ıdan University of Science & Technology

College of Postgraduate Studies

Primary Health Service Distribution in Urban Areas Using GIS

توزيع الخدمات الصحية الأولية في المناطق الحضرية بإستخدام نظم المعلومات الجغرافية

A dissertation Submitted for Partial Fulfillment for the requirement of the Degree of Master of Science

In Geodesy and GIS

Prepared by:
Mohamed Abdel Gadir Rahama Abdel Gadir

Supervisor:
Dr. Abdel Rahim Elhag Abdel Aziz

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الآية

قال تعالى :(وَمَا أُوتِيتُمْ مِنَ الْعِلْمِ إِلّا قَلِيلًا)

الإسراء -الأية (٨٥)

Dedication

TO MY MOTHER

TO MY FATHER

TO MY SISTERS

TO MY FRIENDS

TO ANY ONE HELPED

Acknowledgement

I express my deep gratitude to the Almighty Allah who created and nurture of in this transitory world. I also express my gratitude to Him for giving me an opportunity to do this research successfully.

I would like to express my thanks to all my friends and colleagues who have given me much help full advice and engorgement during this study,I am very thankful to my supervisor **Dr. Abdel Rahim Elhag Abdel Aziz**

Finally, I would like to express my gratitude to all the people who helps me by providing their valuable assistance and time during this study.

Abstract

Dealt with the subject of the study through spatial distribution of the governmental health centers, for understanding its relationship with the numbers of population, health outcomes and access, in light of rapid urbanization worldwide.

The crisis in the health sector of Sudan has seen very obvious since the last decade, particularly in Bahri locality. It turns out the requires of appropriate infrastructure because of lack of attention to proper and suitable planning for the distribution of health establishments, whereas there is a partial an imbalance in the distribution of health centers in the study area.

The study was primarily examined the spatial distribution of governmental health centers in Bahri locality densely populated within the urban area (two administrative units) with a view to ascertaining whether there is any imbalance. The study is based on methodology; mainly on the descriptive approach in gathering information and databases belonging to health facilities (provided by 20 governmental health centers) within the city, and using the 2008 population census data (National Bureau of Statistics(NBS)), and the analytical method by using spatial analysis using geographic information systems(GIS) which provide a set of tools for describing and understanding the changing spatial organization of health care, and study its efficiency in the region.

After discussing the subject of research it became clear that there is an obvious disparity in the sites of health centers, found that there are some regions are defective because they do not have health center and therefore, the health facilities in the city are far away in terms of distance for the residents of those areas. Also the research has proven that health services do not fit the size of the population, where there are some health establishments that serve the number of patients larger than its capacity.

This research also aims to assess the compatibility of the distribution of health services with the standards universally followed and established a clear vision for the distribution of such services in locality according to the scientific founding. In order to identify the impact of geographical factors, and identify deficit areas, thus assessing the possibility of access to health centers by evaluation of the services's locations used by residents as well as create digital maps to describe the current distribution of government health centers to be used in public health management for planning and organization of healthcare services.

الملخص

تناول موضوع الدراسة التوزيع المكاني للمراكز الصحية الحكومية، لفهم علاقتها مع أعداد السكان، والنتائج والمخرجات الصحية والوصول إليها، في ضوء التوسع العمراني السريع في جميع أنحاء العالم.

أزمة القطاع الصحي في السودان أصبحت واضحة جدا منذ العقد الماضي، ولا سيما في محلية بحري. اتضح أنه يتطلب بنية تحتية مناسبة بسبب عدم الاهتمام بالتخطيط السليم والمناسب لتوزيع المنشئات الصحية، حيث أن هناك خللاً جزئياً في توزيع المراكز الصحية في منطقة الدراسة.

ونظرت الدراسة في المقام الأول على التوزيع المكاني للمراكز الصحية الحكومية في محلية بحري ذات الكثافة السكانية العالية في المناطق الحضرية (وحدتين إداريتين) منها بهدف التأكد مما إذا كان هناك أي خلل.

ارتكزت الدراسة في منهجيتها بصورة أساسية على المنهج الوصفي في جمع المعلومات وقواعد البيانات الخاصة بالمرافق الصحية (المقدمة من 20 مركز صحي حكومي) داخل المدينة، وكذلك إستخدمت بيانات التعداد السكاني للعام 2008 (الجهاز القومي للإحصاء)، والمنهج التحليلي عن طريق التحليل المكاني باستخدام نظم المعلومات الجغرافية والتي توفر مجموعة من الأدوات لوصف وفهم تغير التنظيم المكاني للرعاية الصحية، ودراسة كفاءتها في المنطقة .

وبعد مناقشة موضوع البحث اتضح أن هناك تفاوت واضح في مواقع المراكز الصحية. حيث وجد أن هناك بعض المناطق بها قصور لأنه ليس لديها مركز الصحي، وبالتالي فإن المنشئات الصحية في المدينة تكون بعيدة من حيث المسافة لسكان تلك المناطق. كما أثبتت الأبحاث أن الخدمات الصحية لا تتناسب مع حجم السكان، حيث توجد بعض المؤسسات الصحية التي تخدم عدد من المرضى أكبر من طاقتها.

يهدف هذا البحث أيضاً لفحص مدى توافق توزيع الخدمات الصحية مع المعايير المتبعة عالميا وتأسيس رؤية واضحة لتوزيع هذه الخدمات في المحلية وفقاً للأسس العلمية، من أجل التعرف على أثر العوامل الجغرافية، وتحديد مناطق العجز، وبالتالي تقييم إمكانية الوصول إلى المراكز الصحية عن طريق تقييم مواقع الخدمات المستخدمة من قبل السكان ، وكذلك إنشاء خرائط رقمية لوصف التوزيع الحالي للمراكز الصحية الحكومية لاستخدامها في إدارة الصحة العامة لتخطيط وتنظيم خدمات الرعاية الصحية.

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Chapter One

Introduction

1.1 Introduction:

Primary health care is essential health care for maintaining population's health and made universally accessible to individuals and families in the public, and if properly distributed it is most effective in preventing disease progression on a large scale.

Primary Health Care addresses the principal health problems in the community, providing promotive, preventive, curative and rehabilitative services accordingly. While these services reflect from the economic situation and social values of the country and its communities, they will vary from country and community to others.(Organization, 1978a)

Health care has many definitions and meanings as it is more than the absence of disease(Organization, 1978a). To some, health care and health oriented services is hospital or medical care, while to others it may mean a plethora of other 'health' oriented services, from primary health care right through non-medical services or complementary and alternative medical care. (Ansari, 2007) However, as primary health care services is the first-point-of-contact which occurs between individuals of the community and the national health system in Australia and in Sudan similarly, in accordance with the principles of primary health care service delivery to the population where they live, work in a fair way. Similar to defining health care, access to health care is complex and may mean many things to different people. It is "not limited to the availability of care, the ability to get to and pay for available care, or the act of seeking and utilising available care"(McGrail, 2012)

GIS and health information system in general is considered as the main pillar in the development of strategies, policies and future plans on a unified informational

scientific basis, which guide decision-making process leading towards the improvement and development of health services provided to citizens on the level of all the different sectors of the service and the development of health centers. In order to create a society that enjoys welfare, prosperity and equality among its members. Hard-working in various successive governments' policies is that the human being is the goal of development. And its scheme is that people's health is always among the main priorities.

The most important reforms needed to achieve the convergence of basic health care values and expectations of the citizens and the common challenges of performance on the field of health lies in universal coverage, which will help to achieve social justice, as well as a way to provide services that are based on people's needs and expectations.

Despite the various factors which impact health care utilisation, geographic access of health services continues to impact on the delay in treatment, increased hospitalisations, but also the overall health and wellbeing of individuals.(Luo and Whippo, 2012)&(Humphreys et al., 2008) , and maintaining health is by providing preventive and curative health services in a fair, high quality way and that the optimum use of resources, technologies and that partnership actors are effective with relevant authorities to achieve organizational role.

Melissa M Terry, Daniel R Terry declared that The National Primary Health Care Strategy in Australia recommends primary health care services need to be clinically and culturally appropriate and delivered in a timely and affordable manner". However simultaneously recognised, access is still inequitable in among various population groups and many areas of Australia. Geographical Information System (GIS) have been used to explore geographical health disparities, planning health care service delivery and provide data in a meaningful way to inform public health strategies. Moreover, GIS has also been used to spatially analyse, measure and provide insight into a population's accessibility to health care services".(Terry and Terry, 2013).

Doubtless the strategic planning is very important in the present day, on the way check nations and peoples' goals and achieve their desired objectives, the emergence of the urgent need to plan on the use of health services. Which are an

essential part of the physical infrastructure within the Bahri city and therefore, the development of health services must be parallel with the urban development of the city. Where the main tasks of these services are meeting the needs among the population as required and type.

This study intends to assess the existing distribution of the governmental health centers. The present distribution of health centers had been evaluated using up-to-date digital maps (as shape files), using GIS techniques in the production of multi-layers maps program and displayed spatially and conducts a thorough analysis to support decision makers to control and regulate the delivery of health services and directing this delivery to satisfy the needs among the population, and this requires optimum distribution services to investigate their needs and to overcome the problems they may face.

1.2 Statements of the Problem:

The City of Bahri has seen an unexpected increase in the numbers of population in recent years as a result of the influx of residents of other towns around the city, which lies within the boundaries of the Sudanese capital Khartoum but is one of the three components of the capital cities, as a result of the lack of quality social services (education, health, ... etc.). The health services and its distribution, in particular are not copying with this increase in population, due to changes in city map through horizontal expansion to its borders, so the health services are distributed disproportionately with the distribution across the population and hence the low efficiency of health services throughout the city.

1.3 Research objectives:

- To highlight the importance of research through the examination and verification of the regular distribution over the variables of health services in accordance with criteria approved by the Sudanese Ministry of Health in order to achieve the objectives of health services for the best and the degree of acceptance and satisfaction.

- To Good distribution of health services increases the efficiency of the least expenditure of effort, whether some efforts were in the money and Manpower or any other things.
- To Access to equitable distribution of sites of health services at the level of urban neighborhoods in Bahri suit the size of population where they can positively affect the lifting of the practical and productive level of the city's population by creating the appropriate climates.
- To help in Decision Support through the necessary decisions in the field of spatial balance of health care and the organization of health services, as well as the lack of specialized and integrated study of precedent in this area of bahri city so that they can hope to participate in health planning for the city in the future.

1.4 Thesis layout:

Chapter one: Is introduction about the importance of primary health care services, geographic access of health services as a factor to impact on the health care utilisation, using GIS and applying its principals on the health sector, the study area, the study period, materials, data and software used for the accomplishment of search, in addition to problem of the study, the goals that the Thesis is seeking to achieve, results intended to be accessible and Thesis layout. Chapter two: Illustrates the concept of primary health care : introduction, definitions and the current situation, the primary health care approach, the concept of universal health coverage and developing it, also explain the health System in the Sudan: develop and improve health services in the Sudan, besides the current situation of health services in Khartoum State and the coverage indicators for Primary health care centers, health map, levels to provide primary health care services, Family Health Center and Reference Family Health Center. Chapter three: highlighting the geographic information system (GIS), Introduction, Definition, Components of GIS, Functionalities of GIS. Chapter four: reviews the applications of GIS in the health Field, GIS &public health, GIS and analyzing access to health care, measuring Health Access and Alternative Methods of Measuring Access, Spatial Accessibility in Urban Areas, Spatial Analysis in Epidemiology. Chapter five: shown the study

area, its climate, sources of data, and how data collection, and methodology (data processing) steps were done to undertake the thesis. . Chapter six: Results, Data analysis and Discussion: Showing results and an analysis of distribution of Family Health centers, Coverage health service of Family health centers and Reference Family Health Centers. Discussion the Distance and Population criterion. Also analysis of Phenomena resulting. Chapter seven: Conclusion, Recommendations and References.

CHAPTER TWO

The Primary Health Care and Health System in the Sudan

2.1 The Primary Health Care:

2.1.1 Introduction:

Primary health care consists at least of: promotion of proper nutrition and an adequate supply of drinking water; basic sanitation; maternal and child care, including family planning; immunization against the major infectious diseases; prevention and control of locally endemic diseases. Awareness of common health problems and the methods of preventing and controlling them; and appropriate treatment for common diseases and injuries.

In order to make Primary Health Care universally accessible in the community as quickly as possible, community and individual self-reliance for health development are essential, to attain such self-reliance requires full community participation in the planning, organization and management of Primary Health Care. They will thus be in a better position to take rationality of the decision concerning Primary Health Care and to make sure that the right kind of support is provided by the other levels of the national health system.

These other levels have to be organized and strengthened so as to support Primary Health Care with technical knowledge, training, guidance and supervision, logistic support, supplies, information, financing and referral facilities including institutions to which unsolved problems and individual patients can be referred. Primary Health Care is likely to be most effective if it employs means that are understood and accepted by the community and applied by community health workers at a cost the community and the country can afford.

Primary Health Care is an integral part both of the country's health system and of economic and social development, without which it is bound to fail, it has to be coordinated on a national basis with the other levels of the health system as well as with the other sectors that contribute to a country's development strategy.

2.1.2 Definitions:

Primary Health Care defined as the fundamental health care made universally accessible to individuals and families in the community by means acceptable to them, through their full participation and at a cost that the society and government can afford. It forms an integral part both of the country's health system of which it is the nucleus and of the overall social and economic development of the community.(Organization, 1978b)

Primary Health Care is a practical approach to making essential health care universally accessible to individuals and families in the community in an acceptable and affordable way and with their full participation(Organization, 1978a).

ALMA ATA declare "Primary Health Care means much more than the mere extension of basic health services and having the aim of using only those technologies that have really proved their worth and can be afforded, primary health care delivered by community health workers who understand the real health needs of the communities they serve and have the confidence of the people".

Primary health care is the way to achieving an acceptable level of health throughout the world in future as part of social development and in the spirit of social justice. It is equally valid for all countries, from the most to the least developed, though the form it takes will vary according to political, economic, social and cultural patterns. For developing countries in particular.

2.1.4 The primary health care approach:

Primary health care is a practical approach to making essential health care universally accessible to individuals and families in the community in an acceptable and affordable way and with their full participation. This approach has evolved over the years, partly in the light of experience, positive and negative, gained in basic health Services in a number of countries. But it means much more than the mere extension of basic health services. It has social and developmental dimensions and if properly applied will influence the way in which the rest of health system functions. Its shape is determined by social goals, such as the improvement of the quality of life and maximum health

benefits to the greatest number; and these goals are attained by social means such as the acceptance of greater responsibility for health by communities and individuals and their active participation in attaining it. The healthier people are, the more likely they are to be able to contribute to social and economic development, and such development in turn provides the additional resources and social energy that can facilitate health development. So primary health care and community efforts towards social and economic development in general are most likely to succeed when they are mutually supportive. Also, just as the health sector functions best in harmony with the other social and economic sectors, so there is a need for harmony within the health sector through support to primary health care by all other levels.

2.1.5 Coordination with other sectors:

Health cannot be attained by the health sector alone. In developing countries in particular, economic development, anti-poverty measures, food production, water, sanitation, housing, environmental protection and education all contribute to health and have the same goal of human development. Primary health care, as an integral part of the health system and of overall social and economic development, will of necessity rest on proper coordination at all levels between the health and all other sectors concerned.(Organization, 1978b).

2.1.6 Universal health coverage:

It means all people should have access to the health services they need without risk of financial ruin or impoverishment. Working towards universal health coverage is a powerful mechanism for achieving better health and well-being, and for promoting human development.(Dye et al., 2013)

There are the two facets of universal health coverage: the provision of, and access to, high-quality health services; and financial risk protection for people who need to use these services. “Health services” that is means methods for promotion, prevention, treatment, rehabilitation and palliation, encompassing health care in communities, health centers and hospitals. The term includes ways of taking action on social and environmental determinants both within and beyond the health sector. Financial risk protection is part of the package of measures that provides overall social protection.

Scientific research has been fundamental to the improvement of human health including this search, Research is vital in developing the technology, systems and services needed to achieve universal health coverage. Many recent advances have been made in health service coverage and in financial risk protection as shown, for example, by progress towards the United Nations Millennium Development Goals (MDGs). Despite this progress, the gap between the present coverage of health services and universal health coverage remains large for many conditions of ill-health in many settings. For instance, nearly half of all HIV-infected people eligible for antiretroviral therapy were still not receiving it in 2011, and an estimated 150 million people suffer financial catastrophe each year because they have to pay cash out-of-pocket for the health care they need. The focus of this report is on the research needed to provide wider access to essential services of this kind, and how to create the environment in which this research can be carried out.

2.1.7 Developing the concept of universal health coverage:

The world health report 2010 represented the concept of universal health coverage in three dimensions: the health services that are needed, the number of people that need them, and the costs to whoever must pay – users and third-party funders (Fig. 1.1)(Organization, 2010)&(Busse et al., 2007)

Measuring progress towards universal health coverage in three dimensions:

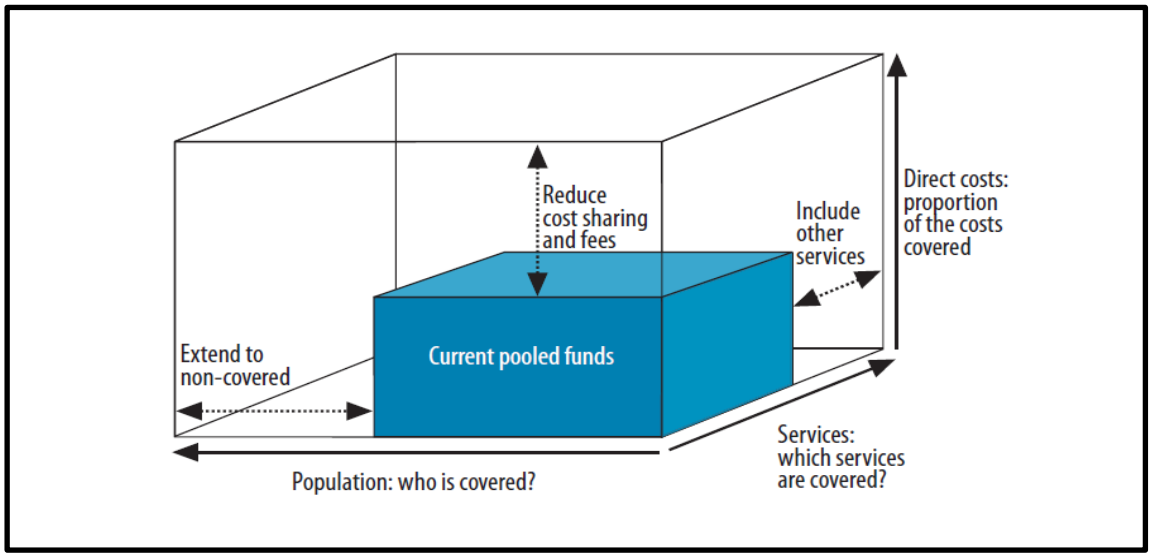


Fig (2.1) the concept of universal health coverage in three dimensions.

Source: World Health Organization(Organization, 2010)&(Busse et al., 2007)

The health services include approaches to prevention, promotion, treatment, rehabilitation and palliative care, and these services must be sufficient to meet health needs, both in quantity and in quality. Services must also be prepared for the unexpected – environmental disasters, chemical or nuclear accidents, pandemics, and so on. The need for financial risk protection is determined by the proportion of costs that individuals must themselves cover by making direct and immediate cash payments. Under universal coverage, there would be no out-of-pocket payments that exceed a given threshold of affordability – usually set at zero for the poorest and most disadvantaged people. The total volume of the large box in Fig. 1.1 is the cost of all services for everyone at a particular point in time. The volume of the smaller blue box shows the health services and costs that are covered from pre-paid, pooled funds. The goal of universal coverage is for everyone to obtain the services they need at a cost that is affordable to themselves and to the nation as a whole.(Organization, 2010)

All governments should therefore decide what health services are needed, and how to make sure they are universally available, affordable, efficient, and of good quality.(Organization, 2010)

The services that are needed differ from one setting to another because the causes of ill-health also vary. The balance of services inevitably changes over time, as new technologies and procedures emerge as a result of research and innovation, following the changes in the causes of ill-health.

The general solution for achieving wide coverage of financial risk protection is through various forms of prepayment for services. Prepayments allow funds to be pooled so that they can be redistributed to reduce financial barriers for those who need to use services they could not otherwise afford. This spreads the financial risks of ill-health across whole populations. Prepayment can be derived from taxation, other government

charges or health insurance, and usually comes from a mixture of sources(Organization, 2010).

