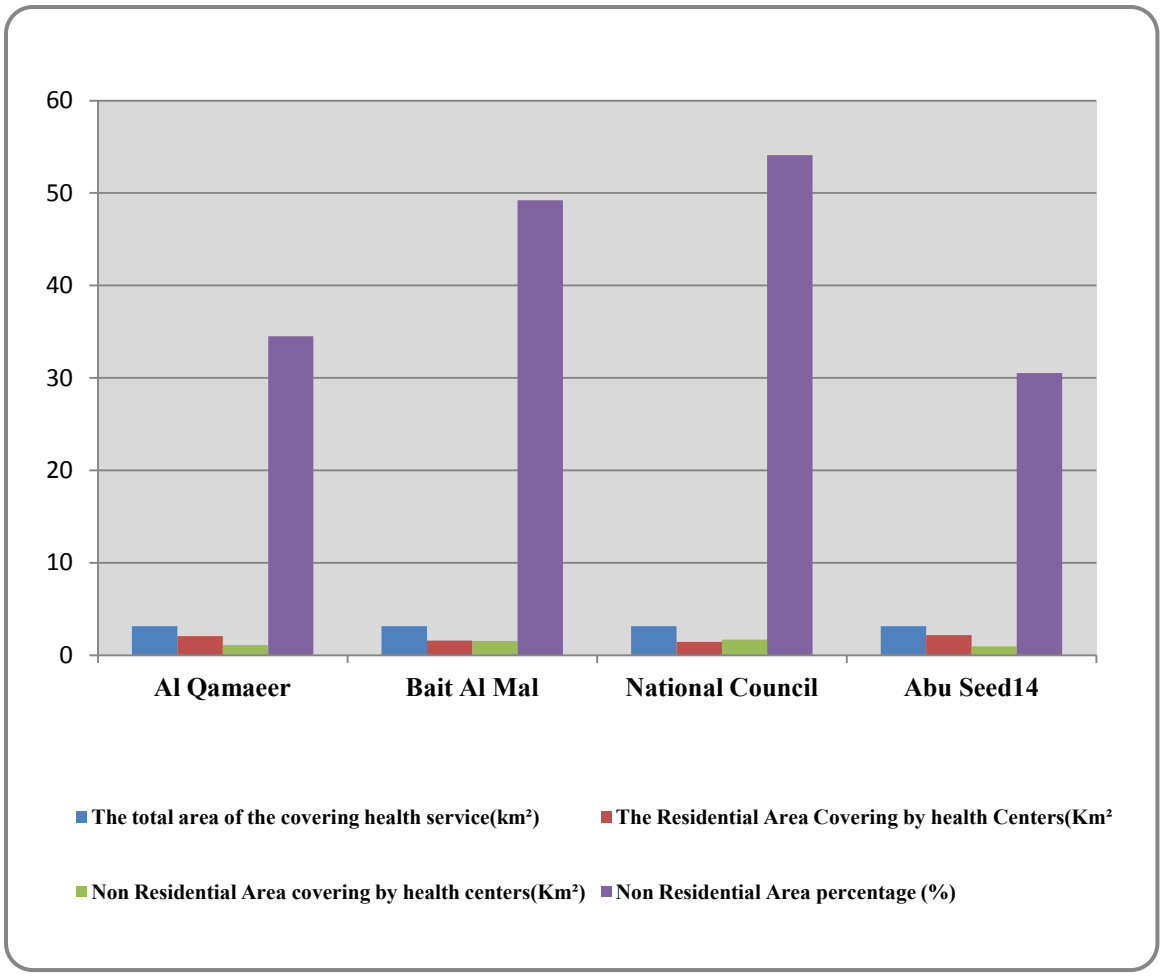


Fig (5.3) the Residential Areas & Non Residential Areas Covered by Four Family Health Centers

5.1.2 Analysis Of Family Health Centers:

The study area contains twenty-one public health centers, the center is designed to serve 10000 patients for one health center, according to the Sudanese Federal Ministry of Health Standards.

Analysis of family health centers attribute tables and it‘s buffer zones table (5.2), It found that the total capacity of the population in the study area, which should be covered by government family health centers (21 health center) is 210.000 people, according to the Sudanese Federal Ministry of Health Standards, While the actual number of residents (patients) beneficiaries of the health service is 763407 inhabitants, that means there is a

surplus in the population of about 556275 people, an increase of entirety of approximately 5563% of the total capacity for the centers.

As a result from table, health centers have been classified into five categories in terms of the proportion of the surplus in the number of people served by the specified health center:

1- Health centers, that not containing the excess number of the population that means surplus ratio of 0%, such as National Council Family Health Center Fig (5.4), because the area in which is located the center of sparsely populated and the area of service covers a large part of the neighboring agricultural areas of the region.

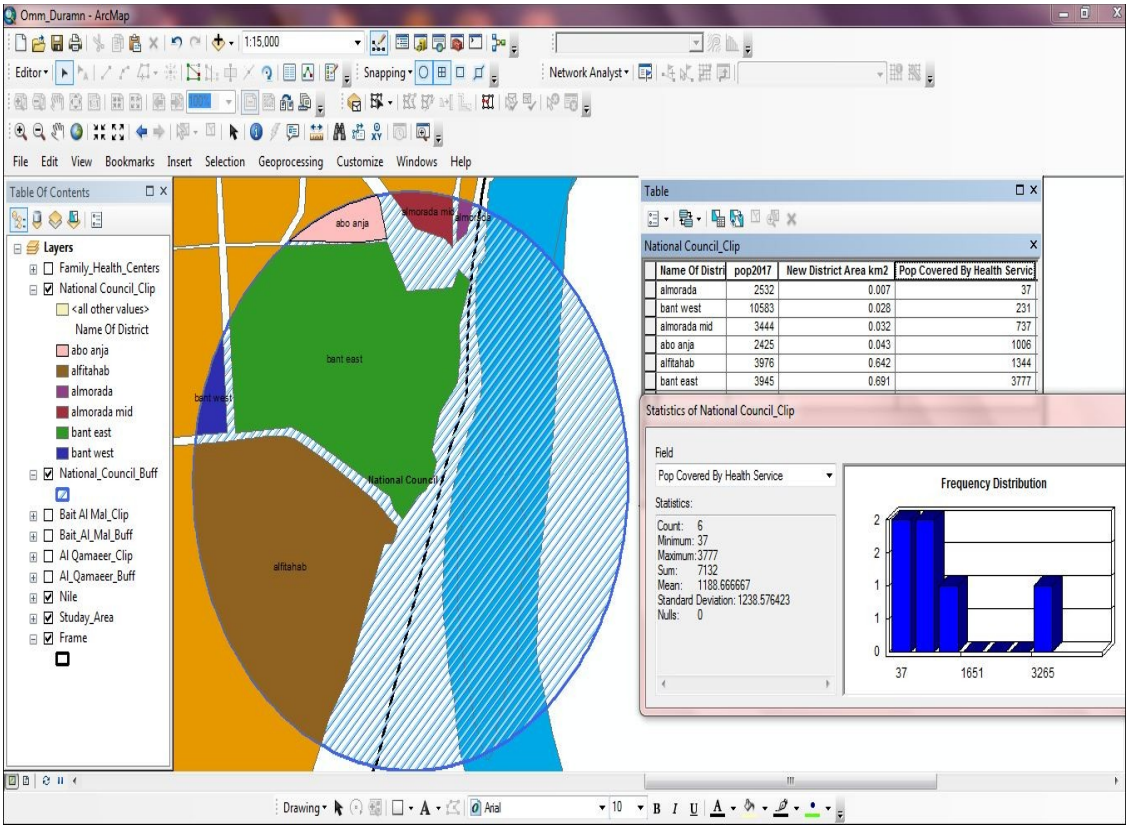


Fig (5.4) Attribute table of National Council Family Health Center illustrate The number of population benefiting from health service

2- Health centers that serve the population increased by the excess in the number of population more than 5% and less than 100% and these centers are Al Tejani Helal

Family Health Center, Hara 21 Family Health Center, ALfateheen Family Health Center and Hara 10 Family Health Center Fig (5.5).

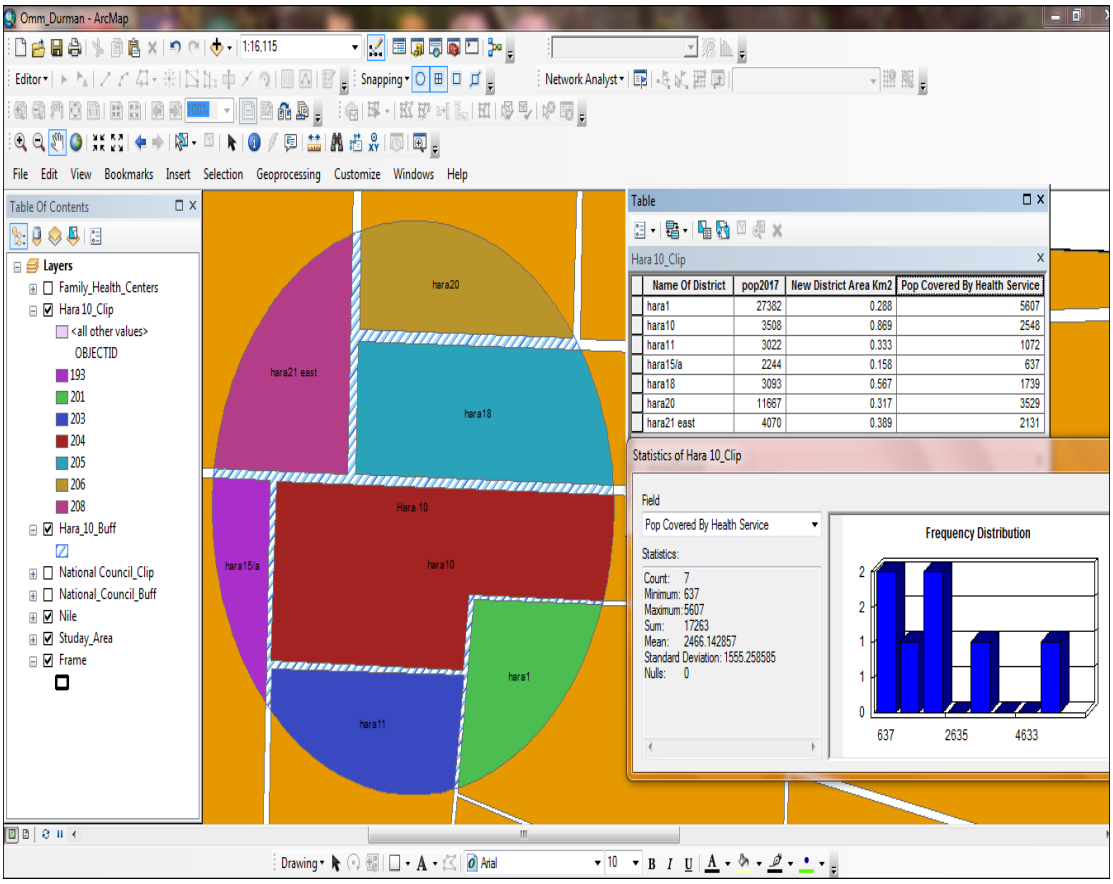


Fig (5.5) Attribute table of Hara 10 Family Health Center illustrate the number of population benefiting from health service

3- Health centers that serve the population increased by the excess in the number of population ratio Between (100-300)% and these centers are Abu Seed14 Family Health Center, Bait Al Mal Family Health Center, Al Jemiaab Family Health Center, Hara 32 Family Health Center, Al Qamaeer Family Health Center and Hara 20 Family Health Center Fig (5.6).