Financial risk protection of this kind is an instrument of social protection applied to health(Bachelet and Office, 2012). It works alongside other mechanisms of social protection – unemployment and sickness benefits, pensions, child support, housing assistance, job-creation schemes, agricultural insurance and so on – many of which have indirect consequences for health. Governments, especially in low-income countries, cannot usually raise sufficient funds by prepayment to eliminate excess out-of-pocket expenditures for all the health services that people need. It is therefore a challenge to decide how best to support health within budgetary limits. Fig. 1.1 offers three options for spending: maximize the proportion of the population covered by existing services, diversify health services by offering more types of intervention, or use the money for financial compensation, thereby reducing cash payments for health care(Organization, 2010).

2.2 Health System in the Sudan:

To discuss the health situation in Sudan has been reviewing background to the health system of the Sudan.

2.2.1 Introduction:

Health system history in Sudan extends in ancient times to the colonial period where it began in response to the need of the colonizer to provide medical services for its military and civilian machine and throughout history had been marked by adopting the western approach and its concept of modern medicine biased often Urban side and focused mainly on the therapeutic side.

After independence, the health system has seen a great development in infrastructure, human and physical aspects where as the number of health facilities had increased clearly during the five decades that followed the colonial era as well as manpower in various specializations. Despite this expansion, but the lack of equitable distribution of health institutions and human resources remained a prominent feature during the evolution for the health system where the bias is clear to major cities for

many reasons, most important of which is this main cities owned force in influencing the decision-making centers and the lack of vision of complete and comprehensible health or the health system in Sudan and the weakness of the capabilities of the center of planning and supervisory because of not setting for standards and specifications.

Despite the expansion in the health system in Sudan, but the performance is still considered in the rank of weakness with the low quality and effectiveness and weak influence, responds to the needs of society and the lack of justice to the distribution of resources and funding.

Although there are no clear studies, but what is available from the accumulation of scientific experiments, the most important reasons include:

(1) The lack of a holistic and clear vision for the health system.

(2) The weakness of government spending and the inability of citizens to follow health and medical expenses.

(3) Weak planning and management capabilities at all levels throughout the health system.

(4) The lack of characterization and clear definition of the functions for each level and the absence of social outreach activities.

Since the situation in the state of Khartoum is somewhat similar to the situation in other states although strong expansion in the number of units provided for health service and quality of available services and provide rare specialties unlike the rest of regions, but there are still many problems and shortcomings, which prevent the existence of a complete and privileged healthy system which achieve health care goals in terms of the comprehensive and fair coverage for all people, taking into account the citizen cost consideration based on clear scientific foundations.

According to the increasing health awareness and interest in increasing order of health, both on the side to the government or the citizen, there are concern in the delivery of health services for each member of the citizens throughout the state, to reach the community enjoy with best health standards.

Due to the analysis of the current situation of health services in the state at all levels in terms of coverage and frequency with the presentation of the most important health indicators for the state and then was presented the general objectives and sub and basic programs which designed to develop the service in quantity and quality, in addition to increase the horizontal and vertical coverage in order to raising the efficiency of performance.

Also has been the development of programs in the application of modern methods of treatment and improve the efficiency of personnel and the development of systems for measuring, monitoring, evaluation and development of new administrative methods of operation as well as raising health awareness of citizens and expand the partnerships with relevant authorities sought to achieve the goals then review the levels of health care delivery service in its new form on the scope for the state of Khartoum, starting from community service through the centers of family health and ending with the centers of reference family health detailed to all functions and tasks at each level on all axes with the identification of needs' areas as required in addition to define specific pathways for conversion of each level to another according to the controls and control systems effective system for the assignment.

2.2.2 Development and improvement of health services in the Sudan:

The goal of an optimizing health system is the application of a healthy system that guarantees universal coverage to all citizens, a group of high-quality primary health care services.

2.2.2.1 The principles of health reform:

Health Reform is a general definition used to discuss health policy to create or change, for the most part, government and politics that affect the delivery of health care in a particular place. There are six principles to reform the health system include:

1. Universal coverage.

2. Equality and justice.

3. Efficiency and effectiveness.

4. Quality and pleasing citizen.

5. Availability and remove differences.

6. Continuity.

2.2.2.2 Strategic thrusts of health reform program:

There are important axes for the implementation of the health reform program:

1. Human-Resource Development.

2. The advancement of health care services (family medicine - Quality).

3. Infrastructure development.

4. Institutional Development.

5. Continuity of funding.

6. Sophisticated drug policies.

2.2.2.3 Procedures concerning the reform of the health sector:

There are several important steps to reform the system of health care in numerous aspects of financing health services and training for health professionals and development of work within the health departments and can be summarized as follows:

1. Expansion of the social health insurance system to new segments within the society (universal coverage).

2. Financing of provided health services must be separated from other services and the development of new systems for Funding.

3. Application of family medicine system and achieve cooperation and integration between all sectors and departments and vertical programs (Intersectoral Collaboration).

4. Development should include all health departments.

5. Scientific Strategic Planning must be used (Master plans & GIS).

6. The application of quality systems and accreditation within the health care institutions.

7. Training for all health workers in the modern administrative and medical systems (capability development and skills) and continuing medical education.

8. Investment in basic health care and preventive medicine (buildings and structures).

9. Public participation.

10. Information, education and communication.

11. Assessment and follow-up (complete system).

12. Integration and partnership between government health services' and the services sector to the private and civil sector.

2.2.2.4 Challenges faced the delivery of health care services:

There are challenges facing the introduction of health care services in Sudan, including the following:

1.The onus of the population problem.

2. Burden of disease (chronic diseases - tumors -Kidney failure - disability and birth defects).

3. Environmental factors (air pollution- smoking and addiction -Garbage - noise).

4. High rates and maternal mortality and child.

5. High rates of injuries and accidents.

2.2.2.5 Problems facing the development of health care services:

There are obstacles preventing the development of health services, including:

1. The absence of quality programs.

2. Weak management systems and inadequate funding for health.

3. The absence of public awareness of health issues.

4. Health Insurance Problems.

2.2.3 The current situation of health services in Khartoum State:

Current status of the health services in Khartoum State affected by several factors, including number of people in the state in addition to the economic characteristics for the population also the workforce indicators in the field of health and Coverage indicators for Primary health care centers, these factors can be customized as follows:

2.2.3.1 Geographical location:

Khartoum state is the national capital of the country, medium to seven states, which is bordered in the south, the Al Jazeera state and the White Nile state and on the east by the states of Kassala, Gedaref and North River Nile State and the West North Kordofan State.

Khartoum state stretching from the Longitude 24º 34 ′ east and west line up along the 35º 31 □. As from the south Bounded by the Latitude 15º 9 □ and is bounded by the North Latitude 45º 16 □ north. While the total area of the state's 20,000 square miles.

2.2.3.2 Population:

The population through the state of Khartoum 5558647 people, according to the 2008 census and the rate of growth of 2.69.

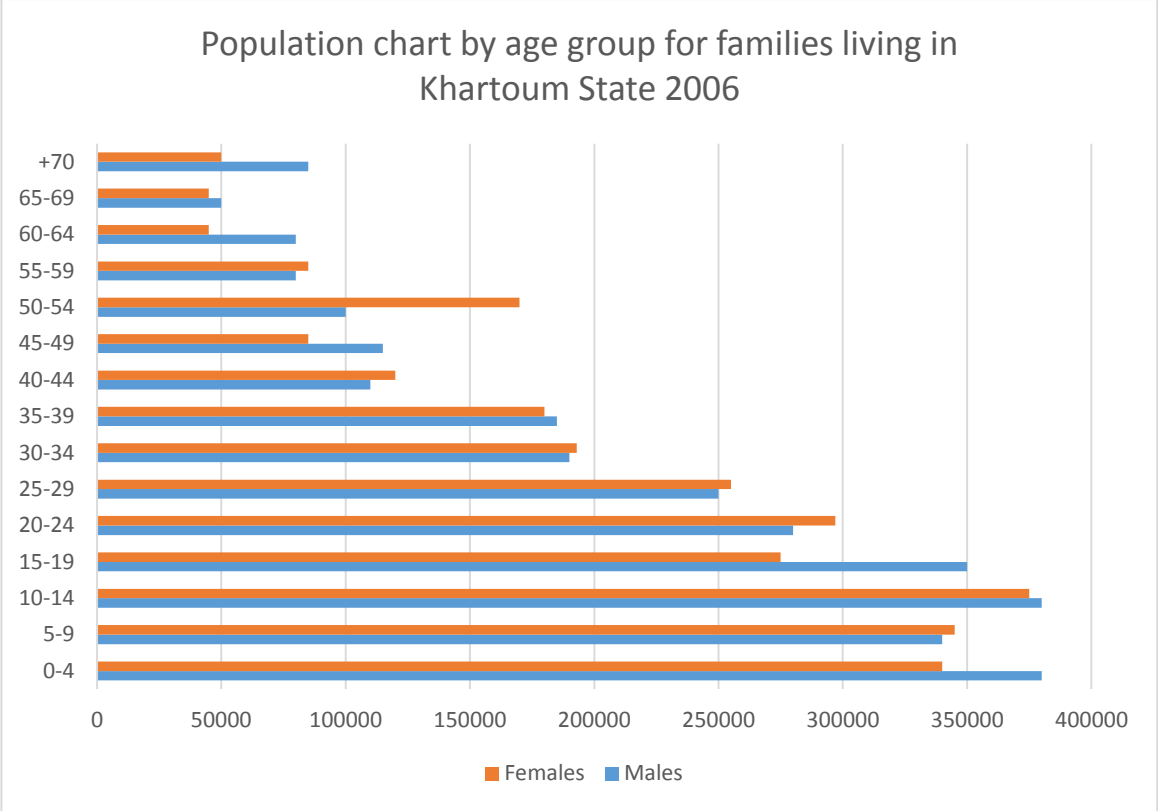


Fig (2.2) Population chart by age group for families living in Khartoum State 2006

2.2.3.3 Economic characteristics for the population within the state of Khartoum:

Economically active ages represent 42.4% of the total population, 67.8% of male economically active, while the active category among women represented 13.4%.

(Source: Census 1993).

2.2.3.4 Health services provision in Khartoum State:

Several institutions for the provision of health services in Khartoum state involvement. These entities are:

1. Federal Ministry of Health.

2. Ministry of Health - the state of Khartoum.

3. Academic medical institutions.

4. Department of Defense.

5. Regular forces.

6. Private sector.

7. Local and foreign voluntary organizations.

2.2.3.5 Workforce indicators:

Comparing the population rates with respect to workforce for other countries and the state of Khartoum, the statistics indicate the following:

1-the doctors:

Population rates ranging from doctors in some other countries between:
The United States, The Netherlands, Finland, 1: 400
Kuwait, Qatar, 1: 700
Khartoum 1: 2065

2- Dentists:

The total service rates in some states are as follows:

United Arab Emirates 1: 5556

Bahrain 1: 7690

Spain 1: 3701

Chile 1: 2500

Khartoum 1: 2500

3- Pharmacists:

The statistics indicate the following:
Bahrain 1: 4166
Belgium 1: 833
Canada 1: 1200
Cyprus 1: 7143
Denmark 1: 3450

France 1: 1100

Khartoum, 1: 13402

4- Nursing:

Compared with other countries, the rates are:

-Sweden, Finland, The Netherlands is about 1: 120

-Italy, Bahrain, and United Arab Emirates about 1: 350

-Khartoum is about 1: 987

5- Health professionals' specialists:

Due to the multiplicity of technical disciplines (labs, X-ray, pharmacy, nutrition, etc....), it is difficult to compare with other countries; it is appropriate taking an average of 1.3 per technician specialist doctors any rate specialist and one technician for every 450 populations of the current situation 1: 1084.

2.2.3.6 Coverage indicators for Primary health care centers:

1- Family Health Unit: from 1000 to less than 5,000 of the population.

2- Family Health Center:

- In the urban center for every 10,000 of the population within 2 km

- In the countryside center for every 5000 of the population within the range of 5 km.

3- The health to the family as a reference center: center for every (50 - 60 000) of the population within the range of 5 km.

4- Obstetrics room: Room for each 100,000 of the population.

The standard distance and easy access had been adopted to cover areas that does not apply these criteria for solving the problem of providing the service in accordance to the principles of primary health care service delivery.

2.2.4 Development of health services in Khartoum State:

Raising the efficiency of the health services and make them available to cover the increasing numbers of population in the short and long- term, needs to strategic framework and a package of future health policies that should be applied on a several main axes are:

1 - Providing health care.

2 - Health facilities and operation management.

3 - Financing of health services.

4 - Workforce development.

5 - Improvement on the health system and restructuring it.

The Ministry of Health has begun upon the development of ideas constitute an integrated framework for the draft health strategy in Khartoum State for the future. General and sub objectives and essential programs are as follows:

1. Providing health care and accessibility.

2. Improve health and reduce morbidity and mortality.

3. Provide high therapeutic care in health facilities.

4. Increased performance efficiency and cost containment.

5. Provide adequate alternatives for funding health services.

6. Run the hospitals by modern administrative methods.

7. Preparing and development of the workforce.

8. Developing information systems, healthy studies and research.

2.2.5 Levels of primary health care services:

Khartoum state health services are offered according to the following four levels:

1- Level one:

1. Community Services Package.

2. Family Health unit.

3. Family Health Center.

4. Reference Family Health Center.

2- Second Level:

1. Public hospital of the locality.

2. Specialist Hospital (specializing in one or more and less than four disciplines).

3. State Hospital Reference.

3- The third level:

Specialized centers

4- Fourth level:

Medical City

2.2.6 Family Health Center:

2.2.6.1 Definition and coverage:

Is the health unit, which operates under the supervision of Primary Health Care department in the region, aims to improve the health of the local community through the provision of primary health care services by medical staff trained for a group of the population according to specific criteria based upon the concept of primary health care and strategy adopted at Khartoum state.

1. in urban areas:

offering the service in urban areas based on each family's health center per (10.000) people to be in the range of distance (2 km), that means the health center must be the center of circle its radius equals (1km).

2. in rural areas:

one family health center for each (5,000) people of the population to be within the limits to the distance (5 km) and to offer dental services for rural areas in all (10,000) of the population, in the distance and the limits (10 km).

2.2.6.2 The service package for Family Health Center (Urban / Rural):

1. Public clinic offers the service by the medical specialist Family Medicine and supported by diagnostic instruments such as ultrasound and ECG.

2. Formatted laboratory for routine and some special check-ups.

3. Minor surgery to the treatment of wounds and common injuries, at least.

4. Pharmacy with essential drugs and medicines for chronic diseases.

5. Department of the vaccination against childhood diseases.

6. Department of Preventive Nutrition Services.

7. Department of Prenatal care and family planning services.

8. Dormitory for short stay.

9. Eye medical Clinic and simple surgical cases.

10. Dental Clinic.

2.2.6.3 The expected benefits from the application to the family doctor system in the Family Health Centers:

• Capita:

1. Get a good service.

2. Improve the health level (physically, psychologically and socially).

3. Increased productivity.

4. Improve the lives of the individual style.

• Community:

1. Improvement of health services provided.

2. Improve the level of health in general.

3. Increase production and achieve comprehensive development and sustainable.

• Doctor:

1. Training and Continuing Education.

2. Professional stability.

3. Favorable climate for work.

4. Improve income.

5. Acquire new skills.

• Reduce the cost (economic viability):

1. There is no duplication service delivery.

2. There is no duplication dispensing without medical reasons.

3. Reduce the number required and repeated tests.

4. Reduce the number of admissions in the hospital.

5. Increase health awareness among the community.

2.2.7 Reference Family Health Center:

2.2.7.1 Definition and coverage:

It provides therapeutic services and advanced diagnostic, training and associated technically with a number of service centers and receiving of cases transferred from a number (5-7) centers around the center to be the distance within the range of 5 kilometers and serve between (60,000 - 65,000) people.

It offers in addition to the basic packages of ten services that offered by family health center, the following services:

1. Services Consultant Family Medicine.

2. Visiting Specialist Clinic in four major disciplines, adolescents and the elderly.

3. Clinic to quit smoking.

4. Mental health service.

5. Advanced social welfare service.

6. Advanced nutritional care service.

7. Advanced diagnostic services such as:

- X-ray department for the supervision of a specialist doctor.
- Department of sound waves in various fields under the supervision of a doctor who specializes.
- Modern laboratory equipment and advanced laboratory equipment.
- Pre-marriage check-ups for those interested.

8. Periodic examination of the citizens according to specific schedules and deadlines.

9. Generating services for cases of natural childbirth and ambulance services.

10. Headquarters for training and library serves the center and its centers.

11. Department of the database of the reference center and its centers with a link of network between centers.

CHAPTER THREE

Geographic Information Systems (GIS)

3.1 Introduction:

The use of Geographic Information Systems (GIS) in public health has rapidly increased over all the world. This is because structured planning makes use of both spatial and attribute data which are supported by GIS. Data storage, management and processing are powerful capabilities of GIS that can be utilized in public health and evaluating the current health situation for the accessibility to the governmental health centers. It is also able to output data in various formats e.g. maps which can be useful in decision making in public health especially primary health care processes.

3.2 Definitions:

The Geographic Information Systems (GIS) can be described as: "A computer assisted system for the acquisition, storage, analysis and display of geographic data". (Nayak et al., 2010).

(GIS) also defined as follows:" A computer tool for capturing, storing, querying, analyzing and displaying spatial data from the real world for a particular set of purposes" (Shoba and Rasappan, 2013).

There are many other definitions for GIS depending on its components and functions. The United States (U.S) Federal Interagency Coordinating Committee (FICC, 1988) definition stated that "a GIS is a system of computer hardware, software, and procedures designed to support the capture, management, manipulation, analysis, modularity and display of spatially referenced data for solving complex planning and management problems".

GIS software is capable of collection, storage, management, retrieval and analysis of geographic information(Toosi et al., 2005) . Shoba and Ra sappan (2013) state that "GIS

has capability of efficient storage, retrieval, integration, manipulation, updating, managing, changing exchanging, combining, analyzing, and presenting geographical and non-geographical information" (Christopher 1988) .

3.3 Overview:

Geographic information systems are an important product of the revolution of information technology, which allow the use and analysis of spatial information in conjunction with connected socio-economic information, and therefore it's an ideal basis for the planning and management of information related to various aspects of life. GIS technology can be used for scientific investigations, resources, management, asset management, environmental impact assessment, urban planning, health, cartography, criminology, history, sales, marketing, logistics... etc. Its applications are tools that allow users to create interactive queries (user-created searches), analyze spatial information, edit data in maps, and present the results of all these operations.

3.4 Components of GIS:

Indeed, the power and comprehensiveness of GIS Emerges from the strength of its components. Mainly it has five components; hardware, software, data, people, and procedures.

3.4.1 Hardware:

GIS needs many types of hardware to satisfy some of its main functions such as data collection, storage, manipulation, and presentation. The heart of GIS is the computer which can be a Personal Computer (PC) or a workstation depending on the volume of data gathered for a given GIS project and the organization of such data. The input and output units are mainly the keyboard and the mouse for; input. A monitor for the output. Many types of devices are attached to the computer as input devices such as scanners, cameras, digitizers, and many others. Also printers and plotters of different sizes are attached to the computer as output devices. Network hardware's, such as modems, cables, hubs, bridges and other network devices, are utilized in GIS to share data, software, and hardware.

3.4.2 Software:

Several comprehensive software systems are developed and fully support GIS applications. GIS has benefited greatly from the rapid, continuous developments in software systems. Many organizations, and companies, concerned with GIS had developed software's to satisfy different functions of GIS such as those developed by The Environmental Systems Research Institute (ESRI) Arc view, Arc info and Arc GIS. Arc GIS is composed of many modules such as Arc Map, Arc Catalogue, Arc Toolbox, Arc Reader, Arc Globe, and Arc Scene. These modules are functioning in an integrating manner for capturing, managing, manipulating, displaying, and analyzing spatial data. There are many other GIS software's such as IDRISI which had been developed by the Graduate School of Geography at Clark University, Geographic Resources Analysis Support System (GRASS) which had been developed by United States (U.S) Army Construction Engineering Research Laboratories (USA CERL), and Intergraph's Modular GIS Environment (MGE) in addition to many other functional systems.

3.4.3 Data:

The efficiency of any GIS scheme depends on the quantity and the quality of data. The expected results of analysis are affected directly by the availability, accessibility, reliability, validity, integrity, and completeness of data (Carver, 1998). Data must be classified in several classes and all data of a particular level of classification, such as roads or vegetation type are grouped into layers or coverage. Layers can be combined in various ways to create new layers that are functions of individual ones. It should be borne in mind that data collection and processing is the most expensive part of GIS and constitute the major expenditure in any GIS project. There are two main types of GIS data, namely, spatial (geographical) data and non-spatial or (attributes) data.