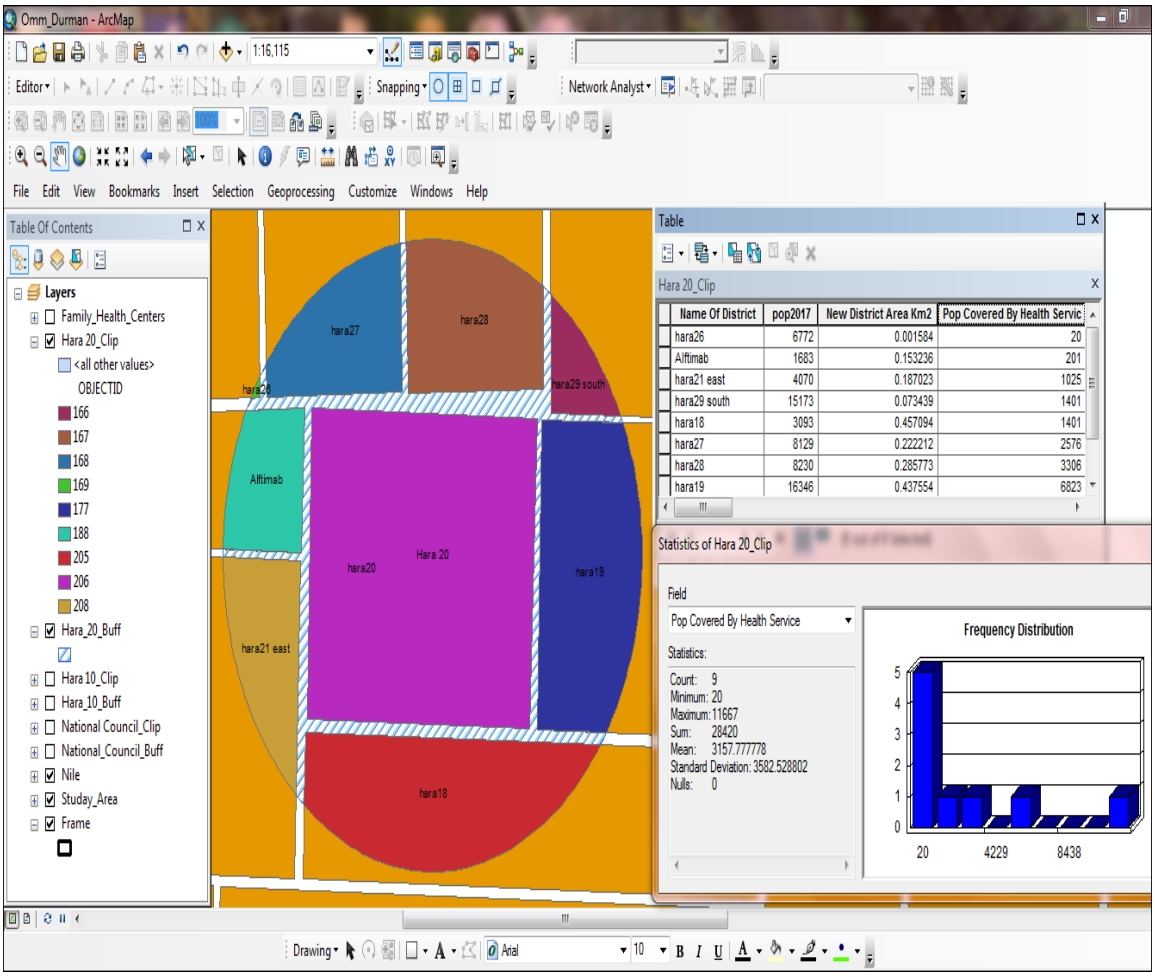


Fig (5.6) Attribute table of Hara 20 Family Health Center illustrate the number of population benefiting from health service

4 - Health centers that serve the population increased by the excess in the number of population ratio Between (300-500)% and these centers are Al Sharfyah Family Health Center, Dar Alargam Family Health Center, Alzaytona Family Health Center, Abo Zaid Family Health Center, Umm Baddah 43 Family Health Center, Dar Almostafa Family Health Center, Hamd Al Neel Family Health Center and Al Shohada Al Sabeel Family Health Center Fig (5.7).

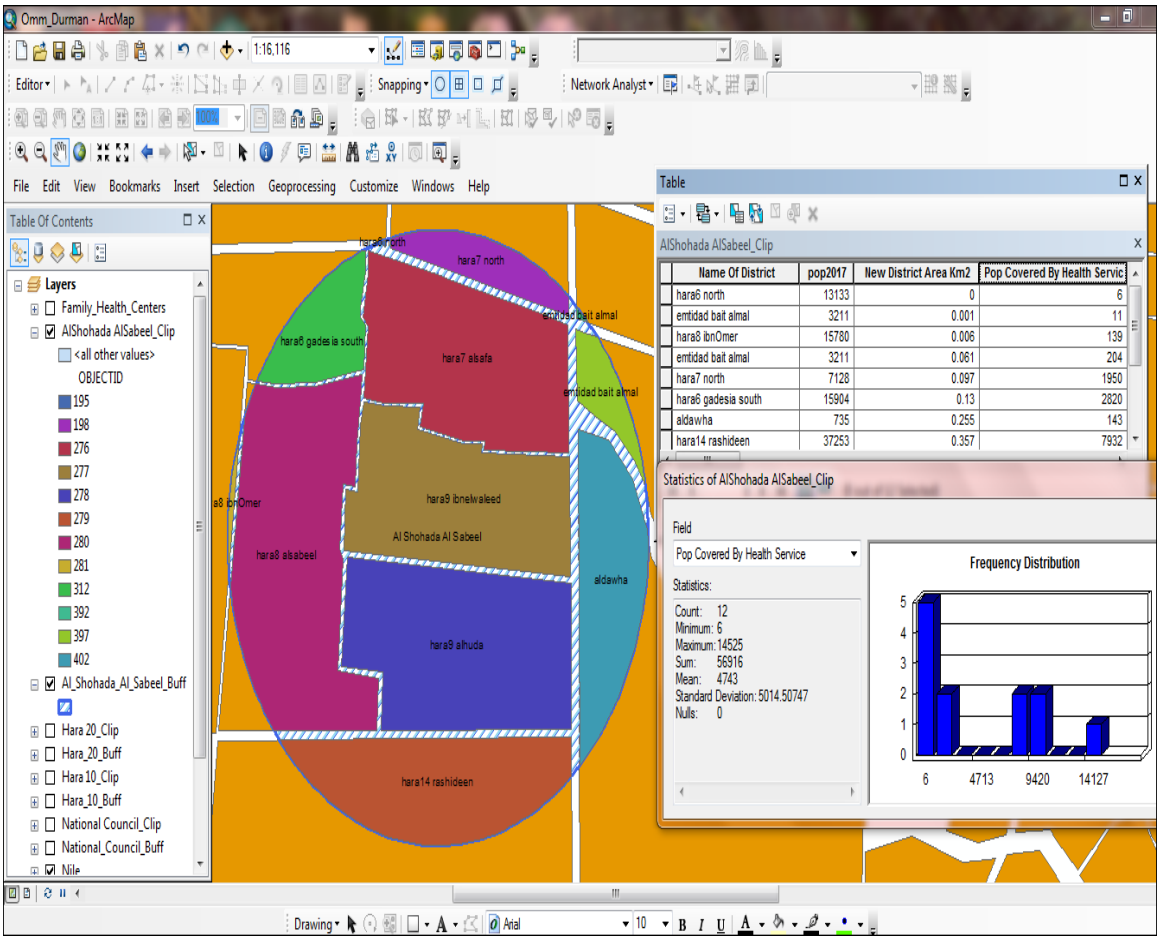


Fig (5.7) Attribute table of Shohada Al Sabeel Family Health Center illustrate the number of population benefiting from health service

5. Health centers that serve the population increased by the excess in the number of population more than 500% There are two Health: Alrayan Family Health Center and Al Salam 17 Family Health Center Fig (5.8), in area where this center is located where the deficit (Shortage) was estimated by two health centers, that means the need for the establishment of six centers in the region

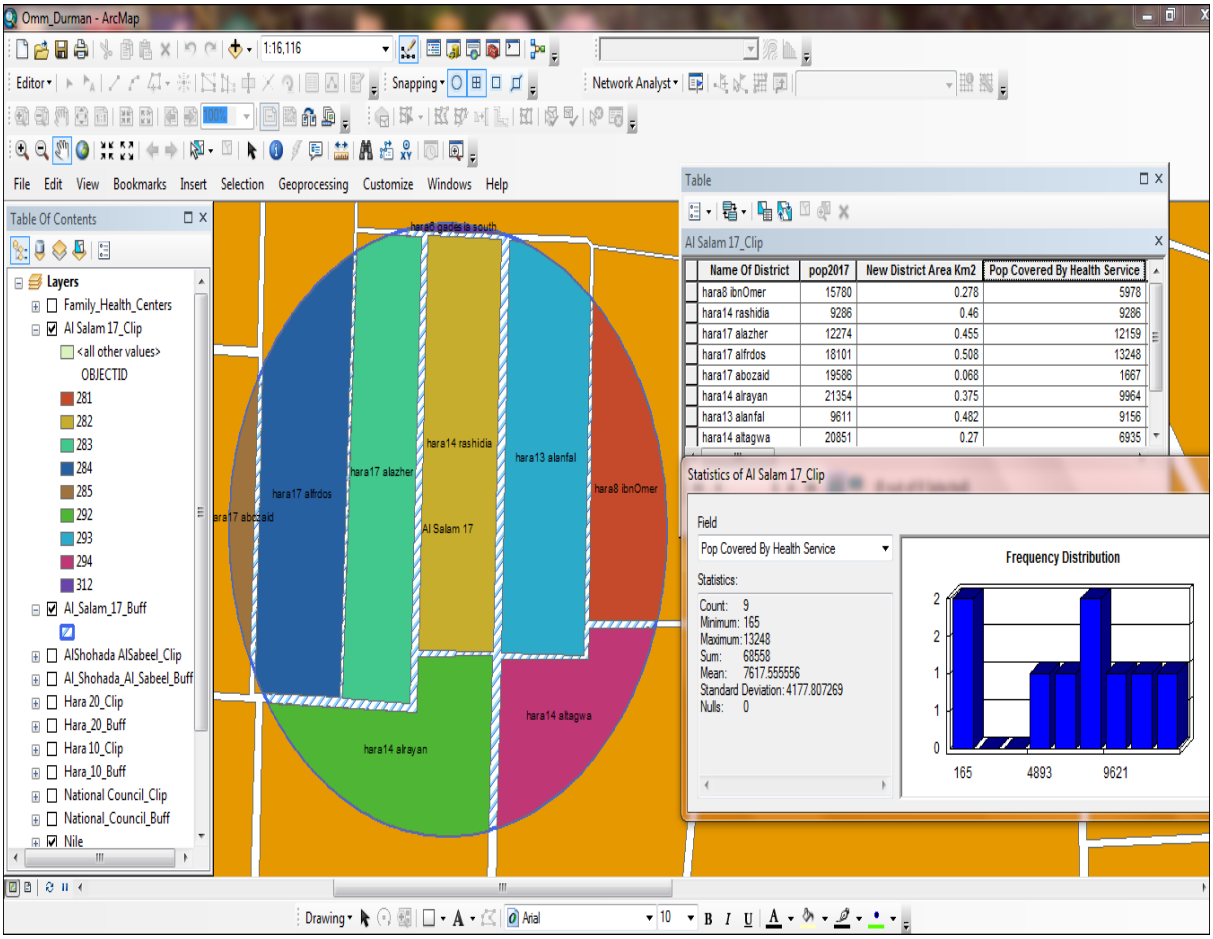


Fig (5.8) Attribute table of Al Salam 17 Family Health Center illustrate the number of population benefiting from health service

Table (5.2) The Population Covered By Family Health Service & The Shortage Of Health Centers

Name of health center	The Full (designed) Capacity of Health Center	The actual capacity	Surplus of the population	The percentage of capacity (%)	Shortage of the Health Centers
Al Qamaeer Health Center	10000	34560	24560	246	2
Bait Al Mal Health Center	10000	22872	12872	129	1
National Council Health Center	10000	7132	0	0	0
Abu Seed14 Health Center	10000	23266	13266	132	1
Al Sharfyah Health Center	10000	44657	34657	347	3
Al Tejani Helal Health Center	10000	11499	1499	15	0
Al Jemiaab Health Center	10000	27081	17081	171	2
Hara 32 Health Center	10000	32095	22095	221	2
Dar Almostafa Health Center	10000	58873	48873	489	5
Al Shohada Al Sabeel Health Center	10000	56916	46916	469	5
Hamd Al Neel Health Center	10000	58422	48422	484	5
Al Salam 17 Health Center	10000	68558	58558	586	6
Umm Baddah 43 Health Center	10000	48461	38461	385	4
Abo Zaid Health Center	10000	44598	34598	346	2
Dar Alargam Health Center	10000	40717	30717	307	3
Alrayan Health Center	10000	69621	59621	596	6
Hara 10 Health Center	10000	17263	7263	73	1
Alzaytona Health Center	10000	41129	31129	311	3
Hara 20 Health Center	10000	28420	18420	184	2
Hara 21 Health Center	10000	10724	724	7	0
ALfateheen Health Center	10000	16543	6543	65	1
Total	210000	763407	556275	5563	54

5.2 Reference Family Health Centers:

5.2.1 Coverage Of Reference Family Health Centers:

The study area contains fifteen reference family health centers fig (4.3), and by using the buffer (2500), we find that there are some family health centers he services cover an intermediate area containing containing non-residential areas, including seven reference family health centers fig (5.9), and these centers are: Al Hejrah Reference Family Health Center, Wad Nobawi Reference Family Health Center, Al Daw Hajoj Reference Family Health Center, East Banat Reference Family Health Center, Abu Seed1 Reference Family Health Center, Real State Bank Reference Family Health Center, and Alftimab Reference Family Health Center.