3.4.3.1 Spatial Data:

Spatial data describes the absolute, or relative, locations of geographic features. It is the graphical representation of the geographic locations in a digital form, and it can be classified into two basic data models: raster data model and vector data model. Raster data model known, also, as a grid model is a mathematical model. It is a set of grid of uniform regular cells, where the cell is called pixel. It refers to a picture element, usually

rectangular or square, but it may be triangular or hexagonal. The main sources of raster data models are satellite imageries, aerial photographs and a digital image scan of existing maps. Vector data model is a representation of geographical phenomena in terms of the spatial components; consisting of points, lines, areas, surfaces and volumes. Each layer in the vector data model must be composed of only one component. The point is an object of zero dimensions called node or vertex; line is the link between two points which has one dimension called a link or an arc, while an area has two dimensions and composed of at least two arcs called a polygon or face. The geometrical relationships and connections between objects are controlled by topology that is independent of their coordinates. A topology model is based on mathematical graph theory that deals with the geometrical properties and employs nodes and links.

3.4.3.2 Attributes Data:

Attributes are non-graphic data that describe properties of the geographic features or elements represented on the map. Attributes are stored in a table in a manner that each record or row in the table corresponds to a given geographic object on the map, whereas each property is stored in a column or a field. Each object must have an Identity (ID) or access key. The number of columns representing the properties is not limited, but is optionally selected due to the available attributes. The number of columns may be extended by joining several tables automatically using a common field. The first line or row in the attributes table contains the name of the field which must not exceed ten characters. The data of each field must be of the same type of characters and the type can be short integer, long integer, float, double, text and date. (Christopher 1988).

3.4.4 People:

Different levels of people from different disciplines are involved to establish a GIS project or organization. People involved in a GIS team depend on the capacity of the organization and the nature of the GIS project. AGIS team may include GIS experts, who advise and solve problems for end users, cartographers, system analysts, computer specialists and people specialized in the field of the project in question e.g. geologists, agriculturists, engineers. AGIS team also include end users, who seek problem solutions and see final products only in the form of maps and reports, and GIS operators of low

levels of experience who understand the functions of specific systems so as to manipulate data and data compilers, who understand the data but not the system.

3.4.5 Procedures:

Procedures include how the data will be retrieved, input into the system, stored, managed, transformed, analyzed, and finally presented in a final output. The procedures are the steps taken to answer the questions needed to be resolved. The ability of a GIS to perform spatial analysis and answer these questions is what differentiates this type of system from any other information systems. The transformation processes include such tasks as adjusting the coordinate systems, setting a projection, correcting any digitized errors in a data set, and converting data from vector to raster or raster to vector (Carver et al., 1998).

3.5 Functionalities of GIS:

Most GIS packages provide functions and tools to enable the execution of different operations necessary for a given GIS project. There are main five functions as shown with their relationships in Figure (3.1) below:

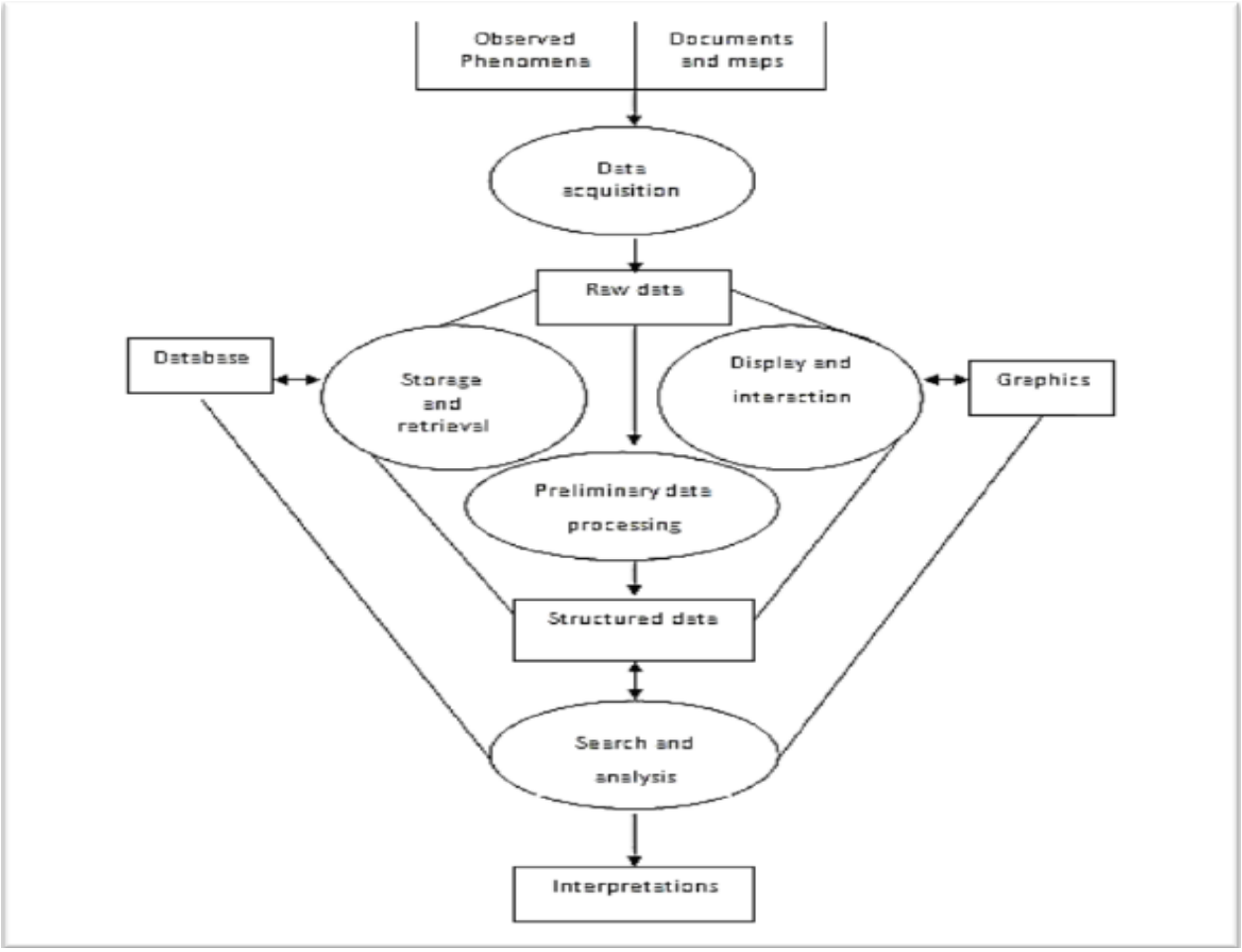


Fig (3. 1): Relationship between GIS functions (Christopher, 1988)

3.5.1 Data Acquisition:

All data needed for a GIS project must be transformed from their original source form to the digital form to satisfy the basic requirements of GIS. Data can be obtained from primary data acquisition techniques such as direct ground survey techniques, whether in a digital form or in a hard copy form. Data in hard copy maps, which are secondary data acquisition sources, are transformed to the digital form by digitization or scanning and the resulting format depends on the employed technique. Satellite imageries and aerial photographs are important source of spatial data which can be obtained directly in digital form or scanned from hard copies. Aerial photographs provide spatial data of high accuracy which is suitable for creation and updating of large scale topographic maps

while the accuracy of the spatial data obtained from remote sensing depends mainly on the ground resolution. Data acquisition is a critical, time consuming and expensive stage in many geographical information tasks.

3.5.2 Preliminary Data Processing:

Preliminary data processing includes creating topologically structured data, classification of remotely sensed data, change of structure of data, coordinate systems and map projections transformation and conversion from raster to vector or vice versa according to the type of analysis tools. The required conversion to a raster data model from a vector data model can be done straight forward by rasterization algorithms while factorization of raster data is more complicated. Data of unknown coordinate systems can be forced by rubber sheet transformation to fit into known coordinate systems data of the same location. Data processing involves the creation of surface models by interpolation techniques to generate contour maps, Triangular Irregular Networks (TIN) or any other relief representation method. Acquiring data from different sources may cause the problem of using two or more classification or coding referring to the same phenomenon. Re-coding must be applied to solve this problem by reclassification to combine several classes to form a generalized less-detailed class.

3.5.3 Data Storage and Retrieval:

The manner by which the data is stored depends on the data model. The storage of vector data model consists of the spatial data or the map and the attribute tables, where every record in the attributes table corresponds to a spatial object or a feature in the map and the fields of the table are the attributes of these spatial objects. Each spatial object must have a unique identifier or access key to link the spatial object to its attributes in the table. The raster data is saved in the computer memory in the form of two-dimensional arrays in which, the coordinates of grid cells, or pixels, are implicit within the row and column ordering of the matrix. The property of this type of storage from a retrieval point of view, that each element can be referred to or addressed directly in terms of the row number and the column number.

3.5.4 Spatial Search and Analysis:

The objective of any GIS project is to use the stored data to make decisions and to solve problems in a particular application. GIS utilizes many functions to carry out searches and analysis to satisfy these objectives, which can be summarized in the following two sections.

3.5.4.1 Containment Search within a Spatial Region:

This is a straight forward spatial analysis to find features or part of features that lie within a given region of space. A rectangular window can be defined to find spatial objects that lie within it.

3.5.4.2 Proximal Search:

There are many types of proximal search. One of them may be regarded as an extension of the spatial containment search, where a zone of specified distance from a particular object is defined. This object can be point, line or area and this zone is called buffer in the case of vector model and spread in raster based systems.

3.5.4.3 Phenomenon Based Search and Overlay Processing:

This type of search may be based on a single phenomenon irrespective of other phenomena or a search for regions that are defined by combinations of phenomena.

3.5.5 Interpolation and Surface Modeling:

Interpolation functions are performed in sample points taken in a regular distance interval forming a regular grid. The values of the known sample points are used to estimate the unknown values by carrying out an analysis of the correlation function between the sample values and the distance.

3.5.6 Best Path Analysis and Routing:

Network data models, or raster data models, are used to find the best route in terms of cost, length or other criteria. Network data models are used to select a path from already existing paths such as roads and rivers while raster data models are used when the problem is to find a path across terrains that may not have any predefined path.

3.5.7 Spatial Interaction Modeling:

Spatial interaction modeling is used for identifying optimal locations of facilities that satisfy particular requirements or criterion.

3.5.8 Correlations:

GIS analysis is useful to integrate information within spatial region to search for links between events. This type of analysis can be applied to find factors that cause a certain phenomenon for example to find correlation between environmental factors and diseases.

3.5.9 Map Algebra with Gridded Data:

GIS analysis is useful to integrate information within a spatial region to search for links between events.

CHAPTER FOUR

Applications of Geographic Information System in the health Field (GIS and public health)

4.1 Introduction:

Public health has been defined as "the science and art of preventing disease, prolonging life, and promoting health through the organized efforts of society." This definition was arrived at in the inquiry established to consider the future development of the public health function including the control of communicable disease in England(Function, 1988). The investigation was started in the wake of the failures of health systems to protect the public health in the control of infectious diseases specifically two major outbreaks of communicable disease caused by salmonella and Legionnaires' disease. Since then, a number of health scares have highlighted the need for continuing improvements in public health protection systems. Recent high profile examples include the outbreak of severe acute respiratory syndrome (SARS) and variant Creutzfeldt-Jakob disease, the human form of bovine spongiform encephalopathy commonly known as mad cow disease. The description of disease epidemiology typically has three elements: time, place, and person. Describing the outbreak and spread of a communicable disease therefore explicitly includes a spatial component. Although this has long been recognized (e.g., the investigation of cholera outbreaks in London by John Snow), an important barrier to examining the spatial element of disease outbreaks has been the lack of both digitized spatial data and the computer tools for mapping and spatial analysis.

The cartographer perspective is a key aspect of public health. Populations and communities are geographically distributed and communities tend to have their own defining characteristics. Factors influencing health are commonly consisting of:

1. Inherited conditions

2. Environment, which includes both physical (i.e., air quality, water quality, soil characteristics, radiation) and socioeconomic aspects

3. Lifestyle.

4. Health care.

All these factors contributed to the geographical variation. The practice of key elements of public health, including communicable disease control, environmental health protection, health needs assessment, planning and policy, surveillance, monitoring and evaluation, and operational public health management, is often explicitly geographical in nature. In addition, resource allocation at the macro and micro levels has a strong geographical component based on demography, health needs, existing provisions, and other factors. GIS, the definition of which has evolved from geographic information systems to geographic information science, involves a scientific problem-solving approach, encompassing the development and application of scientific methods to solve societal problems. It, therefore, has become an integral and essential part of public health research and practice. (Craglia and Maheswaran, 2016). Significant advances in scientific approaches to evaluating and using geographic information are taking place. Health information at a fine spatial resolution has become widely available; the same can be said for mapping technology. These developments enable public health practitioners to link and analyze data in new ways at the international, regional, and even street levels. As part of the drive to promote the use of GIS within public health, the European Commission supported the First European Conference on Geographic Information Sciences in Public Health held in Sheffield, United Kingdom, in September 2001. The scientific program drew upon many of the leading public health researchers and practitioners in this area.

GIS and related spatial analytic techniques provide a set of tools for describing and understanding the changing spatial organization of health care, for examining its relationship to health outcomes and access, and for exploring how health care delivery can be improved. Although GIS has been used for several decades to examine health care systems, the scope of GIS contributions has grown rapidly in recent years. Advances in computing power and graphics, as well as the development of GIS-based

locational analysis models and methods have stimulated innovative health care applications.(McLafferty, 2003).

4.2 Needing to analyze health care:

Geographic variation in population, and population need for health care, provides the foundation for analysis and planning of health services. People are not spread evenly across the Earth's surface, because of several dimensions affect the spread of the population, including age, gender, culture, and economic status—that affect their need for health care, their ability to travel to obtain health care, and the types of services they are willing and able to utilize. GIS is being used to map and explore geographical variation in need for health services and to develop innovative indicators of health care need(McLafferty, 2003).

Need is a multidimensional concept that reflects characteristics of people, their behaviors, and the environments in which they live and work. GIS has been used for many years to link diverse layers of population and environmental information to characterize the many dimensions of health care need for small areas(Hanchette, 1998)&(Mohan, 1993). All of these factors contribute to policy development and planning with regard to health care needs. For instance is the effort at creating "community environmental health profiles" that describe demographic, economic, and lifestyle characteristics of the population as well as exposure to potential environmental hazards(Peters and Hall, 1999), Efforts like these take advantage of the spatial database management and display capabilities of GIS. Generally, they are restricted to predefined geographical areas such as counties or zip codes, but in the future such systems will likely incorporate GIS-based procedures that allow users to query data for user-defined areas.

An alternative approach is to incorporate data from household surveys in needs assessment. Such data can be geocoded to residential addresses to depict detailed geographic variation in health needs and household characteristics. In examining access to services at a primary health care center, data from a needs assessment survey were

geocoded and mapped to better understand spatial variation in health related behaviors, risk factors, and perceptions(Phillips Jr et al., 2000)

Lovett et al declare methods for improving needs assessment by incorporating in a GIS data from patient registers—lists of all patients enrolled with general practitioners in an area. Because register data are continually updated, they can represent population characteristics and needs more accurately over time than data from the decennial census. To check the accuracy of the register information, GIS was used to allocate patients from postcode areas to census enumeration districts to allow comparison of register data for small areas with corresponding data from the census. In a second application, census data were weighted geographically, based on actual patient flows, to generate descriptive health indicators for practice locations.(LOVETT et al., 1998)

This example raises the important issue of using GIS to create geographically compatible data sets for needs assessment. Often the data inputs for multidimensional indicators of health care needs are not available for common geographical areas. Spatial analysis procedures can be used to allocate data from one set of areas to another so that health care needs can be represented for consistent small areas(Cromley and McLafferty, 2002) & (Flowerdew and Green, 1989)

GIS has an important role in assessing health care needs for small areas by facilitating the spatial linking of diverse health, social, and environmental data sets. Although the layering capabilities of GIS have been used for many years, researchers are now making use of the analytic capabilities to relate data sets that rely on non-consistent areal units and to generate meaningful service areas(LOVETT et al., 1998) &(Goodman et al., 2003). As digital information on morbidity, demographics, and utilization becomes more widely available, health needs data will be incorporated in GIS-based decision support tools that allow communities and decision-makers to examine questions of health care needs, access, and availability.(McLafferty, 2003).

4.3 GIS and Analyzing Access to Health Care:

Access to health care is an important issue in all countries around the world. Some populations face significant barriers in obtaining care, and health care policies and imperatives are affecting the location, quality, and quantity of services available with concomitant effects on access. Access describes people's ability to use health services when and where they are needed(Aday and Andersen, 1981).

GIS research emphasizes the geographical dimensions of access. Health care decisions are strongly influenced by the type and quality of services available in the local area and the distance, time, cost, and ease of traveling to reach those services (Goodman et al., 1997)&(Haynes et al., 1999)&(Joseph and Phillips, 1984)

In addition, GIS has been used to explore geographical health disparities, planning health care service delivery and planning health care management strategies.(Teach et al., 2006)&(Wong et al., 2012) It can be a means to provide data in a meaningful way to inform public health strategies and how best to meet the health needs of a local or whole population. Moreover, GIS has also been used to spatially analyse, examine and measure the accessibility of health care services.(Luo and Whippo, 2012) As such, to understand the use of spatial analysis in health care, a number of methods currently used in health GIS will be examined.

4.4 Measuring Health Access:

In health care, there are a number of methods used to calculate spatial accessibility which are area-based or distance-based. Distance-based measures, which focus on the distance or travel time or cost between the population and health service providers, avoid many of these problems. The most widely used measures are Manhattan, Euclidean distance or straight-line, road network distance and travel time. Each method has both positives and negatives to their several abilities to measure spatial accessibility. For example, Manhattan measures a distance between two points as if followed at right angles, which has a propensity to overestimate distance.(Wong et al., 2012, Burkey, 2012). Conversely, Euclidean measures distance between the same two points which

would be the most direct route, which can underestimate distance, however is less complex to calculate. In addition, travel time can be useful, however does not take into account travel conditions, nevertheless road network distance has been argued to provide the most accurate measure of distance(Wong et al., 2012)&(Teach et al., 2006). Euclidean distance is flawed because it fails to incorporate the ease, cost and time of travel, and access to transportation.

Area-based methods measure accessibility through provider-to-patient or supply-demand ratio. These can be simply used to identify where needs exist by using a simple ratio of physicians to the population to measure geographical access (Schuurman et al., 2010)& (Teach et al., 2006)&(McLafferty, 2003) . For example, the World Health Organizations initial provider-to-patient guidelines were 1 physician per 1000 population.(Organization, 1978a)&(Bagheri et al., 2006) However, the current guidelines state accessibility to Primary Health Care should be at an optimal ratio of 3.5 physicians per 1,000 head of population (Scheffler et al., 2008). This then can be used to comprehend where deficiencies are within and among countries. Although, provider-to-patient ratios are good for comprehensive understanding of supply and demand of services, it does not account for borders which individuals can cross nor does it take into account distance or time. (Humphreys et al., 2008)

4.5 Alternative Methods of Measuring Access:

As there is a large group of methods used measure health accessibility and much literature discussing these methods and their development, this literature review will concentrate on the most recent, such as the floating catchment method, the two-step floating catchment area and other advances which are used to measure health accessibility.

4.5.1 Floating Catchment Areas (FCA):

The floating catchment area which is at times is referred to the floating catchment method is closer to the Kernel density estimation model.(Schuurman et al., 2010)& (Guagliardo, 2004)&(Yang et al., 2006)

Floating catchment method (FCM) defines the basic unit within which to calculate this ratio as a circle of some reasonable radius centered on the census tract centroid.