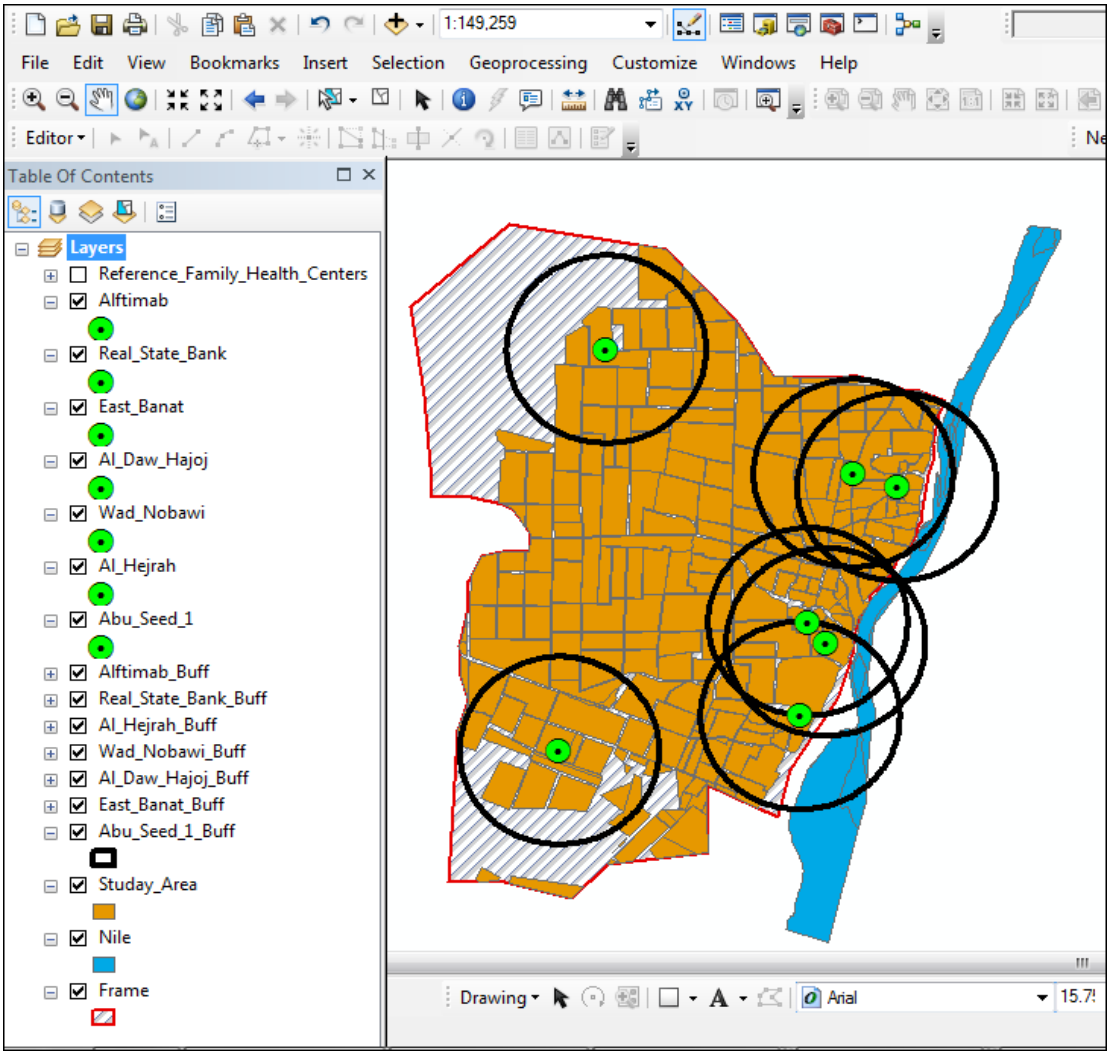


Fig (5.9) The Residential Areas & Non Residential Areas Covered by Seven Family Health Centers

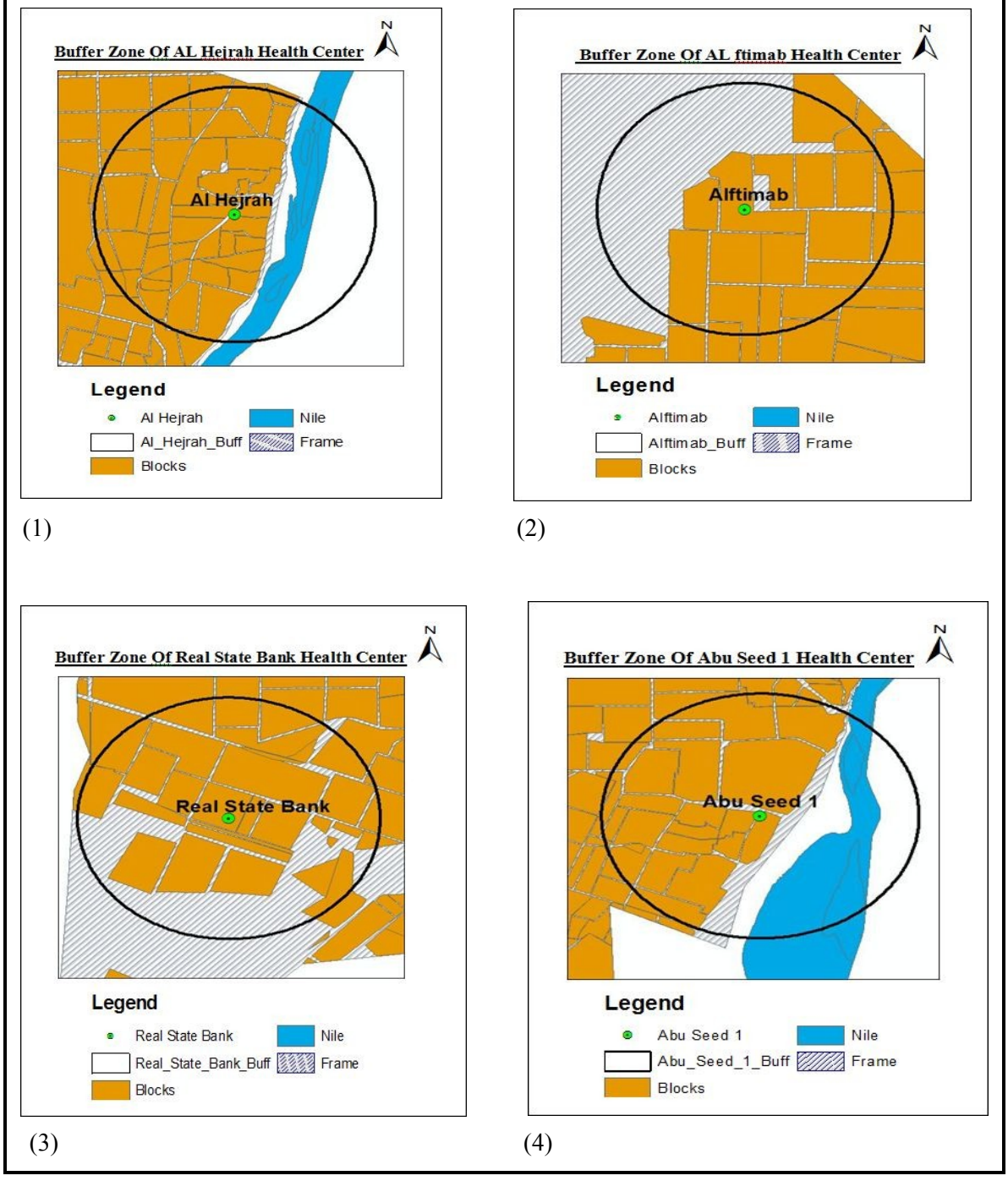
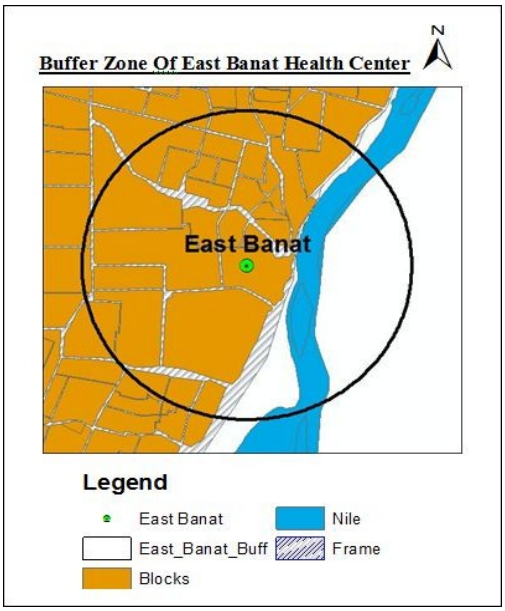
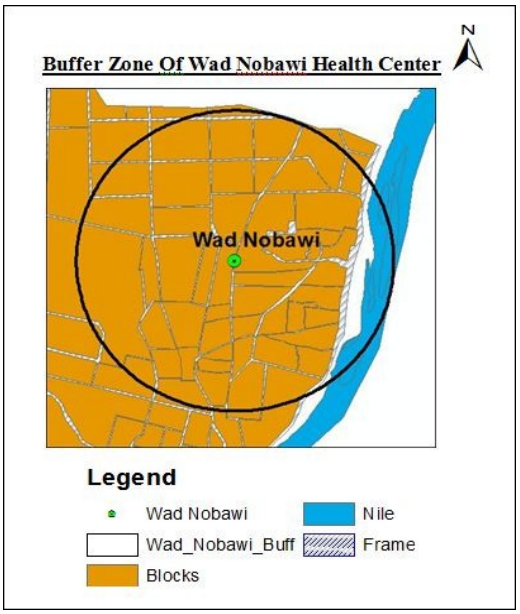