It was initially developed to assess job accessibility but later used to determine health care access. Rather than using fixed state, municipal or census borders – a predetermined 'drive time' radius around a Centre point or centroid is used as the 'catchment' area. This catchment area is determined by the maximum distance or travel time which individuals are willing to undertake to access health care. This can differ depending on individuals or populations under investigation.(Luo, 2004)&(Luo and Wang, 2003, McGrail and Humphreys, 2009a)

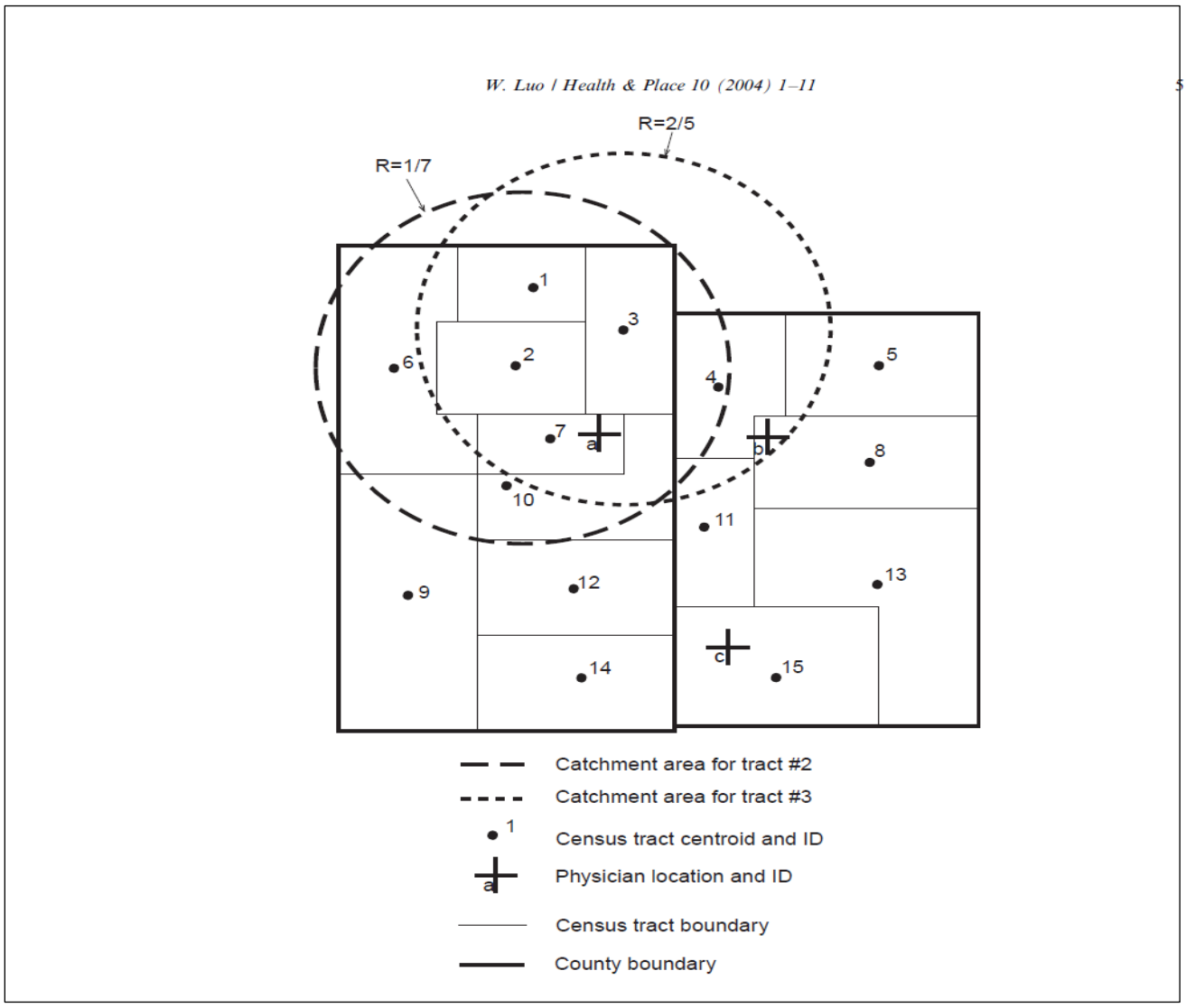


Fig (4.1) Floating catchment method for identifying physician shortage areas. Instead of using the large administrative boundary such as county as the basic unit, a small circle (catchment) drawn around each tract centroid is used as the basic unit to calculate the physician population ratio. The radius of the circle is the reasonable distance a person is willing to travel to see a physician. This circle moves from tract to tract, thus shortage variation from place to place can be identified. R's are the physician to population ratios under the assumption that each census tract has only one person within it and each physician location has only one physician there.

Source: (Luo, 2004)

As a catchment area or 'window' floats over an area, particularly a population area or a centroid of census tract, "the density of events within the window is used to represent the density at the Centre [sic] of the window". For example, provider-to-patient ratios are calculated for those health care providers which fall within the FCA over a population or centroid of a census tract. Nevertheless, the assumptions used with FCAs are that all individuals have equal access to health care providers and the FCA model is focused only on supply.

4.5.2 The Two-step Floating Catchment Area (2SFCA):

To overcome the limitations of the FCA, Radke and Mu were envisioned an alternate model to development of spatial decomposition method of the FCA (Radke and Mu, 2000). This was then further developed and modified by Luo and Wang to become the two-step floating catchment area (2SFCA), where accessibility and availability of services are assessed simultaneously and intuitively.(Guagliardo, 2004)&(Roeger et al., 2010)&(Wan et al., 2012). It was stated the strength and limitation of the 2SFCA is its flexibility. It can be used among the rural and urban populations, but certain rules that apply in one context need to change as they may not work in another.(McGrail, 2012)

The 2SFCA method uses provider-to-patient ratios while focusing on the demand for each medical site by assessing the service catchment, where all populations that fall within the drive threshold from each service. This then is calculated to give a provider-to-patient ratio according to capacity and demand. The second step focusses on the population catchment, where all services nearby and fall within the drive threshold from each population is calculated to give a provider-to-patient ratio, which is added to the ratio from step one.(McGrail and Humphreys, 2009a)&(McGrail, 2012). If these two

catchment areas overlap, it is anticipated the service accessibility available to those individuals is much greater, however if they do not overlap this indicates less accessibility.(Luo and Wang, 2003)&(Wang and Luo, 2005)

Lu and Wang say "the method considers interaction between patients and physicians across administrative borders based on travel times, and computes an accessibility measure that varies from one tract to another."

4.5.3 The E2SFCA and 3SFCA:

The initial 2SFCA was further developed to become the 'enhanced two-step floating catchment area' (E2SFCA). This was achieved by implementing, distance decay function, where separate travel time zones were incorporated for each of the physician and population floating catchment areas. (Luo and Qi, 2009)This allowed greater accuracy in determining health care access, as distance decay shows as distance between two locations increases, their interaction deteriorates. Additional enhancements have been conducted in terms of using a variable catchment size and a step versus continuous decay models, as the same distance-decay function does not apply to all scenarios. (McGrail, 2012)&(McGrail and Humphreys, 2009b) The E2SFCA was further developed to become the three-step floating catchment area (3SFCA), which was to minimize the health care-demand overestimation which was argued to occur in previous models.(Bell et al., 2013)

4.5.4 Spatial Accessibility in Urban Areas:

There were five principle studies which focused specifically on spatial access within urban areas. One single study was conducted in Singapore; however, its main aim was to investigate where the best possible place was to build new polyclinics. Its objective was to ensure minimum travel was to be incurred, while maximizing patient outcomes (Wong et al., 2012). Among the other urban studies, many had commensurate findings, which pertained to reduced accessibility among those with low socioeconomic status, CALD groups or those who are living in outer or most disadvantaged urban areas. (Bell et al., 2013)& (Roeger et al., 2010)&(Guagliardo et al., 2004)&(Bissonnette et al., 2012)&(Hyndman and Holman, 2001).

It was shown in metropolitan Adelaide, Australia; there was an inequitable distribution of GPs within 16% of the urban population living in areas which was considered areas of GP workforce shortage (Cullinan et al., 2012) . However, in metropolitan Perth, Australia, it was shown those who were living in areas of greater disadvantage, were those who has less access to a female GP, unable to access after-hours GP or see their own GP at short notice. Nevertheless, in Washington D.C., it was shown those asthmatic children, who had poor spatial accessibility to their pediatric primary care provider, were those who had lower socioeconomic status or were those children from CALD backgrounds. This was in spite of Washington D.C. being a highly urbanized with high pediatric primary care providers per child population (McLafferty et al., 2011).

A literature search was conducted to identify studies which examined primary health care accessibility using GIS techniques among various urban and rural populations, in this study, we will focus specifically on the side of the urban population and for instance is:

Measuring access to urban health services using Geographical Information System (GIS) a case study of health service management in Bandar Abbas, Iran. Accessibility was evaluated by using Floating Catchment Area (FCA), Interurban road-map, traffic flow data together with hospital/clinic information (name and location) were inputted into GIS (Figure 1a). In the absence of detailed locational data for individuals accessing health services, as in the case of Bandar Abbas, population demand is usually summarized at the population-weighted or, more commonly, Geographic Centroids (GC) of such areas (Higgs, 2004). In advanced urban planning, the designer usually predicts some hypothetical stations for various targets such as health services, Pre-defined stations considered here as patient's locations referred as the GC (Figure 1). Due to the lack of census tracts in Bandar Abbas, the centroids of each geographical polygon containing at least 500 buildings were denoted as GC by using GIS (Figure 1b). We know that summarizing a population of a zone by assuming all live at the centroid may introduce errors in estimation of accessibility (Hewko et al., 2002).Considering this, the points that we have selected as GC in each polygon, have equal traffic accessibility with respect to most of their polygon's boundary. So, we have tried to minimize the errors.

Sixteen GC were located in the territory of Bandar Abbas (Figure 1).(Masoodi and Rahimzadeh, 2015)

4.5.4.1 Creating buffer zones:

"Buffer" is defined as an area of specified width drawn around one or more map elements (Luo, 2004). In order to calculate health services-to- GC ratio for each GC, the FCA method (Aronoff, 1989)uses circles of varying radii with straight-line distances (to buffer an arbitrary Euclidean distance based on density of healthcare services) placed at the centroids of geographic polygons (GC) and counts the number of health services within the circles. This method is referred as the coverage method by some authors (Talen, 2003). There are also questions regarding the sensitivity of the health services-to-GC ratios to the size of the radius of the circle used in the floating catchment methodology. In Bandar Abbas, three buffer zones with 500, 1,000 and 2,000m widths were drawn separately around the hospitals. Considering the overlaps of the varying buffer zones, a width of 500m was specified as the optimal radius. Six buffer zones were drawn for hospitals (Figure 2a). Since clinics have lower facilities for patients, three buffer zones were drawn for them (Figure 2b). For hybrid state (hospitals and clinics) six buffer zones were drawn (Figure 2c).

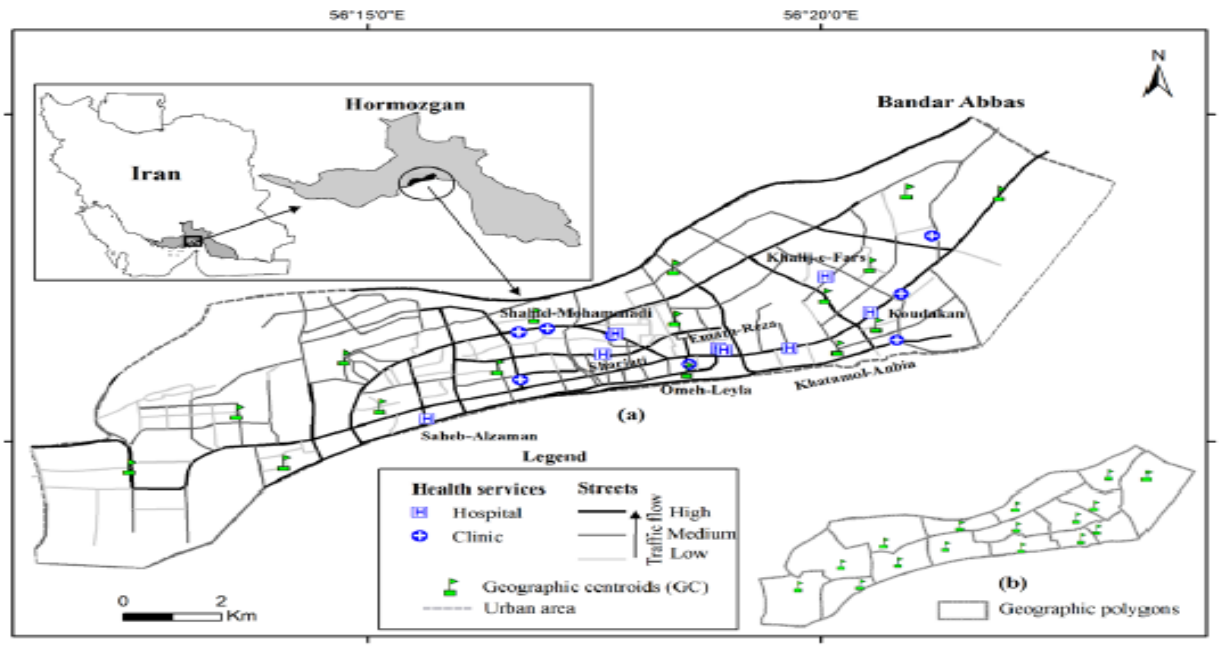


Fig (4.2): Bandar Abbas, Iran with health services and main population centers as Geographic Centroids (GC) (a) and geographic polygons (b).

Source : (Masoodi and Rahimzadeh, 2015)

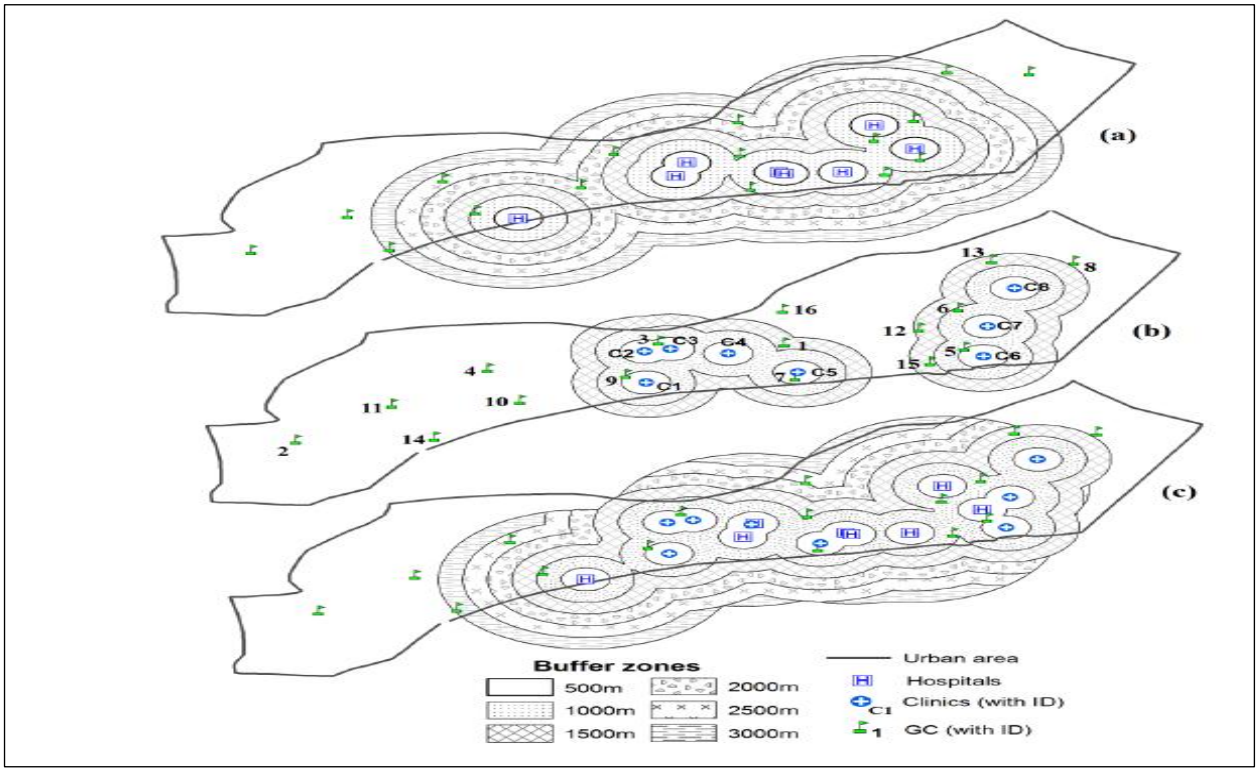


Fig (4.3): Five hundred meters buffer zones centered on hospitals (a), clinics (b) and hospitals together with clinics (c). Clinics and GC locations presented in (b).

4.5.4.2 Results by using Floating Catchment Area (FCA) method:

In the FCA method, for conceptualizing and measuring the geographical accessibility of health services, the number of health services within each buffer zone were counted (Figure 2a)(Luo, 2004) . The accessibility categorized as: excellent (>1,000 m); good (1,000–2,000m); fair (2,000–3,000m); and poor (>3,000m). The results (Figure 2a) indicated that 44.00% of hospitals had accessibility less than 1,000m to GC (GC 1, 5, 6, 7, 10, 12 and 15), 18.00% of hospitals had accessibility between 1,000 to 2,000m to GC (GC 3, 9 and 16), 12.00% of hospitals had accessibility between 2,000 to 3,000m to GC (GC 3 and 14) and 25.00% of hospitals had accessibility more than 3,000m to GC (GC 2, 8, 11, and 14). In developing cities with low to medium facilities as Bandar Abbas, clinics play an important role in healthcare. Clinics provide some medical care and support regions with poor access to hospitals. So, their distribution and accessibility must be considered. Accessibility of hypothetical patients (GC) to clinics in Bandar Abbas also indicated that (Figure2b) 25.00% of clinics had accessibility less than 500m to GC (GC 3, 5, 7 and 9), 31.00% of clinics had accessibility between 500 to 1,500m to GC (GC 1, 6, 12, 13 and 15) and 44.00% of clinics had accessibility more than 1,500m to GC (GC 2, 4, 8, 10, 11, 14, and 16). Evaluation of accessibility to the hospitals together with clinics in Bandar Abbas (Figure 2c) indicated that clinics did not improve accessibility of those regions with more than 3,000m to GC (GC 2, 8, 11 and 14 in Figures 2a and 2c).(Masoodi and Rahimzadeh, 2015)

CHAPTER FIVE

Methodology

5.1 Study Area:

Khartoum Bahri town (The locality of Bahri) is lies to the north of the state capital Khartoum, the capital which is part of the so-called triangular capital, which consists of Khartoum, Khartoum North and Omdurman domestic and includes many of the older neighborhoods, including AlSababi which is originally an agricultural area and Halfayah Kings. (Fig (5.1))

Locality of Bahri lies in the northern part of the state of Khartoum is located between latitudes (15 □ 8 □) and (16 □ 45 □) North and longitudes (31 □ 25 □) and (34 □ 16 □) East. located in the eastern side of the Blue Nile when Totti Island, a relevant geographical area wide stretches northward "even villages and waterfall Sbellouka with the limits of the mandate of the Nile River state along the Nile. And bounded on the eastern side the locality of east - Nile, the locality of Omdurman and the locality of Kararey on the west, separates them from the Bahri locality the Nile River. The study Area includes the urban areas (two administrative units are Bahri city and North Bahri) in this locality which lies between latitudes (15 □ 36 □) , (15 □ 46 □) North and between longitudes (32 □ 30 □),(32 □ 39 □) East.

5.1.1 Climate:

Study area Located in the tropics north of the equator, but its climate feels more like a Semi-desert (very hot summers and very cold winters) sunny, hot and dry. Wind north to northeast, saturate the atmosphere with dust and dirt. And the percentage of wind and sandstorms and dust increase in the dry summer's months.

5.1.2 Temperature:

Khartoum is hot year-round. The rest of the months are even warmer, Temperatures range during the year in the summer and May and June can be absolutely boiling the average temperature is 45 ºC degrees, cooler months of the year are in the winter period from December through February when the average temperature is 22 ºC degrees.

5.1.3 Precipitation:

Most of the rain falling in the summer between July and September, Khartoum sees sporadic rain. Even so, it usually rains only a few days. The wettest month, August, generally sees only about 3 inches of rain on average.

5.1.4 Solar radiation: Is Strong year-round, so solar energy is a source of permanent sources of energy available in locality and the city in general.