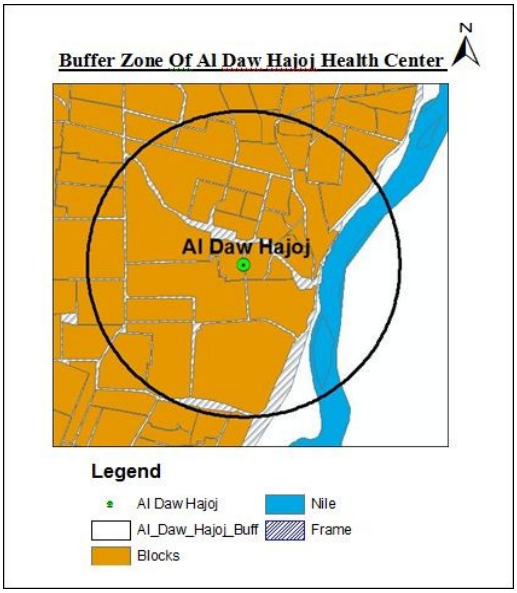
Fig (5.10(1,2,3,4)) Buffer Zones of Seven Reference Family Health Centers Show on Study Area



(5)



(6)



(7)

Fig (5.10(5,6,7)) Buffer Zones of Seven Reference Family Health Centers Show on Study Area

Table (5.3): The Residential Area & Non Residential Area Covered by Health Service of Reference Family health center

Name of health center	The total area of the covering health service(km²)	The Residential Area Covering by health Centers(Km²	Non Residential Area covering by health centers(Km²)	Non Residential Area percentage (%)
Al Hejrah Health Center	19.634	11.604	8.030	40.898
Wad Nobawi Health Center	19.634	16.461	3.173	16.160
Al Daw Hajoj Health Center	19.634	14.214	5.420	27.605
East Banat Health Center	19.634	11.463	8.171	41.616
Abu Seed 1 Health Center	19.634	10.376	9.258	47.152
Real State Bank Health Center	19.634	13.403	6.231	31.735
Alftimab Health Center	19.634	11.405	8.229	41.911
Total	137.438	88.926	48.512	**Average of percentage = 35.297**

Table (5.3) shows the following:

1. There are four governmental family health centers‘ health services covering a wide area is non-residential (more than 40%) including Al Hejrah Reference Family Health Center, Abu Seed 1 Reference Family Health Center, East Banat Reference Family Health Center and Alftimab Reference Family Health Center .
2. The results reflect that, there are two governmental Reference family health centers, health services covering an area of medium which is not residential (less than 40% and more than 25%) containing Al Daw Hajoj Reference Family Health Center and Real State Bank Reference Family Health Center.

3. There is a one Reference family health centers called by Wad Nobawi Reference Family Health Center, its health service covering mostly residential areas, in the other words its location is excellent and distributed in a good way covering non-residential areas less than 25%.

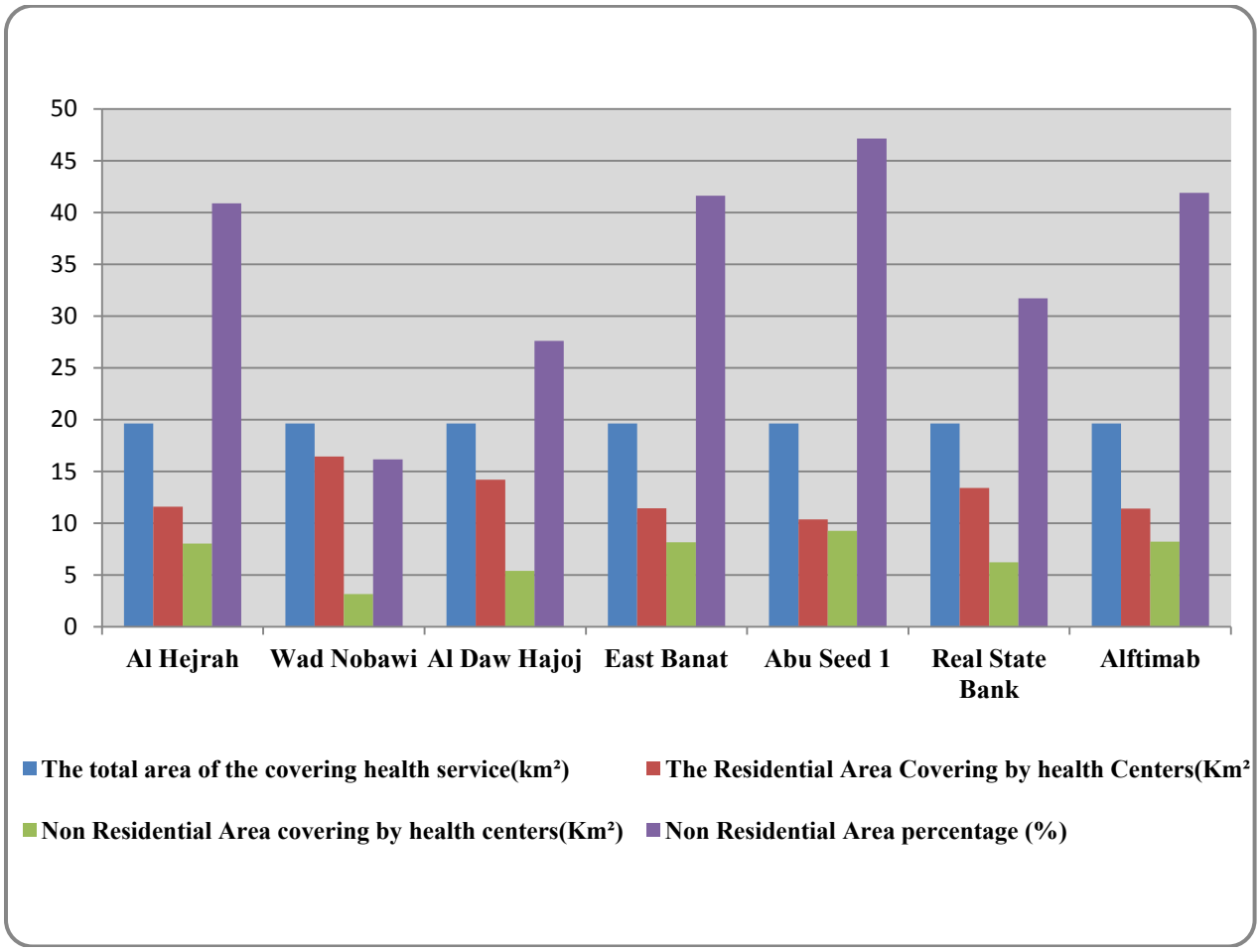


Fig (5.11) the Residential Areas & Non Residential Areas Covered by Seven Reference Family Health Centers

5.2.2 Analysis Of Reference Family Health Centers:

The study area contains fifteen Reference Family health centers, the center is designed to serve 60000 patients for one health center, according to the Sudanese Federal Ministry of Health standards.

Analysis of both reference family health centers attribute tables and its buffer zones (2500m) revealed that the total capacity of the population in the study area, which should be covered by governmental Reference Family Health Centers is (900000 people),

according to the Sudanese Federal Ministry of Health standards, While the actual number of residents beneficiaries (patients) of the health service is 2911762 inhabitants, that means there is a surplus in the population of about 2011762 people, an increase of entirety of approximately 3352% of the total capacity for the centers table (5.4).

As a result, health centers have been classified into five categories in terms of the proportion of the surplus in the number of people served by the specified health center:

1. Health centers that serve the population increased by the excess in the number of population ratio Between (40-100)% and these centers are Alftimab Reference Family Health Centers, Abu Seed 1 Reference Family Health Centers, Real State Bank Reference Family Health Centers and East Banat Reference Family Health Centers Fig (5.12).

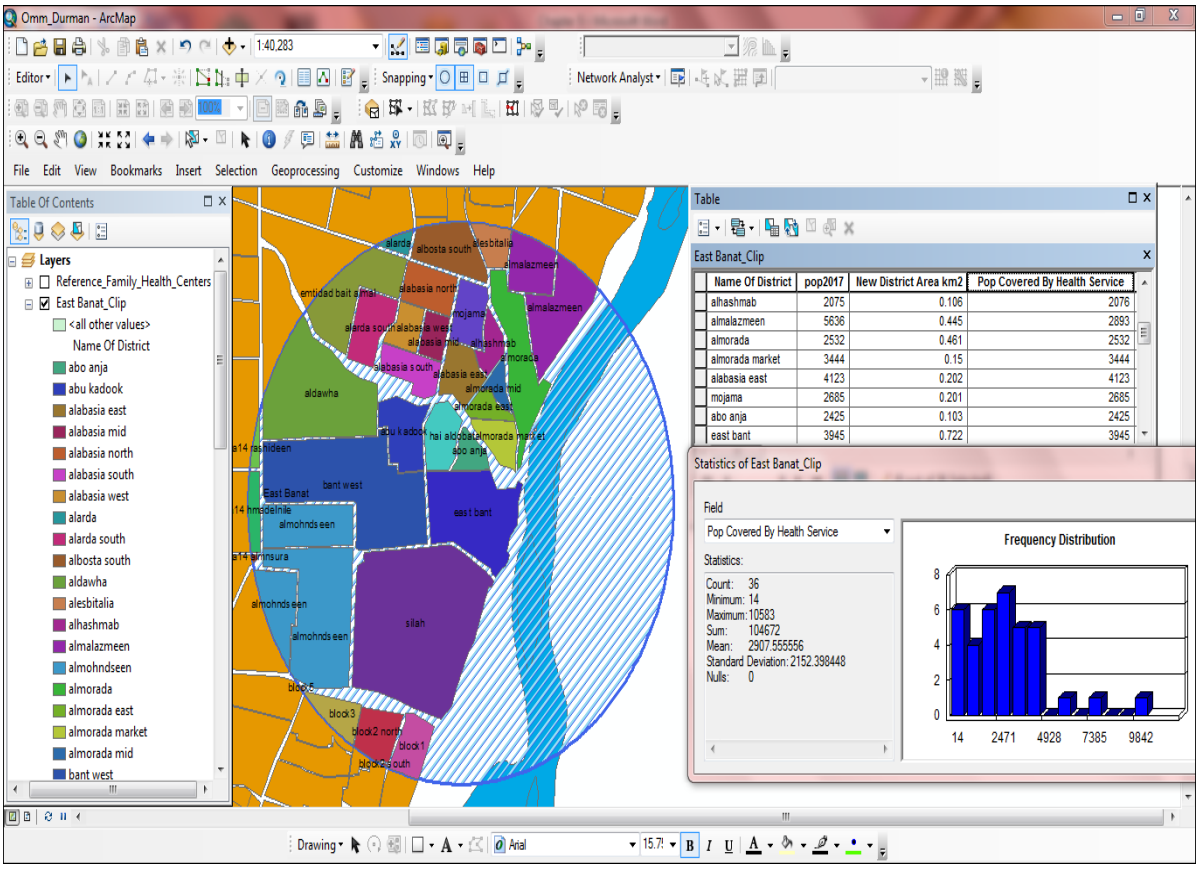


Fig (5.12) Attribute table of East Banat Reference Family Health Centers illustrate the number of population benefiting from health service

2. Health centers that serve the population increased by the excess in the number of population ratio Between (100-250)% and these centers are Al Daw Hajoj Reference Family Health Centers, Al Hejrah Reference Family Health Centers, Gharib Al Qusi Reference Family Health Centers, Awd Hussin Reference Family Health Centers and Hai Al Arab Reference Family Health Centers Fig (5.13).