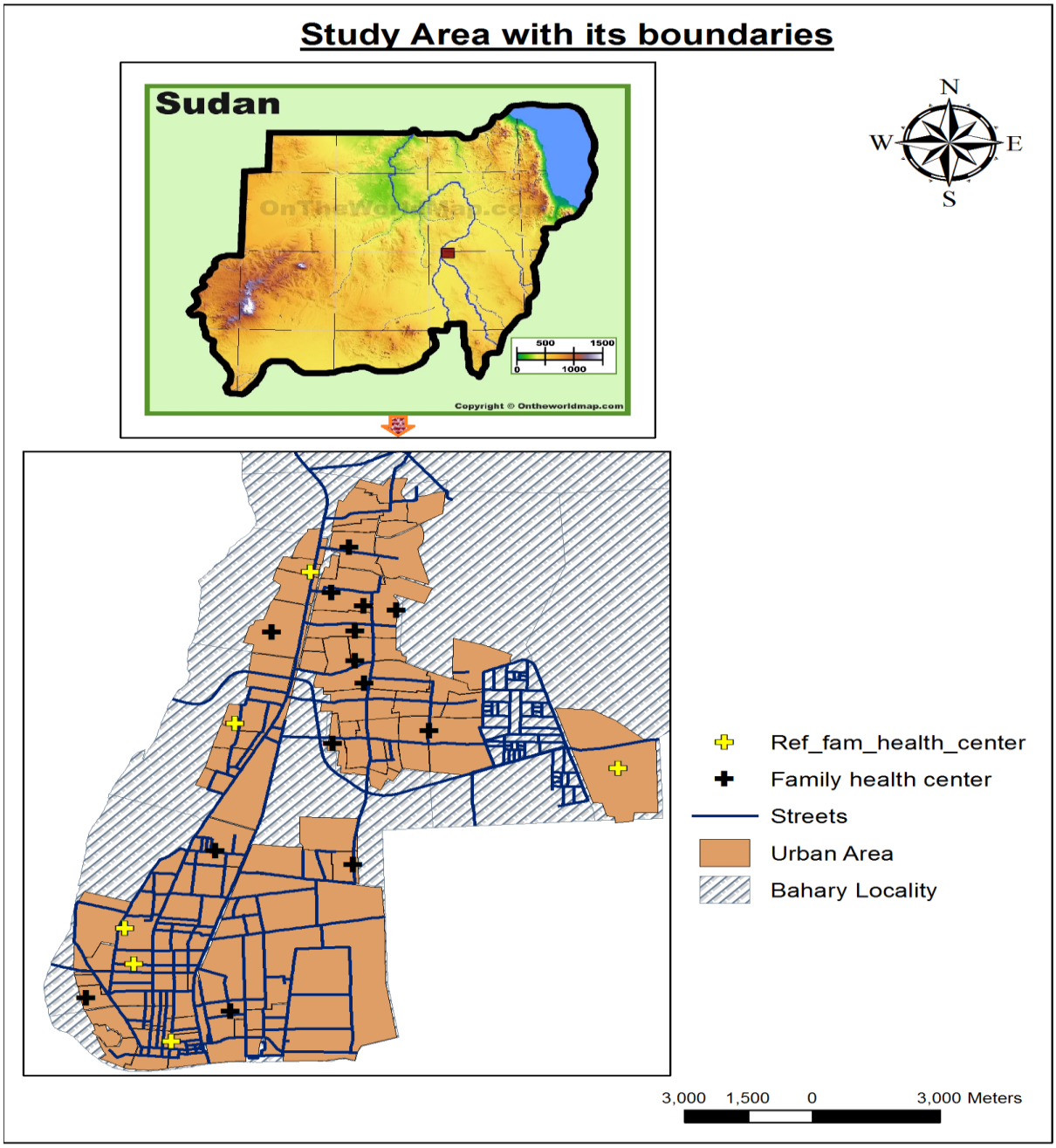


Fig (5.1) Study Area

5.2 Sources of Data:

- Adjusted maps as a Shape files for the boundaries of the study area and all health centers (Health Statistics and Information Center of the Ministry of Health Sudanese 2016).

- Annual Reports (Bahri Locality 2015).
- Reports on the current health situation (Health statistics and information Center of the ministry of Health Sudanese Federal).

-Population Census data (National Census 2008- National Bureau of statistics).

5.3 Data Collection:

-The Data for the analysis is obtained mainly from the 2008 National Bureau of statistics survey in Sudan (population census data). It was chosen only districts in urban areas (Study Area)

-The Data includes the number governmental health centers (20health centers) in study area.

5.4 Data Processing:

Many steps had been conducted to process the data as follows:

5.4.1 Preparation of the Data:

- The descriptive statistics and basic spatial statistical methods including the Geographic Information System (GIS) Specifically (ArcGIS 10.2) were applied to the data for analysis of data and visualization of results.

-The population census data (2008) were joined to attribute table of districts of study area layer.

-Six layers (shape files) had been input to ArcGIS Software, ArcMap Interface (Fig 5.2):

1. Study Area.
2. Reference Family health centers.
3. Family health centers.
4. Hospitals.
5. Streets.
6. Bahri Locality boundaries.

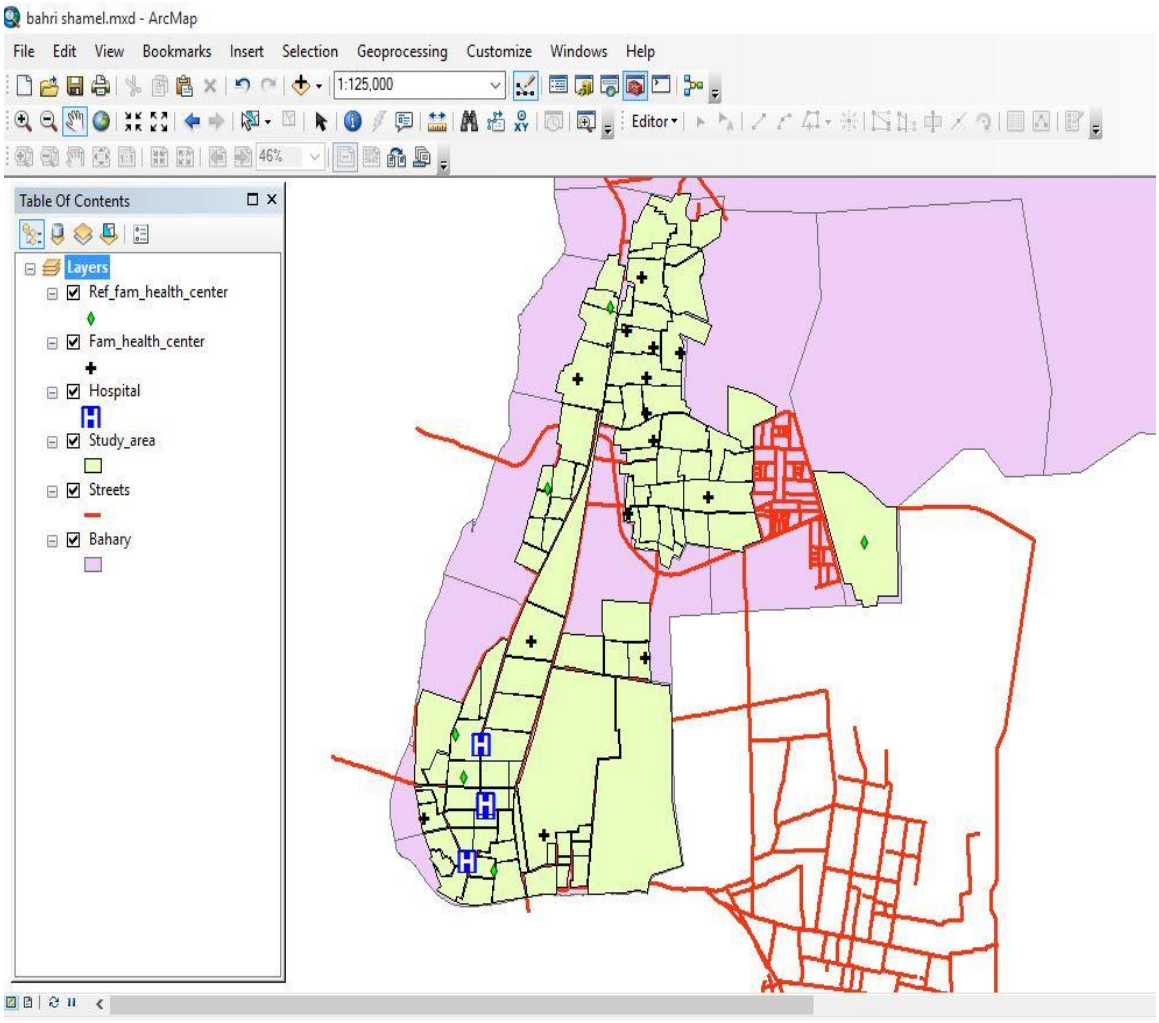


Fig (5.2) Hospitals, Health centers, districts and streets layers in study area

-Shape files were georeferenced to UTM coordinate system, WGS 84, zone 36 North based on (PCS) in study area by Using the procedure (Define Projection) from Arc Toolbox Menu – (Data Management Tools) –- (Projections and Transformations).

5.4.2 Extraction of the Study Area:

- Were merged urban areas layers (residential areas) for the urban administrative units in Bahri Locality (two units Bahri city and North Bahri) by using Merge tool procedure from Arc Toolbox menu (Data Management Tools) _ (General) _ (Merge).

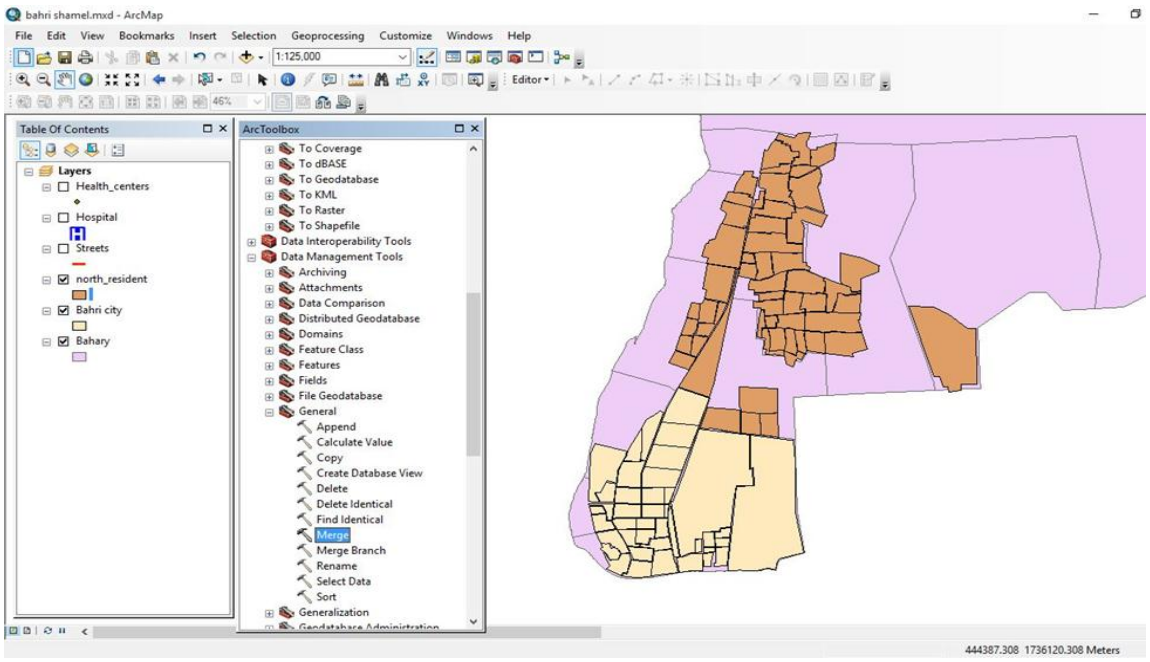


Fig (5.3) Merge tool procedure for the shape files of two Urban Administrative units

-After that has been extracted public health centers, which are located within the boundaries of the study area as well as streets by study area boundaries by using Clip tool procedure from Arc Toolbox menu (Analysis tool)-(Extract)-(clip).

- The number of health centers twenty governmental health centers, six full-fledged health service centers, and have at their disposal specialists and All within the health insurance service. Thus, they represent 30% of the total number of health centers, it is known as “Family Health Reference Center”.

- The rest of the 14 health centers are incomplete health services. Thus, they represent 70% of the total number of health centers. And six of them without the health insurance service, and known as “Family Health Center”.

5.4.3 Distance criterion:

There are two kinds of governmental health centers, according to the classification of the Sudanese Federal Ministry of Health: the first type is family health centers and the second is the Reference family health centers (2.2.6.1 &2.2.7.1) so it was conducted distance criteria by creating buffer zone for Family health centers and Reference family health centers) severally.

- Standard or criteria of thousand meters for radius from the health center to the far house using a buffer tool procedure from (Arc Toolbox Menu–Analysis tools-proximity-buffer) in GIS taken 1000 meters as a parameter for each Family health center of the study area, Figure (5.11)

- For Reference health centers the radius is 2500 meters according to the Sudanese Federal Ministry of Health standards. Figure (5.12)

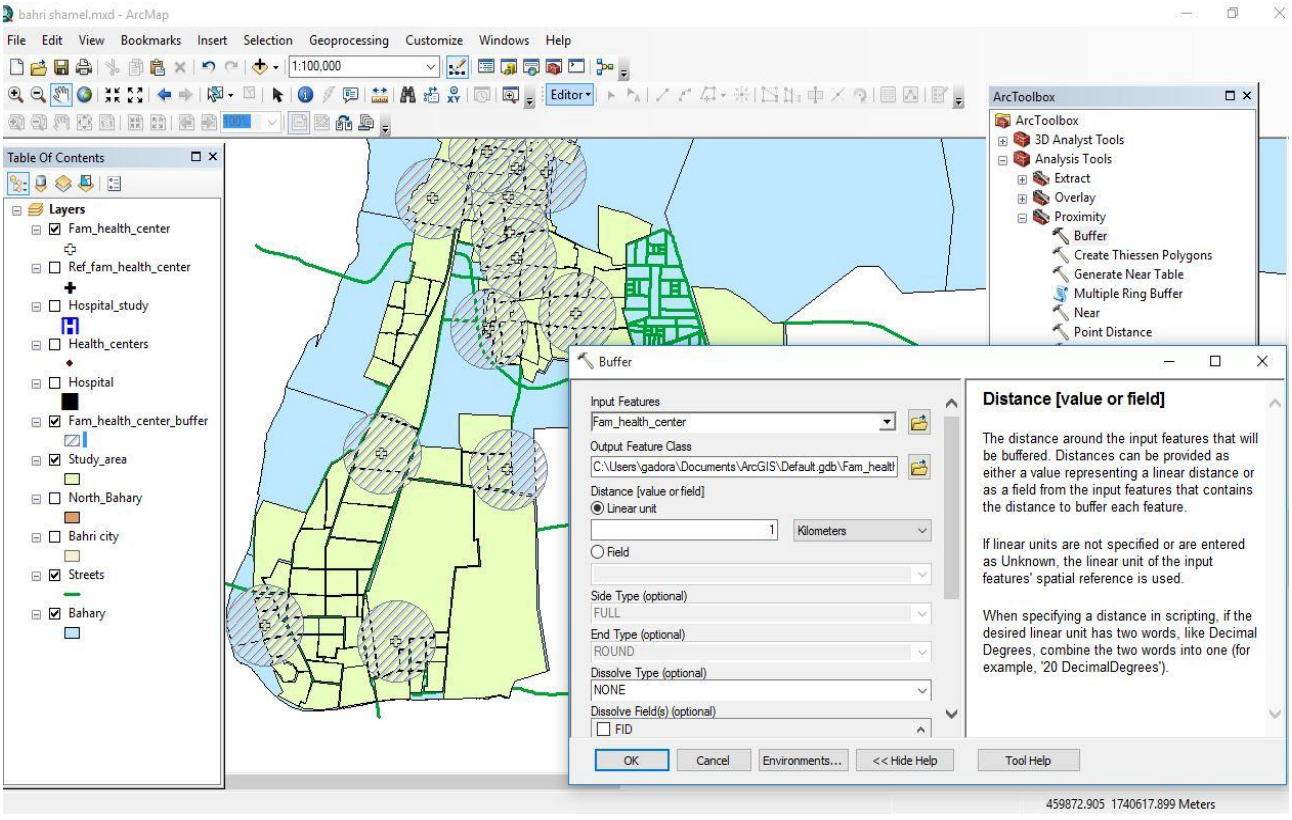


Fig (5.4) Buffer Zones of Family Health Centers (1000 Meters)

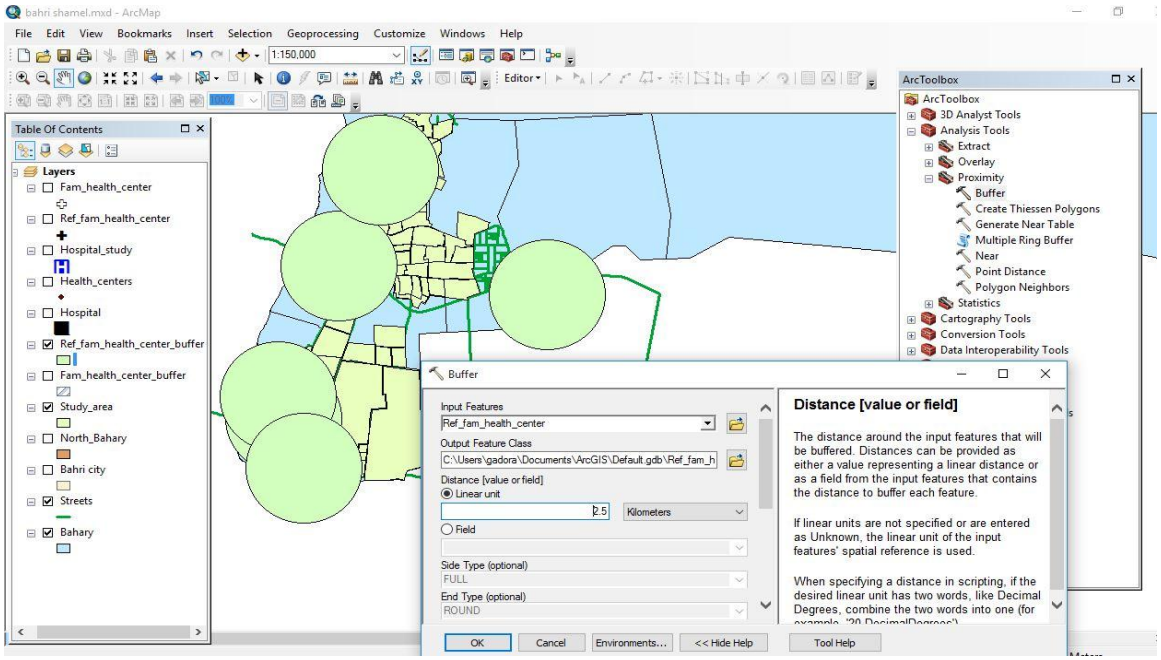


Fig (5.5) Buffer Zones of Reference Family Health Centers (2500 Meters)

5.4.4 Distance and Population criterion:

- Test work has been the standard distance by using Buffer tool procedure (buffer zones of all governmental health centers) were used simultaneously with the standard population (The capacity of the health center, the capacity of Family health center is 10000 people, and the capacity of the Reference Family health center is up to 60000 people (2.2.7) to delineate residents who the center can delivery service them. On screen digitizing were carried out for all health centers to find out number of people benefiting from health service for each health center.
- It has been calculating the number of people covered by health service within the 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 =

$$\sum\left\{\frac{the\ part\ of\ buffer\ Area(Km^2)*population\ of\ the\ district}{district\ Area(Km^2)}\right\}$$

5.5 Model Builder:

Model Builder is very useful for constructing and executing simple workflows, it also provides advanced methods for extending ArcGIS functionality by allowing you to create and share your models as tool.

Model had been built to assemble all the previous procedures in one tool called distrib_health model (figure) added to the toolbox to be used as a flowchart to repeat the process each time.