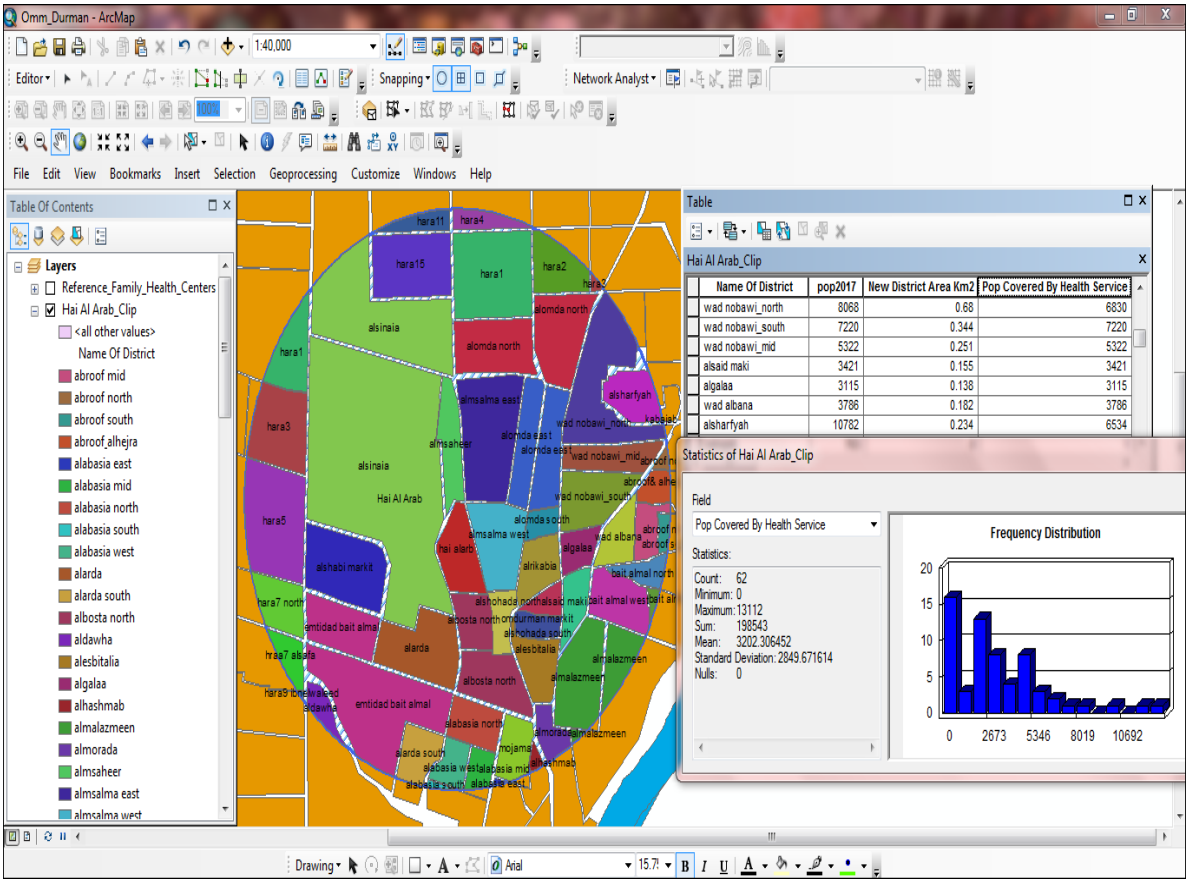


Fig (5.13) Attribute table of Hai Al Arab Reference Family Health Centers illustrate the number of population benefiting from health service

3. Health centers that serve the population increased by the excess in the number of population ratio Between (250-300)% and these centers are Wad Nobawi Reference Family Health Centers and Al Rakhaa Reference Family Health Centers Fig (5.14).

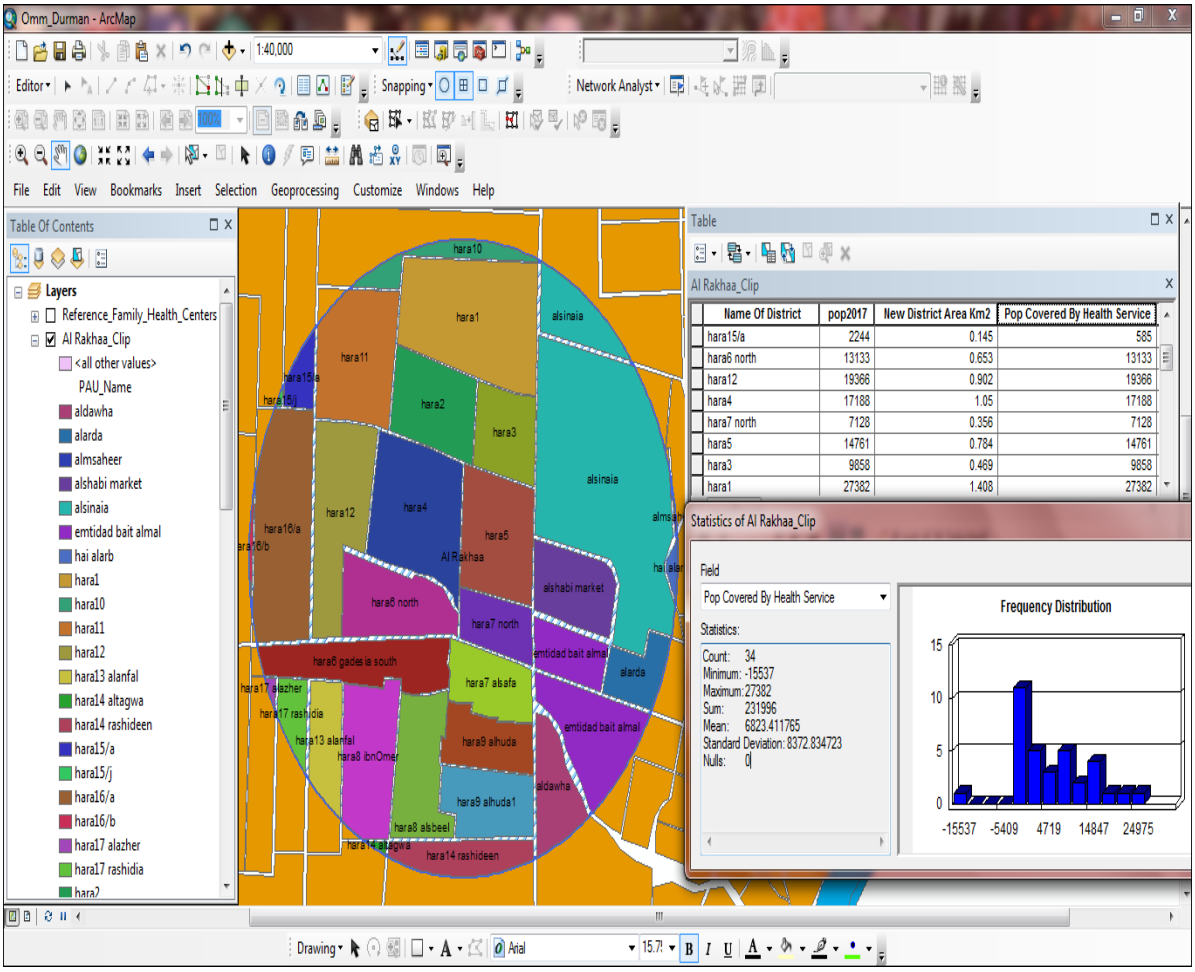


Fig (5.14) Attribute table of Al Rakhaa Reference Family Health Centers illustrate the number of population benefiting from health service

4. Health centers that serve the population increased by the excess in the number of population ratio Between (300-400)% and these centers are Alrashideen Reference Family Health Centers, Alnakhil Reference Family Health Centers and Badr Al Kubra Reference Family Health Centers Fig (5.15).

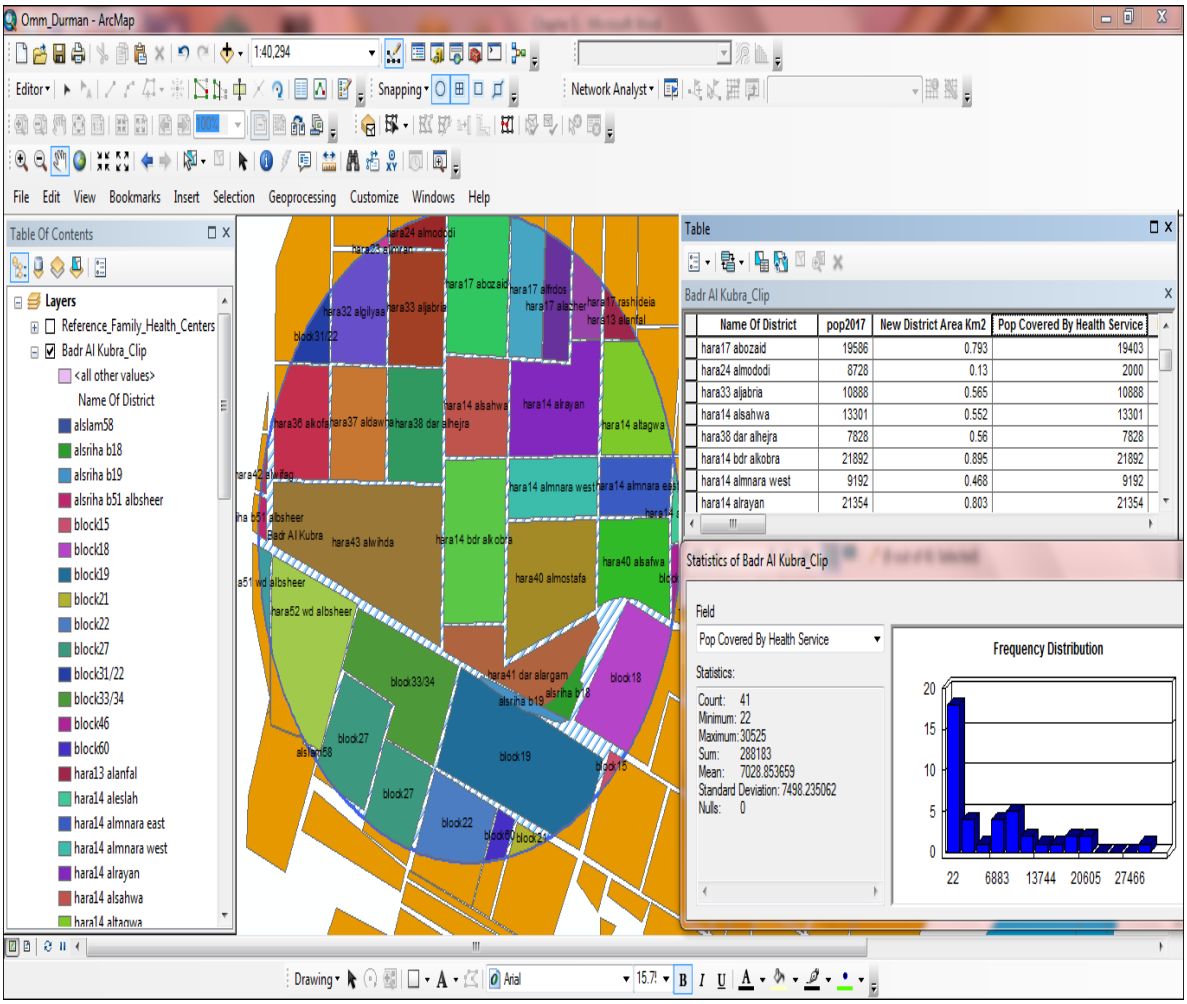


Fig (5.15) Attribute table of Badr Al Kubra Reference Family Health Centers illustrate the number of population benefiting from health service

5. Health centers that serve the population increased by the excess in the number of population more than 400% which is one center called Al Manarh Reference Family Health Centers Fig (5.16).

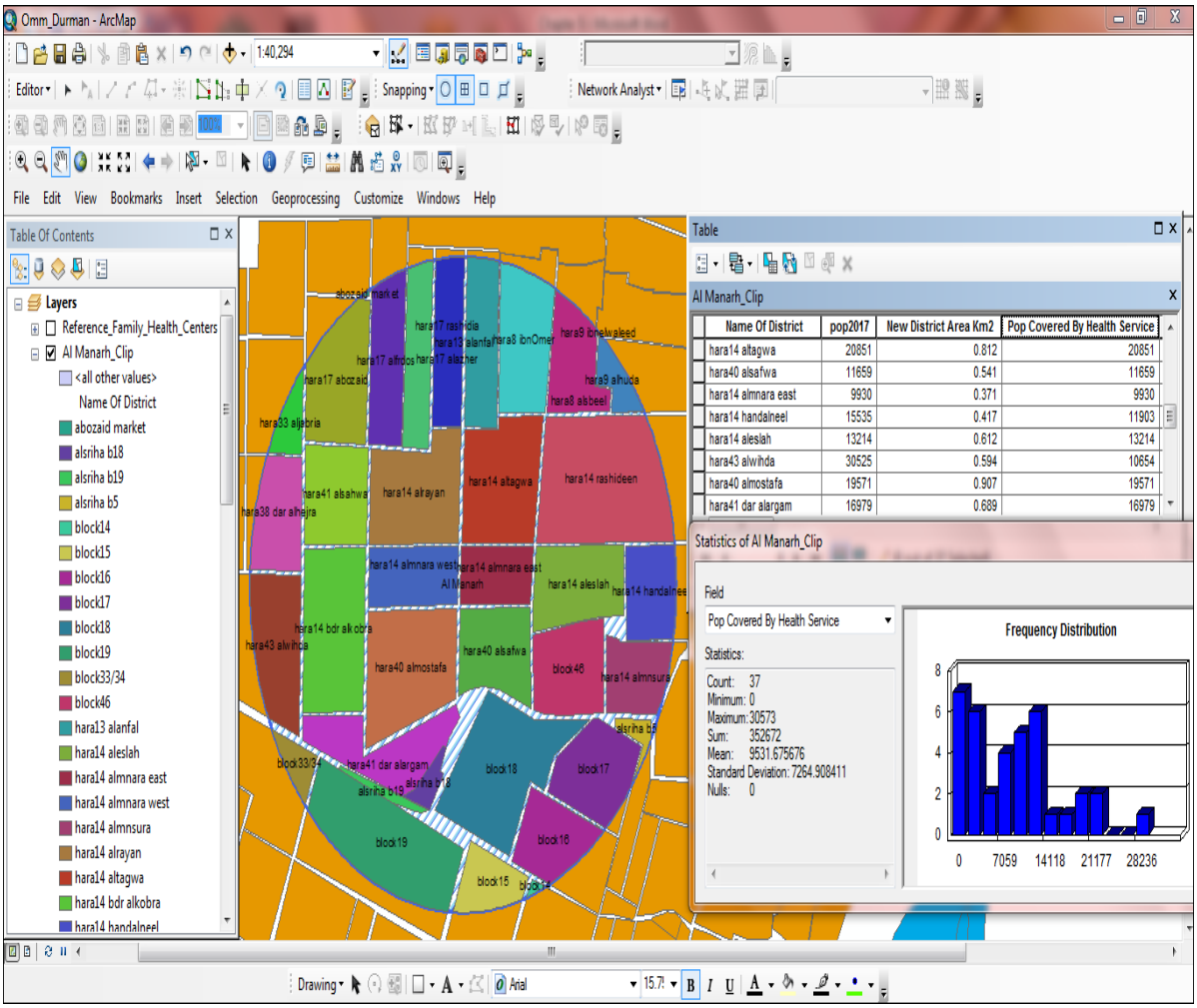


Fig (5.16) Attribute table of Al Manarh Reference Family Health Centers illustrate the number of population benefiting from health service

Table (5.4) The Population Covered By Health Service & The Shortage Of Reference Family Health Centers

Name of Health Center	The Full (designed) Capacity of Health Center	The actual capacity	Surplus of the population	The percentage of capacity (%)	Shortage of the Health Centers
Al Hejrah Health Centers	60000	157088	97088	162	2
Wad Nobawi Health Centers	60000	212651	152651	254	3
Al Daw Hajoj Health Centers	60000	133191	73191	122	1
East Banat Health Centers	60000	104672	44672	74	1
Abu Seed 1 Health Centers	60000	119398	59398	99	1
Real State Bank Health Centers	60000	106754	46754	78	1
Alftimab Health Centers	60000	84606	24606	41	1
Alnakhil Health Centers	60000	282054	222054	370	4
Hai Al Arab Health Centers	60000	198543	138543	231	2
Awd Hussin Health Centers	60000	182631	122631	204	2
Al Rakhaa Health Centers	60000	231996	171996	287	3
Gharib Al Qusi Health Centers	60000	179378	119378	199	2
Al Manarh Health Centers	60000	352672	292672	488	5
Badr Al Kubra Health Centers	60000	288182	228182	380	4
Alrashideen Health Centers	60000	277946	217946	363	4
Total	90000	2911762	2011762	3352	36

5.3 Hospitals:

The size of health facilities may vary considerably and affect comparisons. When smaller geographical units, such as districts are analysed, the population does not necessarily use the facilities in the designated area. Comparisons of densities between districts have to be made cautiously.

The size of hospitals and numbers of inpatient beds may vary considerably making comparisons difficult and, when smaller geographical units such as districts are analyzed, the population may not necessarily use the hospitals in the designated area. Consequently, comparisons of numbers of available inpatient beds between districts and subpopulations need to be done with caution.

Indicators of service availability cannot accurately reflect access to and utilization of services. For example, clients may avoid use of local hospitals or may use ones that lie outside the immediate catchment area because of travel logistics, sociocultural preferences and perceptions of quality. Urban areas present a particular challenge because, although hospitals may be close in proximity, issues of affordability and acceptability become more important obstacles to access (WHO, 2010).

Note:

- Hospital beds are used to indicate the availability of inpatient services. There is no global norm for the density of hospital beds in relation to total population In the European Region, there are 63 hospital beds per 10 000 population compared with 10 per 10 000 in the African Region. Statistics on hospital bed density are generally drawn from routine administrative records (WHO, 2009).

5.3.1 Analysis Of Hospitals:

A number of GIS-based techniques are available to assess the spatial pattern of distances among hospitals and availability.

The following steps had been conducted to process the data:

- Clarification population density of all districts in the study area Fig (5.18).
- Use Clip tool (from Arc Toolbox Menu–Analysis tools-Extract-Clip in GIS) to calculate area at each locality then number of population Fig (5.19, 5.20, and 5.21).

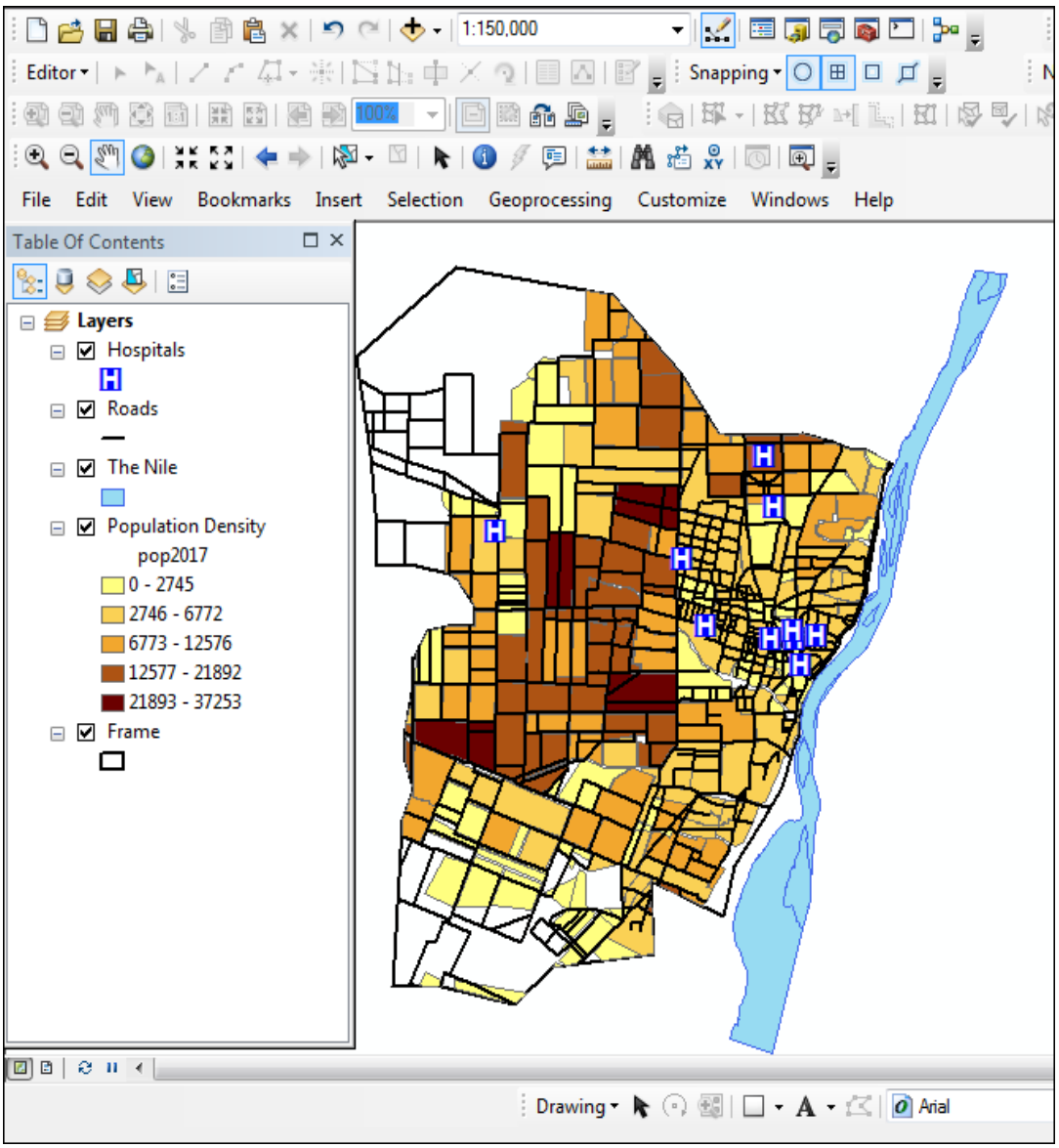


Fig (5.17) Population Density in the Study Area

Fig (5.17) shows the following:

Overall the spatial pattern of distribution of hospitals tends to be in districts that are located in the north and east of the study area, In addition they are located far from the areas with a high population density.

- Locality of Umm Badda has a high density of population and has one hospital.
- The southern parts of the Umm Durman Locality have no hospitals.

Table (5.5) shows the following:

If the number of population in each locality is compared with the number of hospitals located within them, we clearly notice that the number of hospitals is not commensurate with the population size.