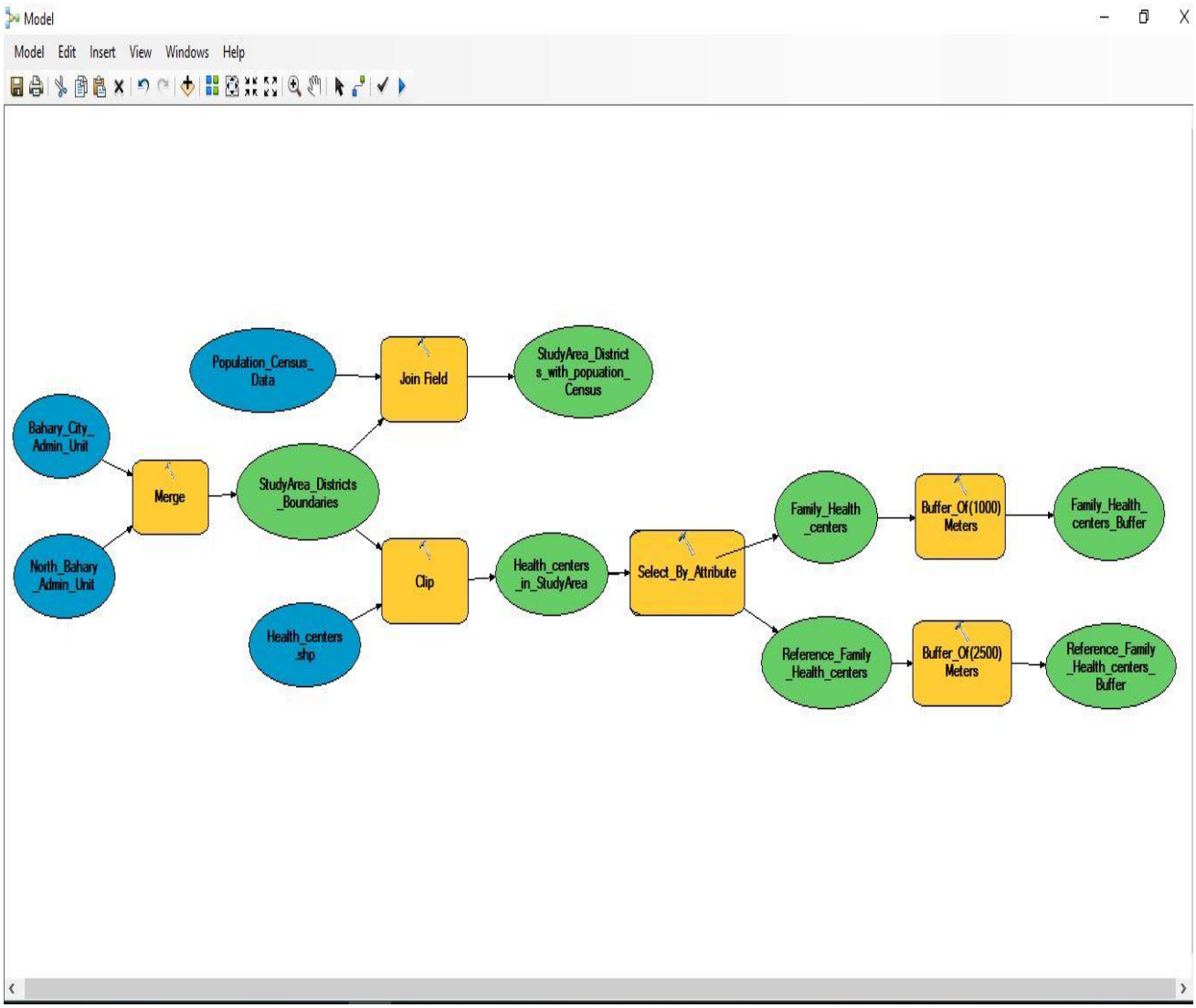


Fig (5.6) distrib_health Model.

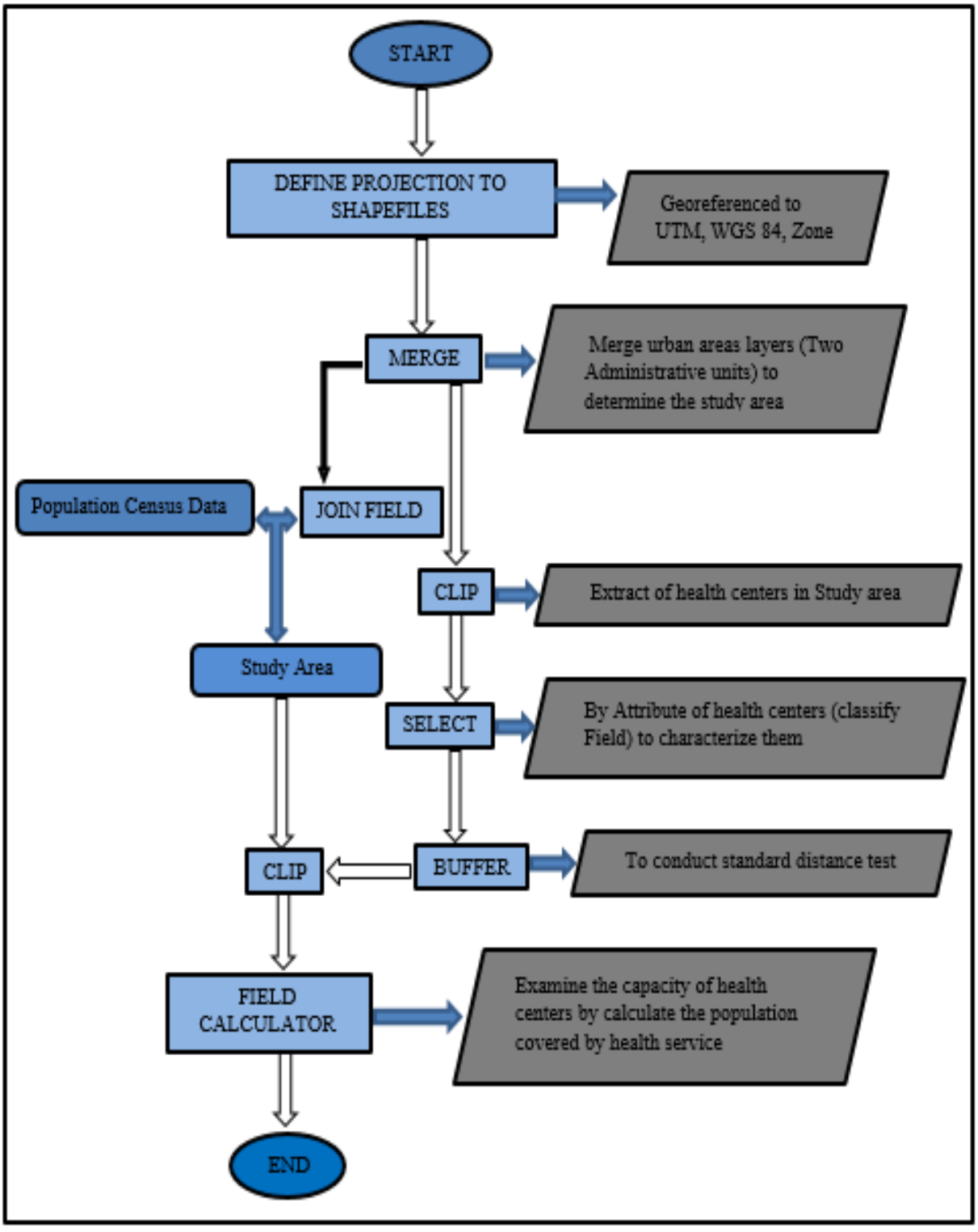


Fig (5.7) flowchart of the Distrib_health model.

CHAPTER SIX

Results and Data analysis

6.1 Distribution of Family Health centers:

Analysis of family health centers buffer zone revealed that the distribution of health centers is not perfect in other words the existing health centers are out of the standard distance Criterion (1000 meters), (2.2.6.1).

- It had been found that the presence of a good distribution of governmental family health centers in the north and northeast of the study area about 10 health centers, while these health centers are distributed in the Central and South of study area (about two health centers of each region) in a bad way (Figure 6.1).
- Usually patients refer to neighboring health centers, there are some neighborhoods not provided for the health service because it does not have health center of its neighbor. That is clear in the western and eastern regions for example, we find that districts Dardog, Alhalfaya and Alshabyah are not contain Family Health Center Facility. (Fig 6.1)

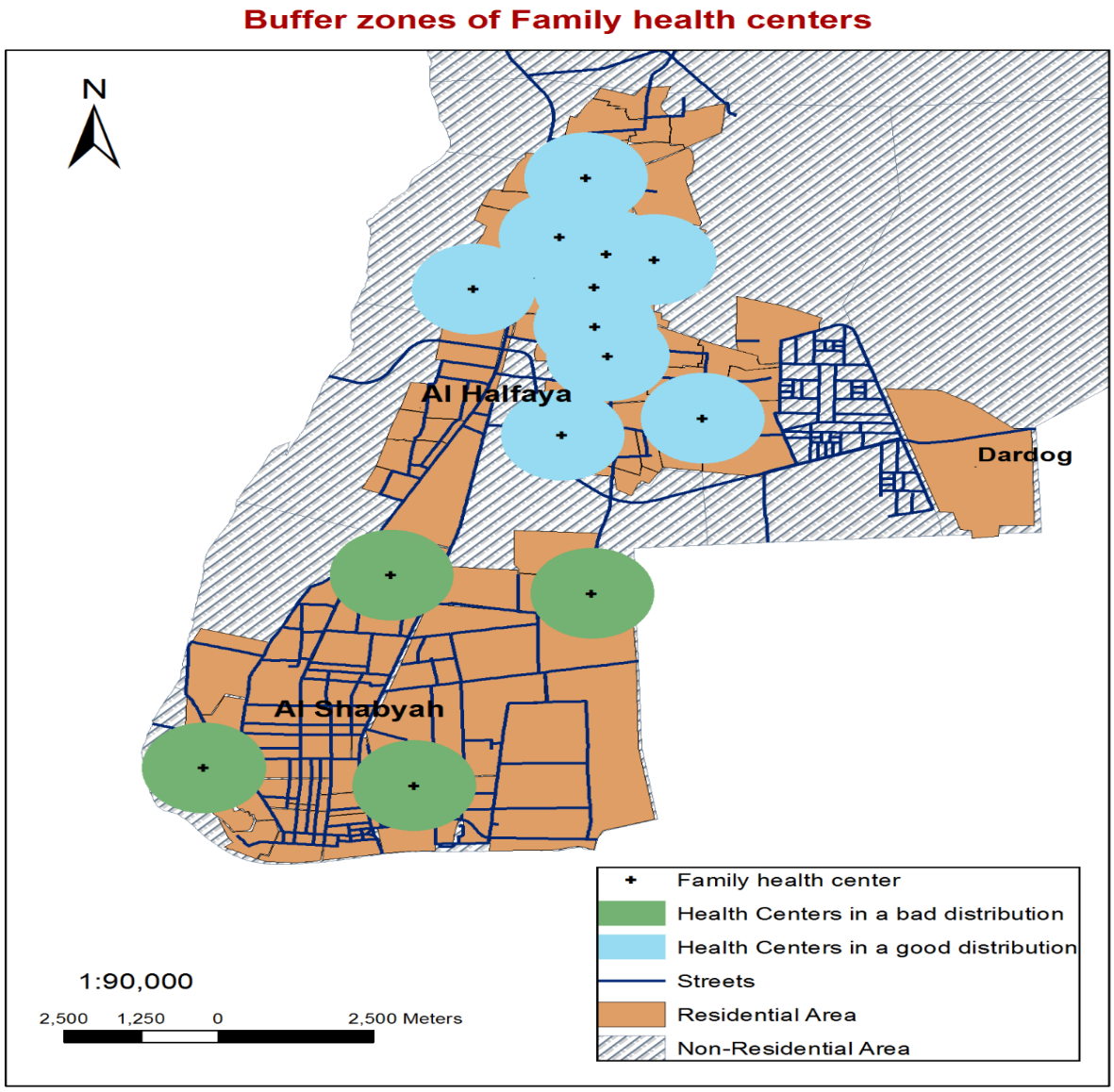


Fig (6.1): a thousand meters' buffer zones centered on Governmental Family health centers in urban area.

6.2 Coverage of health service of Family health centers in the study area:

- Seen from the results table (6.1), there are five governmental family health centers' health services covering a wide area is non-residential (predominantly agricultural areas) more than 25% including AlSababi health center, Taibat Alahamda health center, Alezirgab health center, North AlDroshab health center, AlSamrab health center.

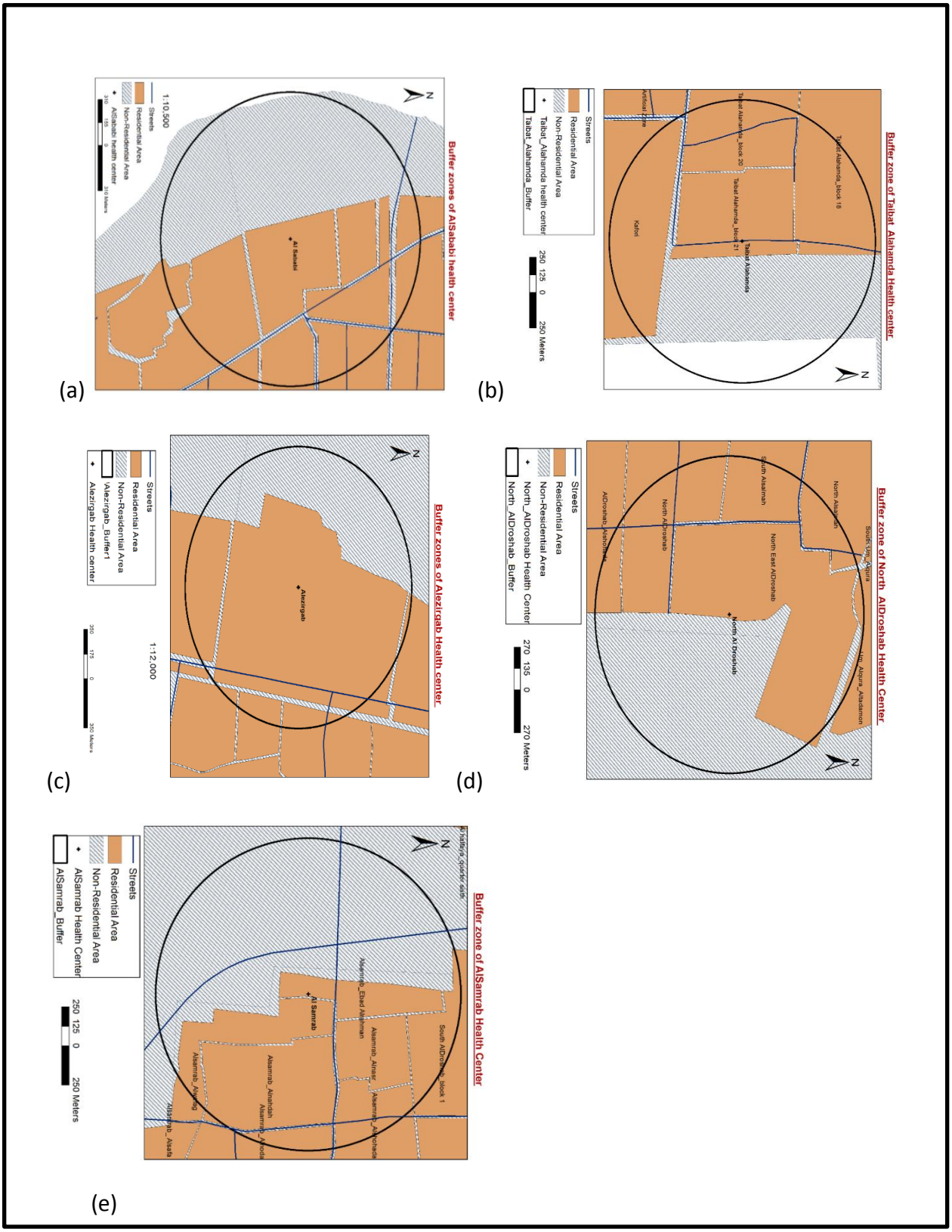


Fig (6.2(a,b,c,d,e)): Buffer Zones of five family health centers were presented on maps

- The results reflect also that, there are five governmental family health centers' health services covering an area of medium and not inconsiderable for areas is not residential (more than 5%) including Shambat family health center, Alsenaat health center, AlSalmah health center, AlSalmah Garib health Center, Um Alqura health center.

- There are four governmental family health centers' health services covering mostly residential areas in the sense that their locations are excellent and distributed in a good way (covering non-residential areas less than 5%) containing South Aldroshab health center, Aldroshab health center, Abo Talal health center, Um Derewah health center.

Table (6.1): The Residential Area& Non Residential Area Covered by health service of Family health center.

Name of health center	The total area of the covering health service(km^2)	The Residential Area Covering by health Centers(Km^2)	Non Residential Area covering by health centers(Km^2)	Non Residential Area percentage (%)
AlSababi health center	3.142	1.539	1.603	51.01
AlSenaat health center	3.142	2.768	0.374	11.89
Shambat health center	3.142	2.58	0.562	17.89
Taibat Alahamda health center	3.142	1.862	1.28	40.74
AlSamrab health center	3.142	1.455	1.687	53.71
Um Derewah health center	3.142	3.036	0.106	3.39
AlDroshab health center	3.142	3.024	0.118	3.74
South AlDroshab health center	3.142	2.999	0.143	4.55
Abo Talal health center	3.142	3.03	0.112	3.55
Alezirgab health center	3.142	2.221	0.921	29.32
North AlDroshab health center	3.142	1.914	1.228	39.08
AlSalmah health center	3.142	2.895	0.247	7.86
AlSalmah Garib health center	3.142	2.923	0.219	6.98
Um Alqura health center	3.142	2.715	0.427	13.6
Total	43.988	34.961	9.027	Average of percentage = 20.27

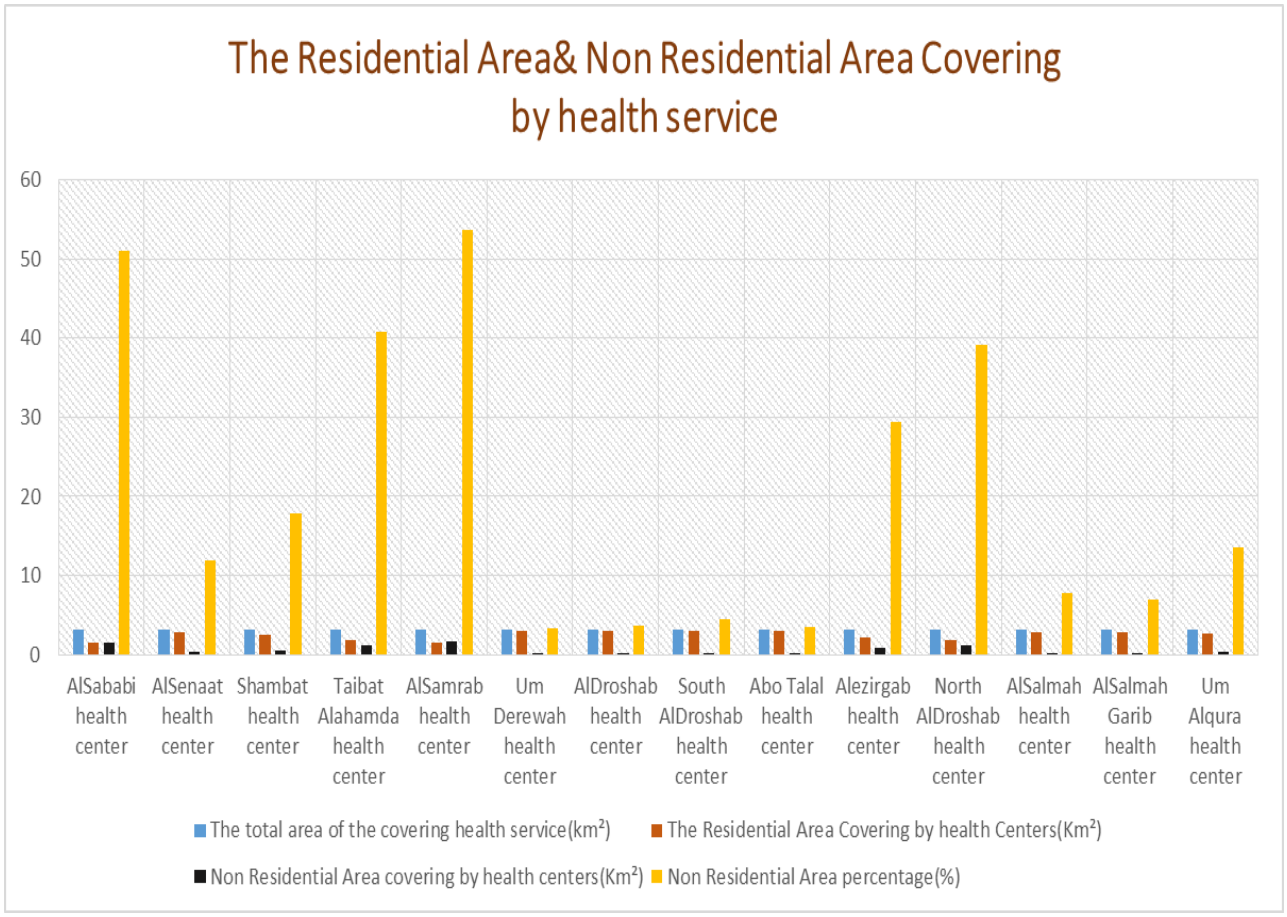


Fig (6.3) the Residential Areas & Non Residential Areas Covered by Health Centers.