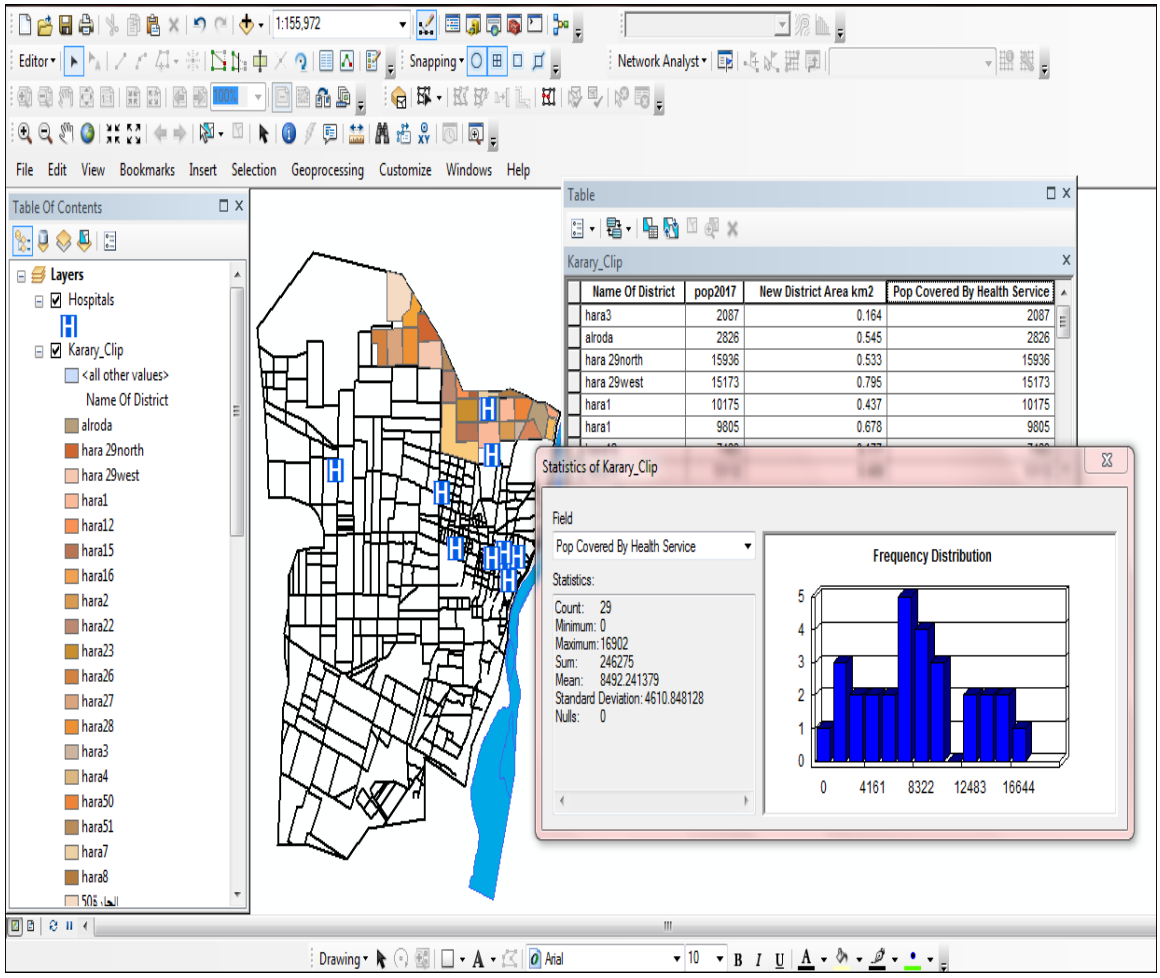


Fig (5.18) Attribute table of Karary Locality illustrate the Number of Population In all Blocks

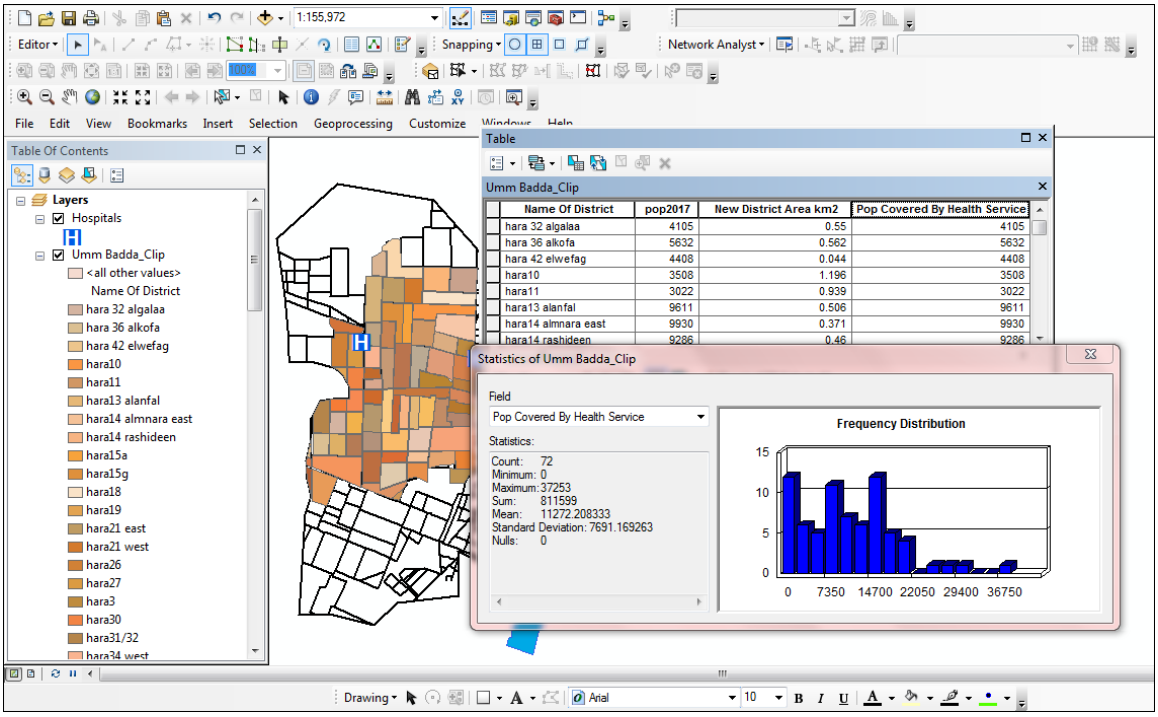


Fig (5.19) Attribute table of Umm Badda Locality illustrate the Number of Population In all Blocks

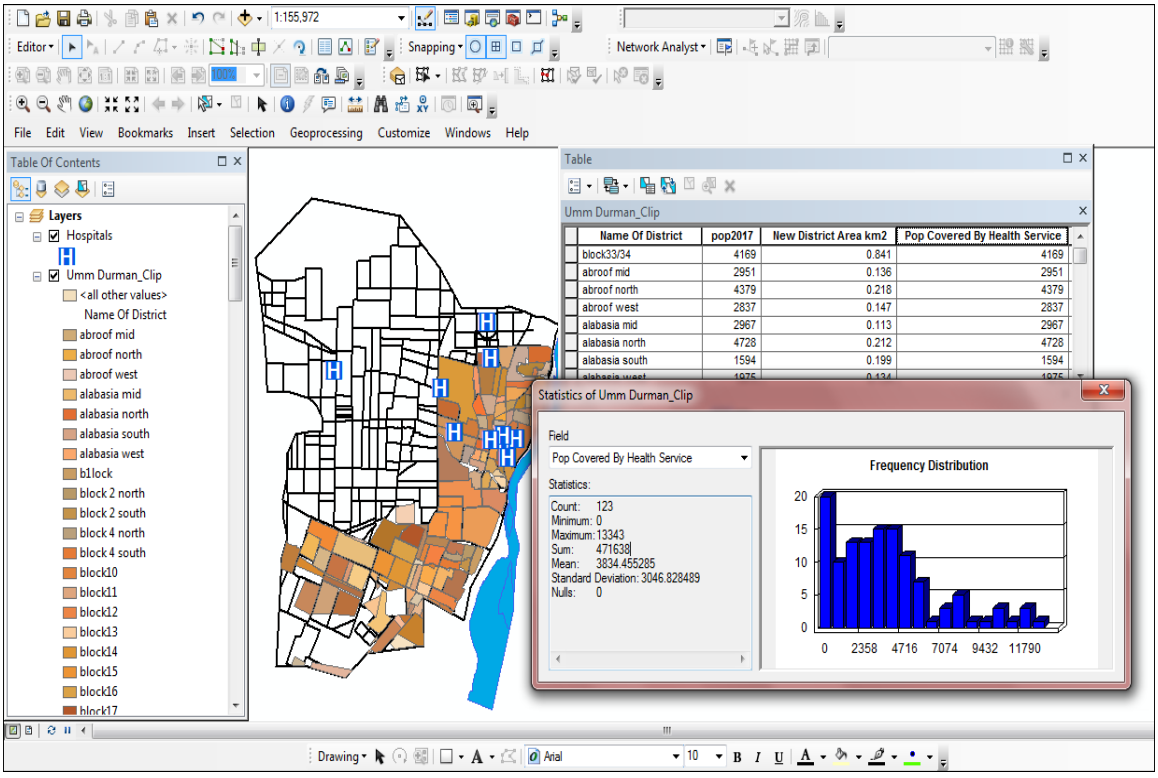


Fig (5.20) Attribute table of Umm Durman Locality illustrate the Number of Population In all Blocks

Table (5.5) Number of Population at Each Locality Within Study Area

Locality Name	No. of Hospitals	No. Of Population
Karary	1	246275
Umm Badda	1	811599
Umm Durman	8	471638

5.4 Petrol Stations:

5.4.1 Analysis Of Petrol Stations:

After the intersect tool procedure Fig (4.9), petrol stations that covered or not covered by fire stations had been obtained Fig (5.21).

- Petrol Stations covered with fire stations appeared in blue colour and petrol stations not covered by fire stations in black colour.

The population density in the study area was clarified to determine the distribution pattern of petrol stations based on the population density Fig (5.22).

- Most petrol stations are located in an area of low to medium population density.