6.3 Distribution of Reference Family Health centers:

Through the analysis of buffer zone of Reference Family health centers revealed that every Reference Family health center (six centers) distributed randomly, that means every health center an existing without distance Criterion, and their locations are not suitable.

- Note the presence of a good distribution of governmental Reference family health centers in the northwest, southwest and in the Eastern parts of the study area,

while these health centers are distributed in Central and Southeast parts of study area in a bad way (Figure 6.4).

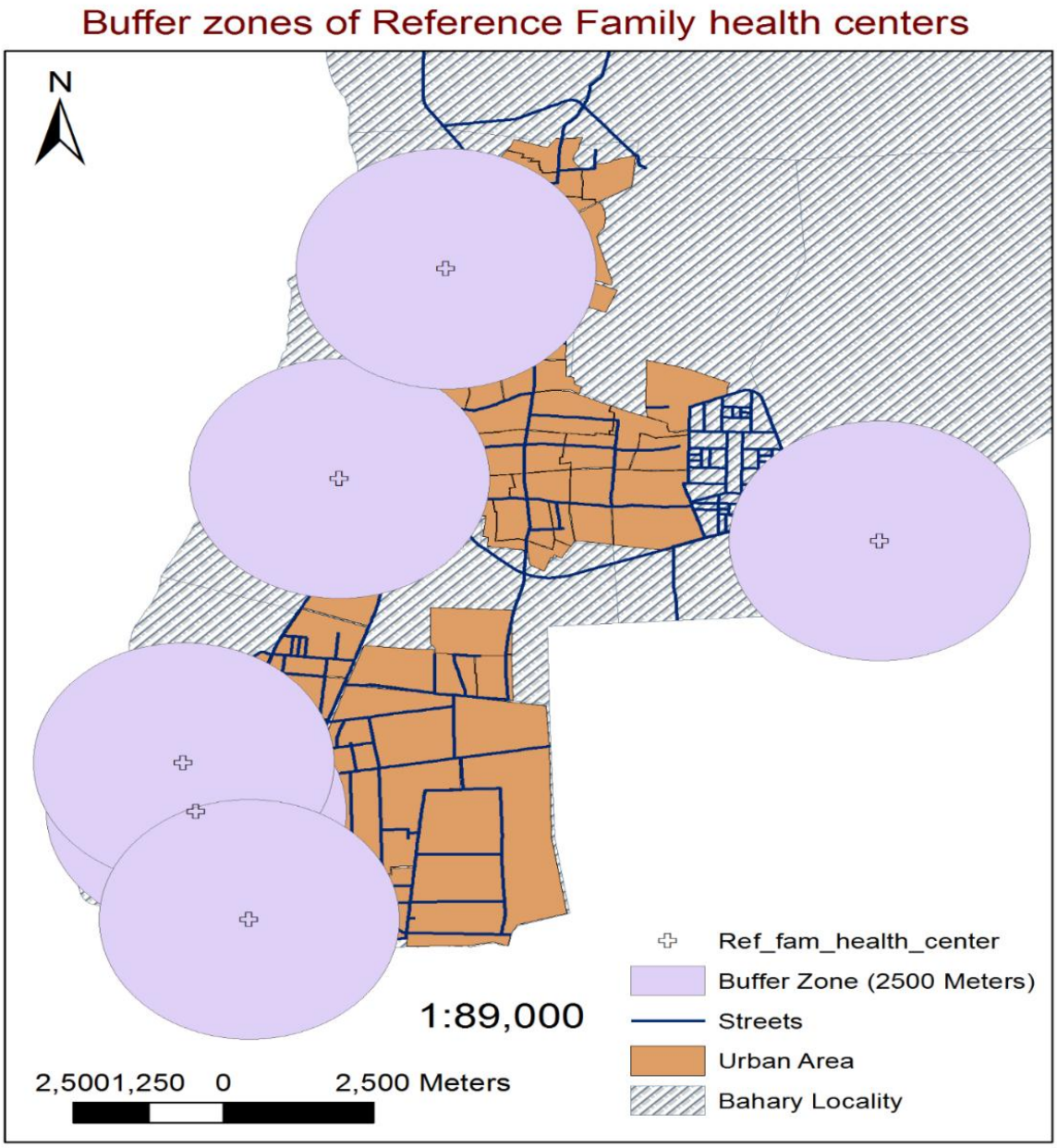
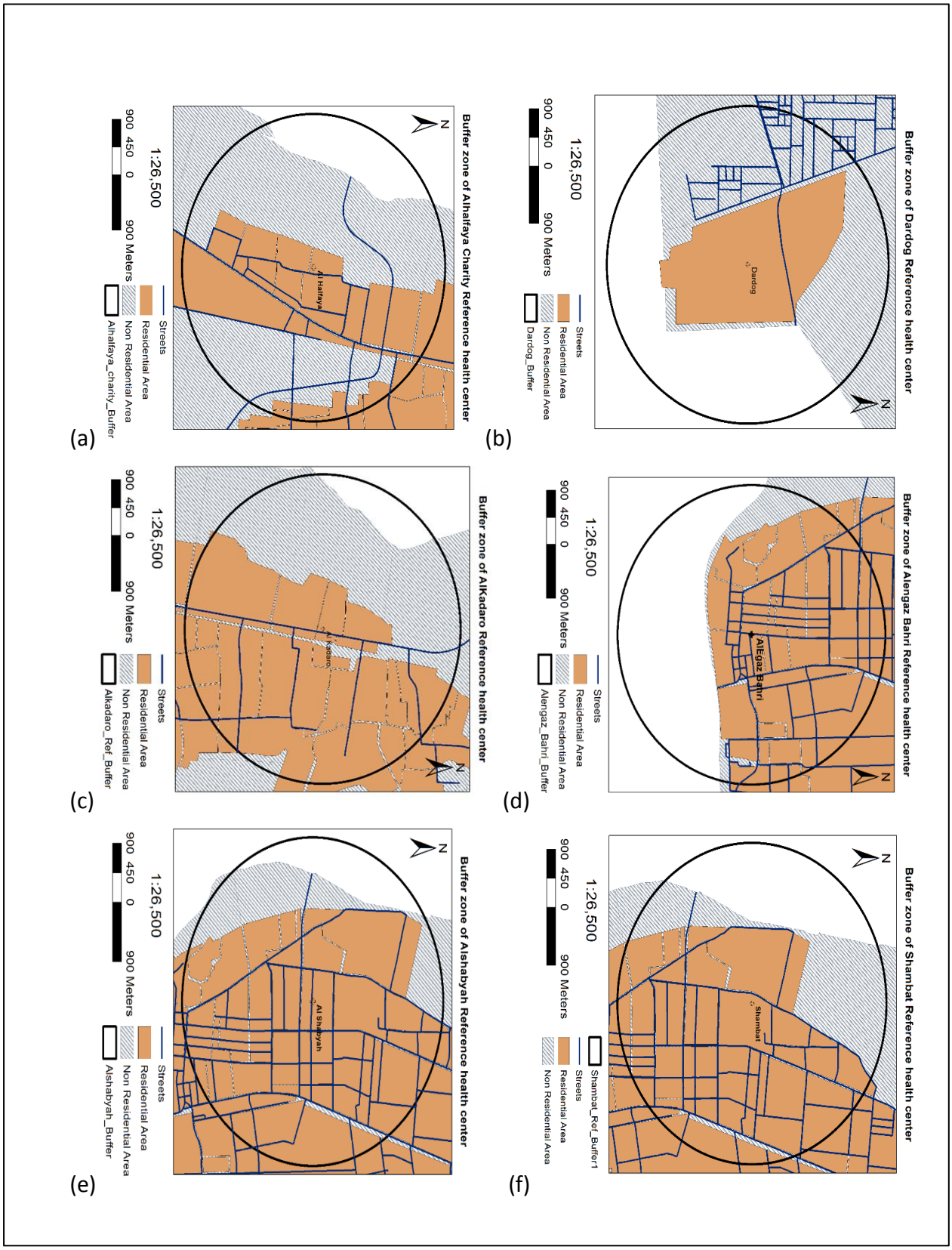


Fig (6.4): Two thousand and five hundred meters buffer zones centered on Governmental Reference Family health centers in urban area.

6.4 Coverage of health service of Reference Family health centers for study area:

From the results table (6.2), it can be seen that all of the Reference Family health center's health services cover the areas of non- residential. It estimated as a percentage of more than a quarter of the area (25%) covered by the health service, which belong to the specified health center, which means that the reference family health centers sites unsuitable. These six governmental Reference Family health centers can be classified into:

- There are two governmental family health centers' health services covering a wide area is non-residential (more than 50%) including Alhalfaya charity Reference Family Health Center and Dardog Reference Family Health Center. Fig (6.5)
- 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 50% and more than 30%) containing Shambat Reference Family Health Center and Alengaz_Bahri Reference Family Health Center
- There is a one Reference family health centers called by Alshabyah 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 30%).



Fig(6.5(a,b,c,d,e,f)): Buffer Zones of six Reference family health centers were presented on maps

Table (6.2): The Residential Area& Non Residential Area Covering by health service of Reference Family health center.

Name of health center	The total area of the covering health service(km^2)	The Residential Area Covering by health Centers(Km^2)	Non Residential – Area covering by health centers(Km^2)	Non Residential - Area percentag(%)
Alkadaro Reference Family Health Center	19.636	11.435	8.201	41.77
Alhalfaya charity Reference Family Health Center	19.636	6.707	12.929	65.84
Dardog Reference Family Health Center	19.636	5.02	14.616	74.44
Alshabyah Reference Family Health Center	19.636	13.834	5.802	29.55
Shambat Reference Family Health Center	19.636	11.615	8.021	40.85
Alengaz_Bahri Reference Family Health Center	19.636	10.005	9.631	49.05
Total	117.816	58.616	59.2	Average of percentage =50.25

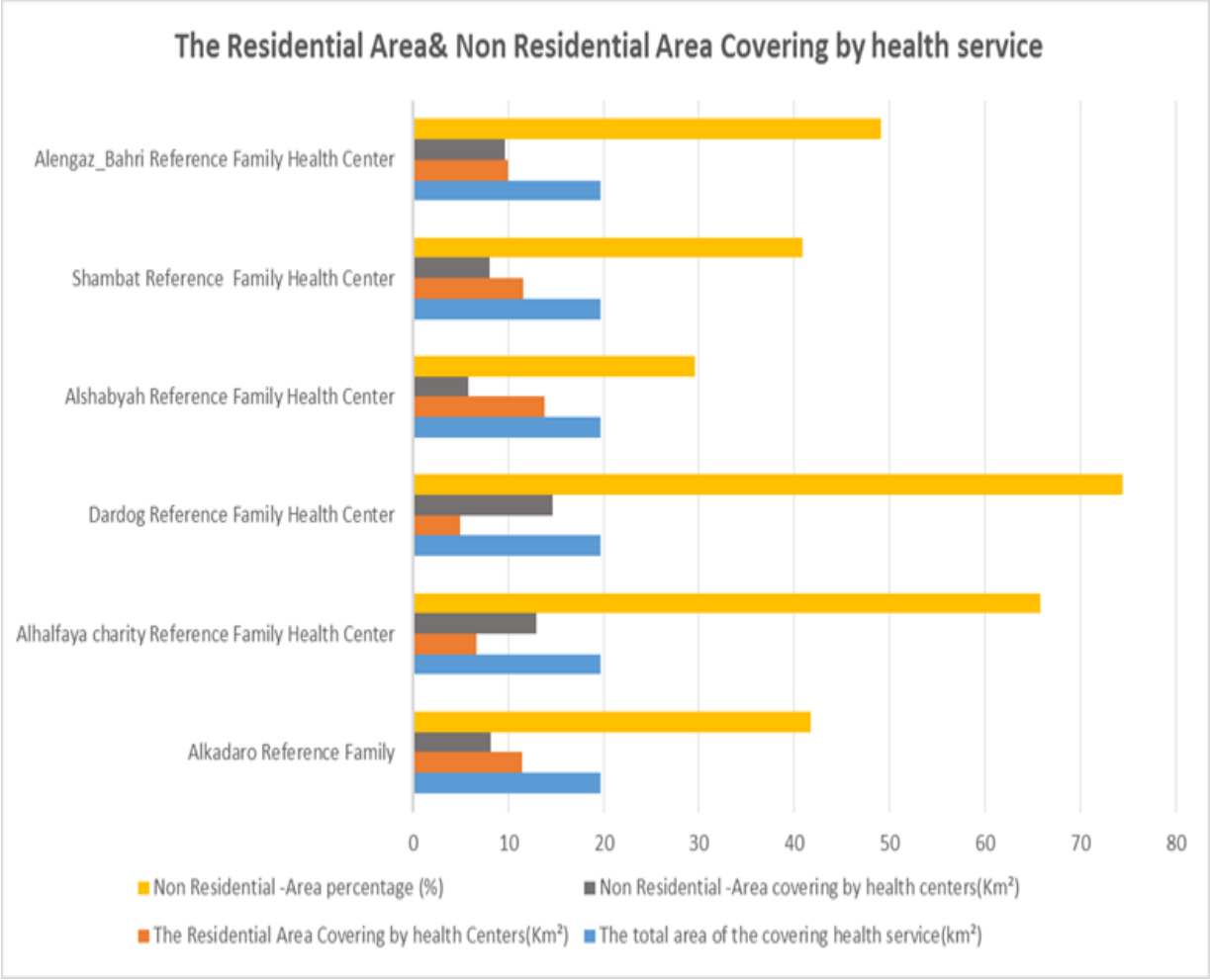


Fig (6.6) the Residential Areas & Non Residential Areas Covered by Reference Family Health Centers

6.5 Distance and Population criterion:

6.5.1 Family Health Centers:

Analysis of both family health centers attribute tables and it's buffer zones, It found that the total capacity of the population in the study area, which should be covered by health services by government health centers (fourteen health center) in urban areas in Bahri locality is 140,000 people, according to the Sudanese Federal Ministry of Health standards, While the actual number of residents (patients) beneficiaries of the health service is 337 572 inhabitants, that means there is a surplus in the population of about 197,572 people, an increase of entirety of approximately 141.12% of the total capacity for the centers (Table 6.3).

As a result, health centers have been classified into four 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 Alezirgab health center 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.

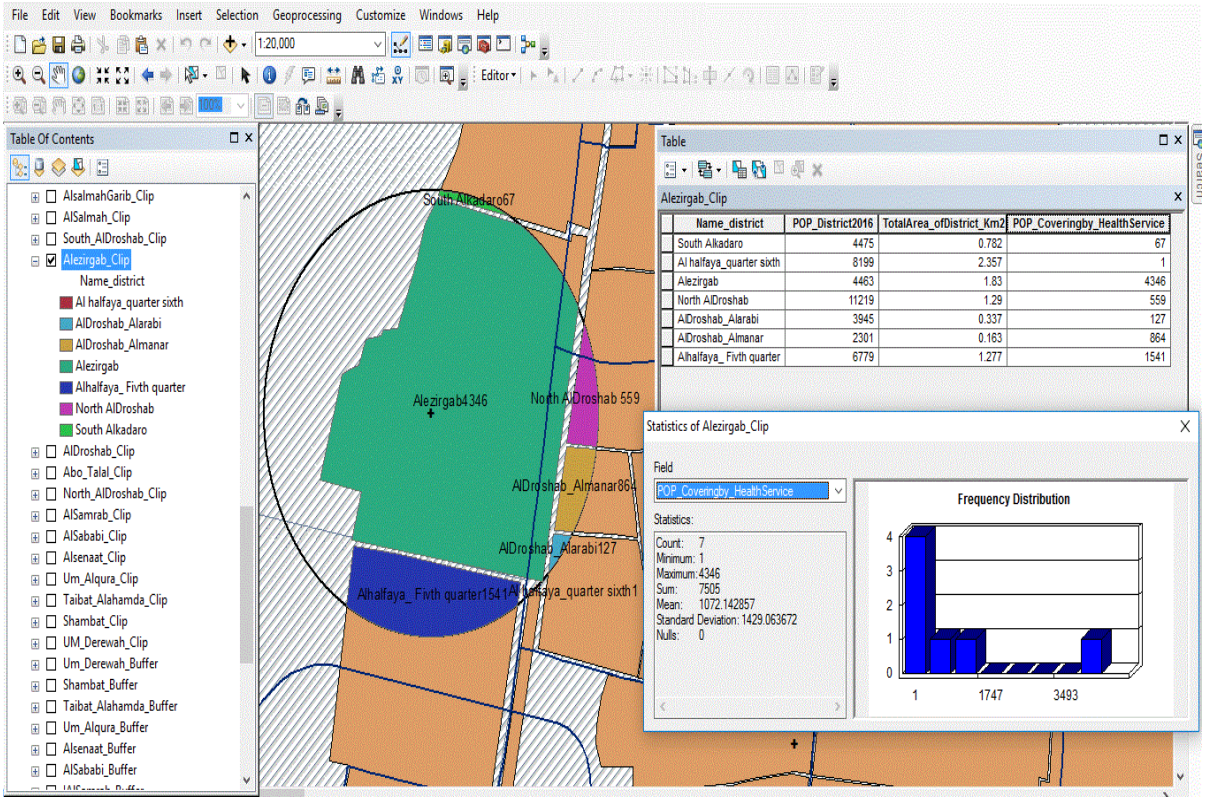


Fig (6.7) Attribute table of Alezirgab health center illustrate the number of population benefiting from health service.

2- Health centers that serve the population increased by the excess in the number of population ratio (more than 40% and less than 160%), and these centers are AlSababi health center and AlSenaat health center and Taibat Alahamda health center and North AlDroshab health center and AlSalmah health center and Um Alqura health center and AlSamrab health center, The work suggests an expansion of

its buildings with increased their sections and improve them. As well as the establishment of new health centers near to relieve pressure on it and make it provide health service in the best form.

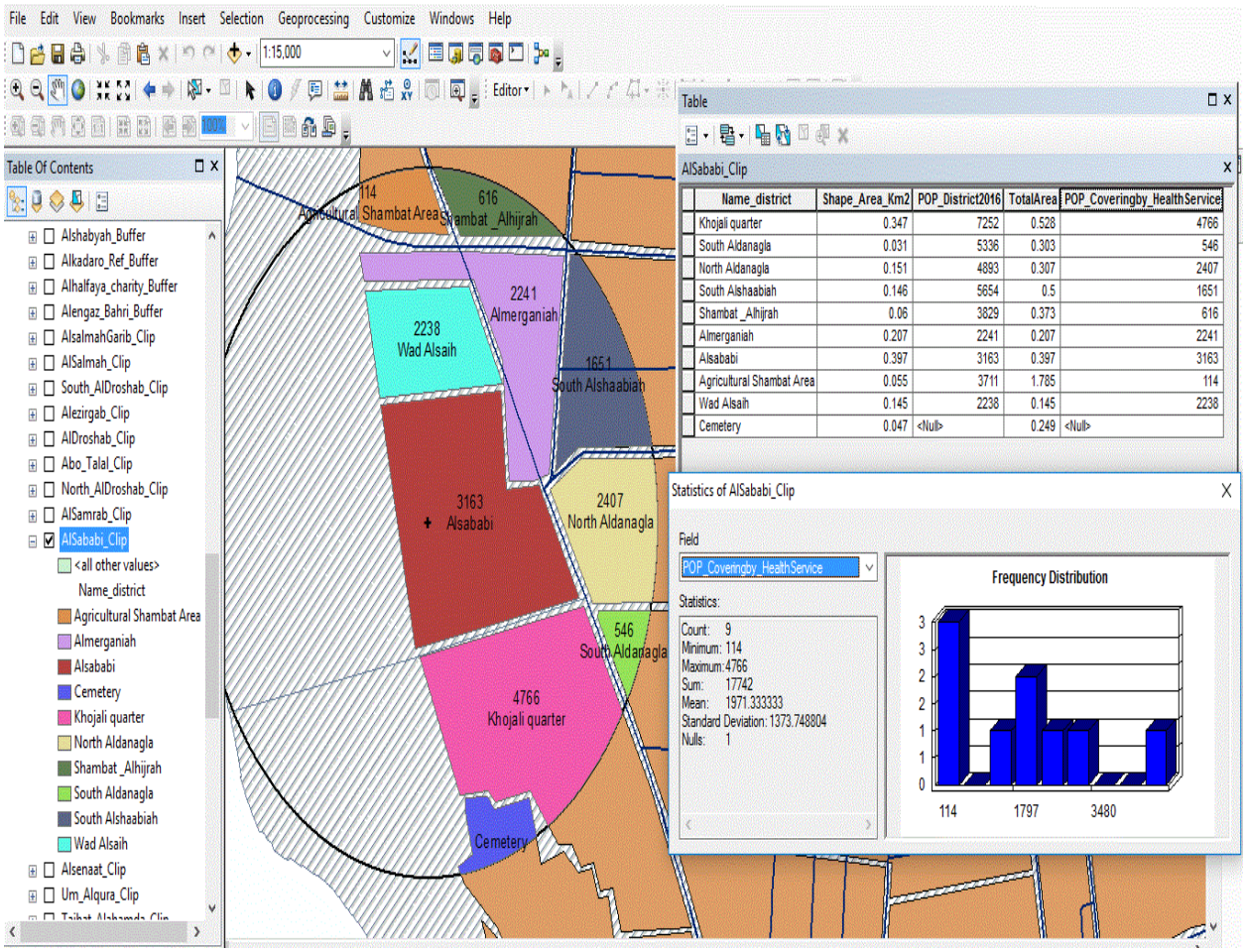


Fig (6.8) Attribute table of AlSababi health center illustrate the number of population benefiting from health service.