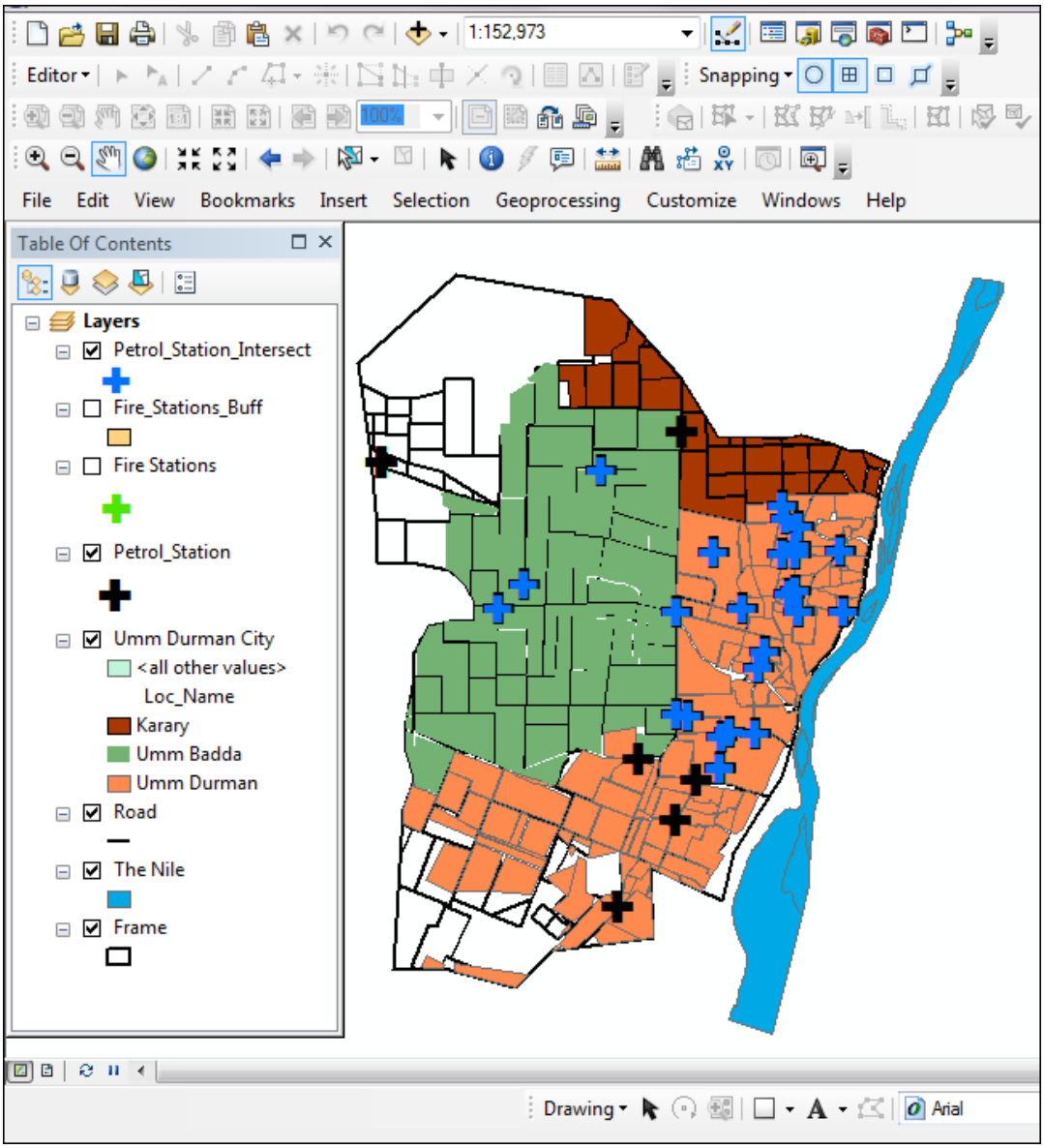


Fig (5.21) Petrol Stations Covered and Non Covered

By Fire Stations Service

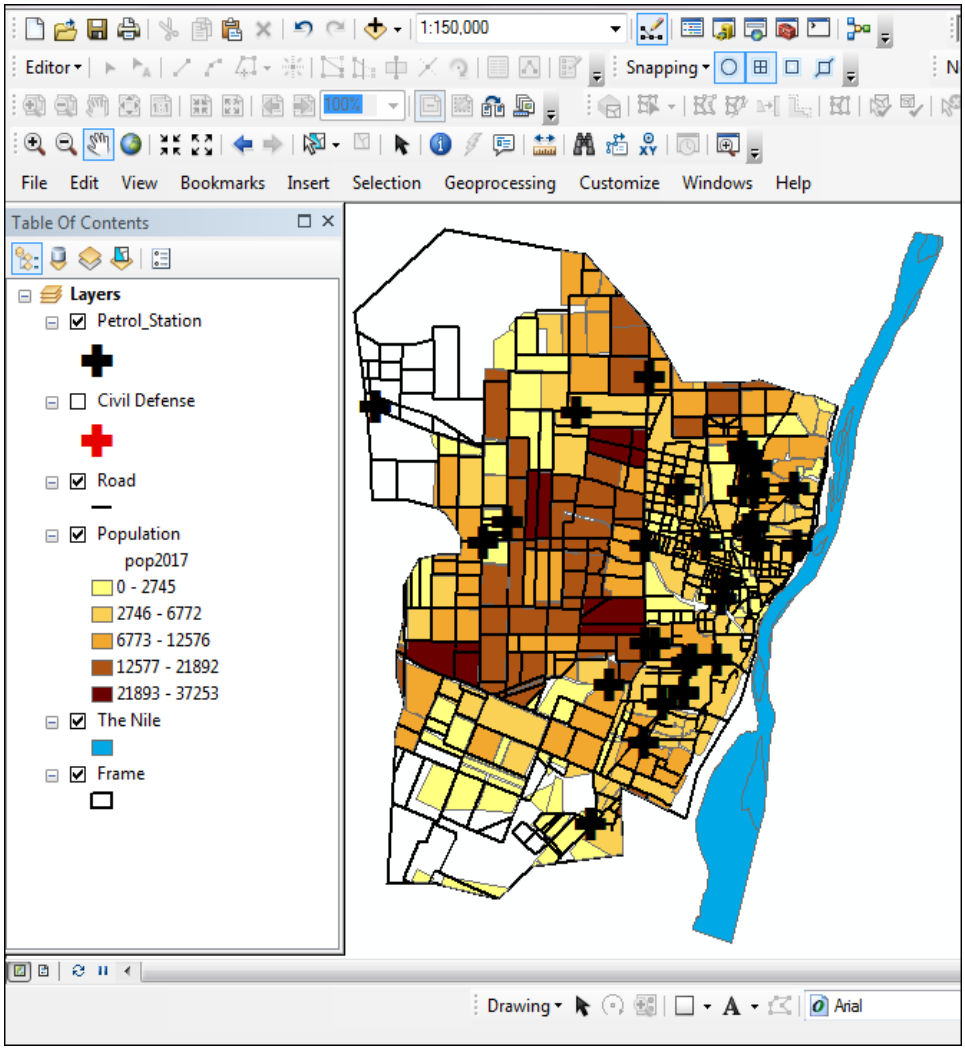


Fig (5.22) Population Density in the Study Area

5.4.2 Coverage Of Petrol Stations:

There are Thirty-two petrol stations in the study area, most petrol stations are located in the east and south-east part of the study area Fig (4.7), locality of Umm Badda suffers from severe shortage of petrol stations, in addition several parts of locality of Umm Durman.

From Fig (4.8) we note that the southern districts of the study area are not covered by the fire service, in addition to limited areas in the northern parts.

From Fig (5.22) we note that the coverage of petrol stations are excellent, most of petrol stations were covered by fire stations service except six petrol stations of the total (32 petrol stations), four located in locality of Umm Durman and they are: (Oil energy,

Petronas Fuel Station, Aman Petrol Station and Fuel C N P C Station), and one located in Locality of Umm Badda this is called petroleum station, one located in Locality of Karary Station Bee Fuel Station.

5.5 Markets Sector:

5.5.1 Analysis Of Markets Sector:

After the intersect tool procedure Fig (4.12), markets covered or not covered by police stations had been obtained.

- Markets covered with police stations appeared in green colour, and markets not covered by police stations in black colour fig (5.23).

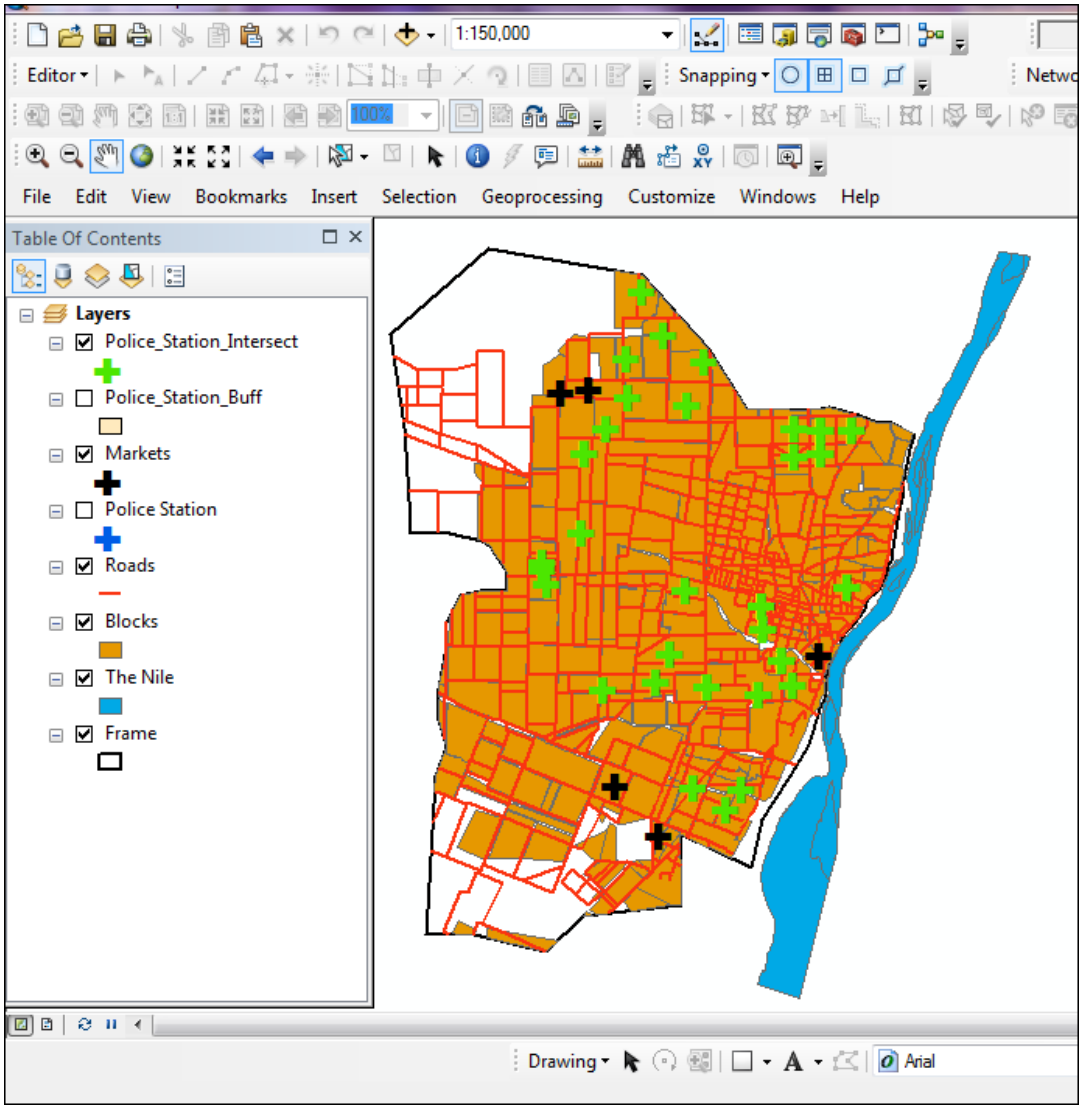


Fig (5.23) Markets Covered and Non Covered By Police Stations

5.5.2 Coverage Of Police Stations For Markets:

From fig (5.23) we note that the coverage of the markets was excellent, where most of the markets were covered by police station except five markets of the total (36 market) there are two markets in locality of Umm Badda and they are: AL Fitemab Market and Almawshi (Alrodwan) Market and three markets in locality of Umm Durman they are: Abu Seed Market, AL Shigla Market and AL Mawrada Market.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion:

This study showed the high effectiveness of the geographic information system (GIS) for data analysis to conduct an assessment of spatial distribution pattern of public services, final results of this study discovered that that the pattern of distribution of public services in Umm Durman City is generally random and uneven (disorderly), do not proportional to population density and there is a lack of public services (particularly the west and south parts within study area). Therefore Population distribution must be a considerable factor in the distribution of public services.

The output of governmental family health centers analysis (21 health centers) revealed that there are four health centers are cover an non-residential areas Fig (5.1), in addition family health centers do not meet coverage criteria, from (Table 5.2) It was found that there is an increase of entirety of approximately 5562.765% of the total capacity for the health centers.

The output of governmental reference family health centers analysis (15 health centers) revealed that there are seven health centers are cover an non-residential areas Fig (5.9), in addition reference family health centers do not meet coverage criteria, from (Table 5.4) It was found that there is an increase of entirety of approximately 3352.936% of the total capacity for the health centers.

Inequalities in distribution of hospitals in the study area were measured, and the finding revealed that the hospitals throughout Umm Durman districts were spatially clustered (Fig 4.6), were significantly clustered in the east of the study area, many districts have a zero number of hospitals, while districts that located in the east of the study area have very high density of hospitals. and the results Fig (5.17) show that all hospitals (except one) are located in a districts with low population density, Locality of Umm Badda have a high density of population and has one hospital (that's means there is a severe shortage of hospitals), and there are no hospitals in the southern parts of the Umm Durman. therefore, providing hospitals based on population density is essential.

The findings of petrol stations analysis Fig (4.7) clearly revealed the spatial pattern of distribution of petrol stations (32 stations) tends to be in districts that are located in the east and south-east part of the study area, locality of Umm Badda have very few petrol stations (3 stations), one of them located in non-residential areas, there are no petrol stations in limited areas in the southern part of Umm Durman, the results Fig (5.22) show that most of petrol stations are located in areas of low to medium population density, the results Fig (5.21) show that all petrol stations were covered by fire stations service except six petrol stations of the total (32 stations), four located in Umm Durman one in Umm Badda one in Karary, the results (4.8) show that large parts of southern of Omdurman region and small parts from south of Umm Badda are not covered by the fire service.

The coverage of police stations for the markets were examined and the results revealed that most of the markets were covered by police station Fig (5.23) except five markets of the total (36 markets), three markets in locality of Umm Durman and two markets in locality of Umm Badda, In addition the coverage of the police stations of the neighborhoods was excellent Fig (4.11) except the southern part of Umm Durman, and small parts along the western border of Umm Badda.

6.2 Recommendations:

Based on the findings presented in this study has been proposed these recommendations:

- Focus on further expansion about data of travel time on road networks, it was not possible to assess accessibility to public services according to temporal distances since data of travel time on road networks are not available.
- Use GIS to determine the current distribution of services according to the population density in order to avoid repetition of the error in the distribution when establishing new services.

CHAPTER SEVEN

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