3- Health centers that serve the population increased by the excess in the number of population ratio Between (160-260)% and these centers are Shambat health center and Um Derewah health center and AlDroshab health center and Abo Talal health center and AlSalmah Garib health center, In areas where these centers are located where the deficit(Shortage) was estimated by two health centers because of the large

number of people who frequent these centers, so there is a considerable need for building new health centers.

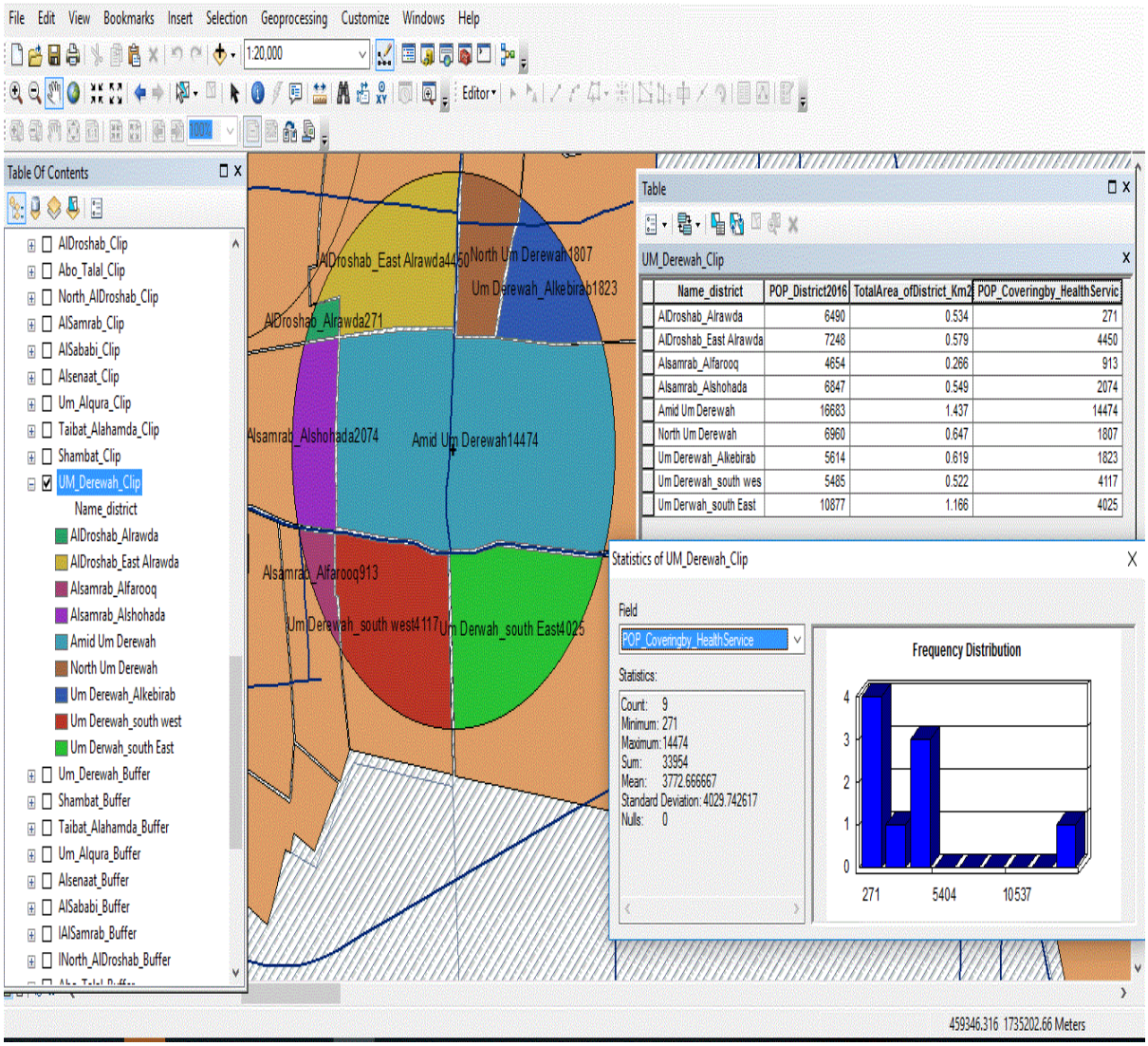


Fig (6.9) Attribute table of Um Derewah health center illustrate the number of population benefiting from health service.

4- Health centers that serve the population increased by the excess in the number of population ratio (more than 260%) There is one South AlDroshab health center represented by the excess of 269.95%, in area where this center is located where the deficit (Shortage) was estimated by three health centers, that means the need for the establishment of three centers in the region.

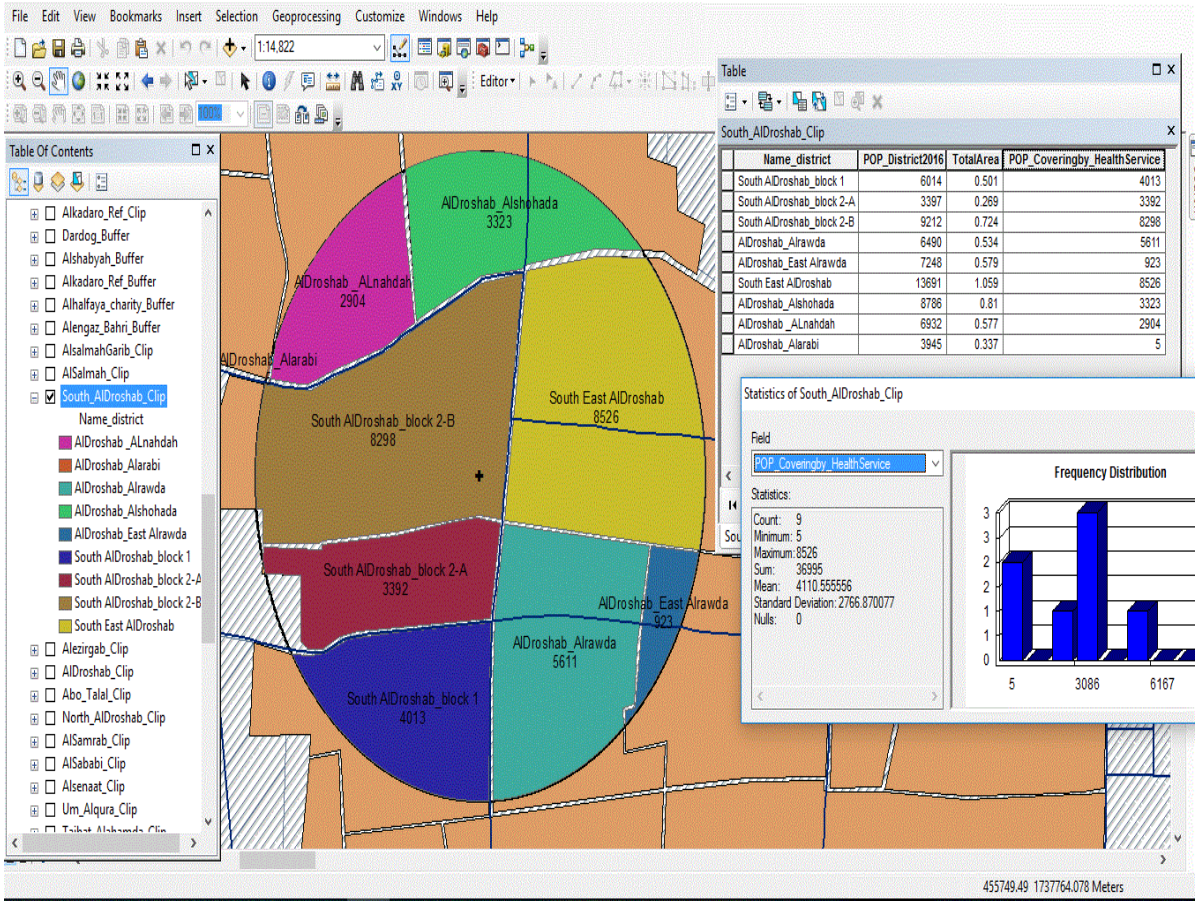


Fig (6.10) Attribute table of South AlDroshab health center illustrate the number of population benefiting from health service.

Table (6.3) The population covered by health service and the shortage of 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
AlSababi health center	10000	17742	7742	177.42	1
AlSenaat health center	10000	15956	5956	159.56	1
Shambat health center	10000	29243	19243	292.43	2
Taibat Alahamda health center	10000	19203	9203	192.03	1
AlSamrab health center	10000	20532	10532	205.32	1
Um Derewah health center	10000	33954	23954	339.54	2
AlDroshab health center	10000	35466	25466	354.66	2
South AlDroshab health center	10000	36995	26995	369.95	3
Abo Talal health center	10000	29999	19999	299.99	2
Alezirgab health center	10000	7505	0	75.05	0
North AlDroshab health center	10000	14187	4187	141.87	1
AlSalmah health center	10000	25863	15863	258.63	1
AlSalmah Garib health center	10000	26558	16558	265.58	2
Um Alqura health center	10000	24369	14369	243.69	1
Total	140000	337572	197572	3375.72	20

The total percentage of the actual capacity of the population covered by health centers is equal approximately 241.12 % .

6.5.2 Reference Family Health Centers:

Analysis of both Reference family health centers attribute tables and its buffer zones revealed that the total capacity of the population in the study area, which should be covered by health services by governmental health centers is 360000 people, according to the Sudanese Federal Ministry of Health standards, While the actual number of residents beneficiaries (patients) of the health service is 509380 inhabitants, that means there is a surplus in the population of about 149380 people, , an increase of entirety of approximately 41.49% of the total capacity for the centers (table 6.4).

Reference Family health centers have been classified into three 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%, and there two health centers Alhalfaya charity Reference Family Health Center, Dardog Reference Family Health Center because the region in which is located the center of sparsely populated specifically Dardog Reference Family Health Center which serves a small population only (10741 people) compared to capacitive borne by the Centre in accordance with the standards (even 60000), while Alhalfaya charity Reference Family Health Center serves acceptable number of population (54693 people) .

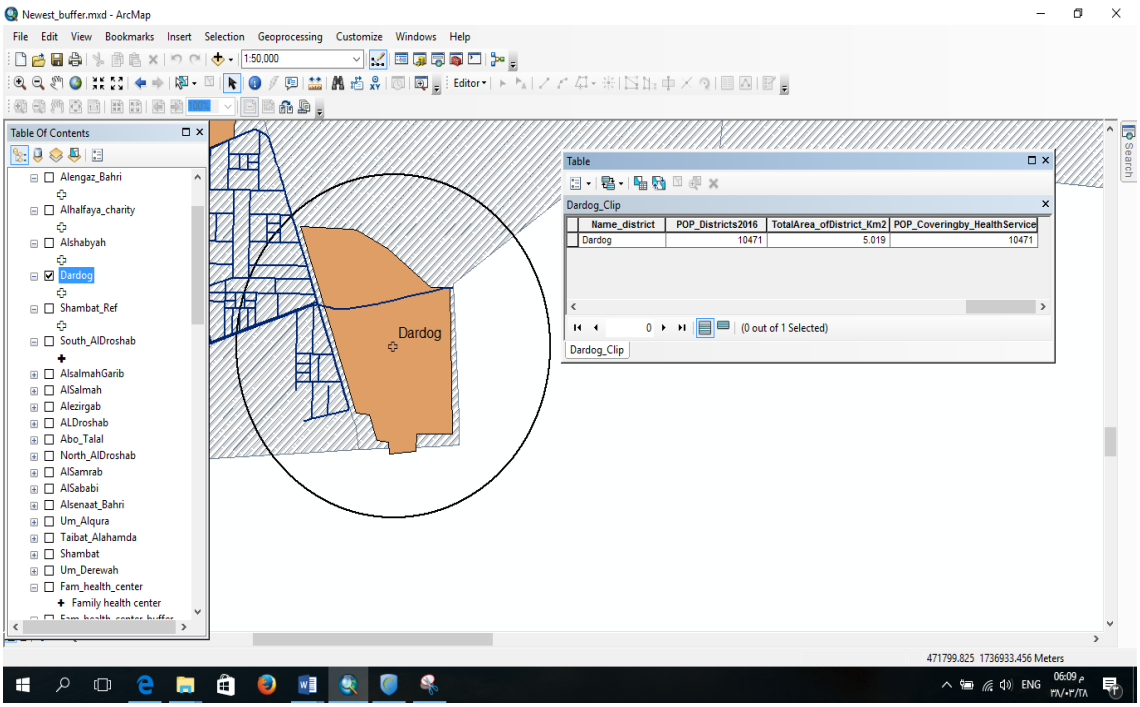


Fig (6.11.a) Attribute table of Dardog health center illustrate the number of population benefiting from health service.

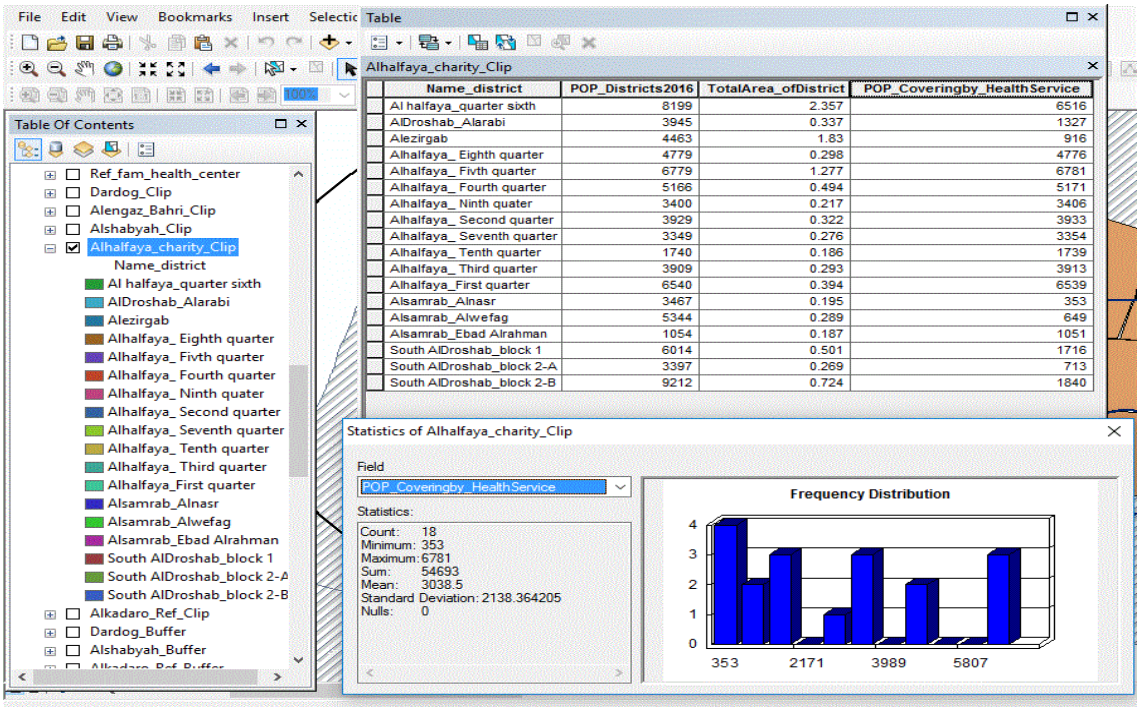


Fig (6.11.b) Attribute table of Alhalfaya Charity health center illustrate the number of population benefiting from health service

2- Health centers that serve the population increased by the excess in the number of population ratio (more than40% and less than 100%), these centers are Alengaz_Bahri Reference Family Health Center, Alkadaro Reference Family Health Center, in areas where these centers are located where the deficit (Shortage) was estimated by one health center.

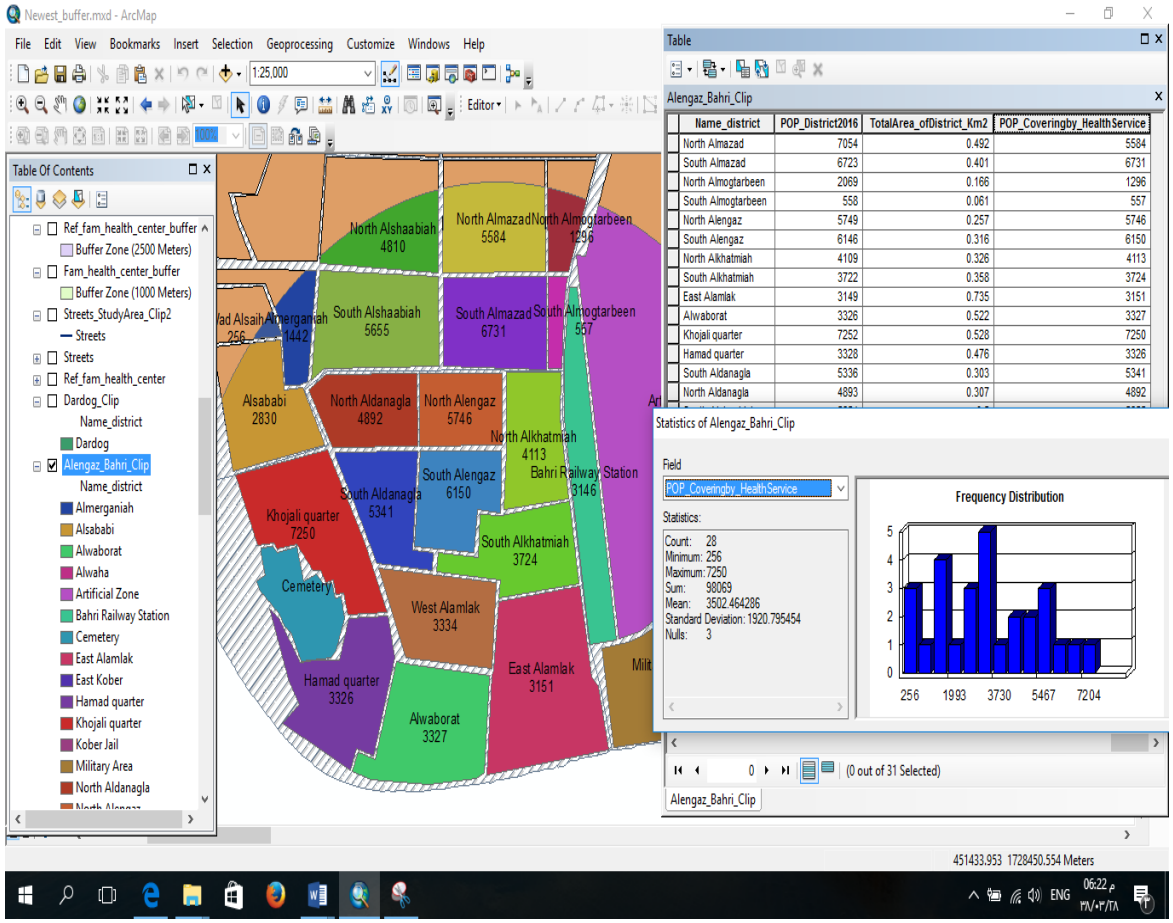


Fig (6.12) Attribute table of Alengaz Bahri health center illustrate the number of population benefiting from health service.

3- Health centers that serve the population increased by the excess in the number of population ratio (more than 100%) and these centers are Alshabyah Reference Family

Health Center and Shambat Reference Family Health Center, in areas where these centers are located where the deficit (Shortage) was also estimated by one health center.

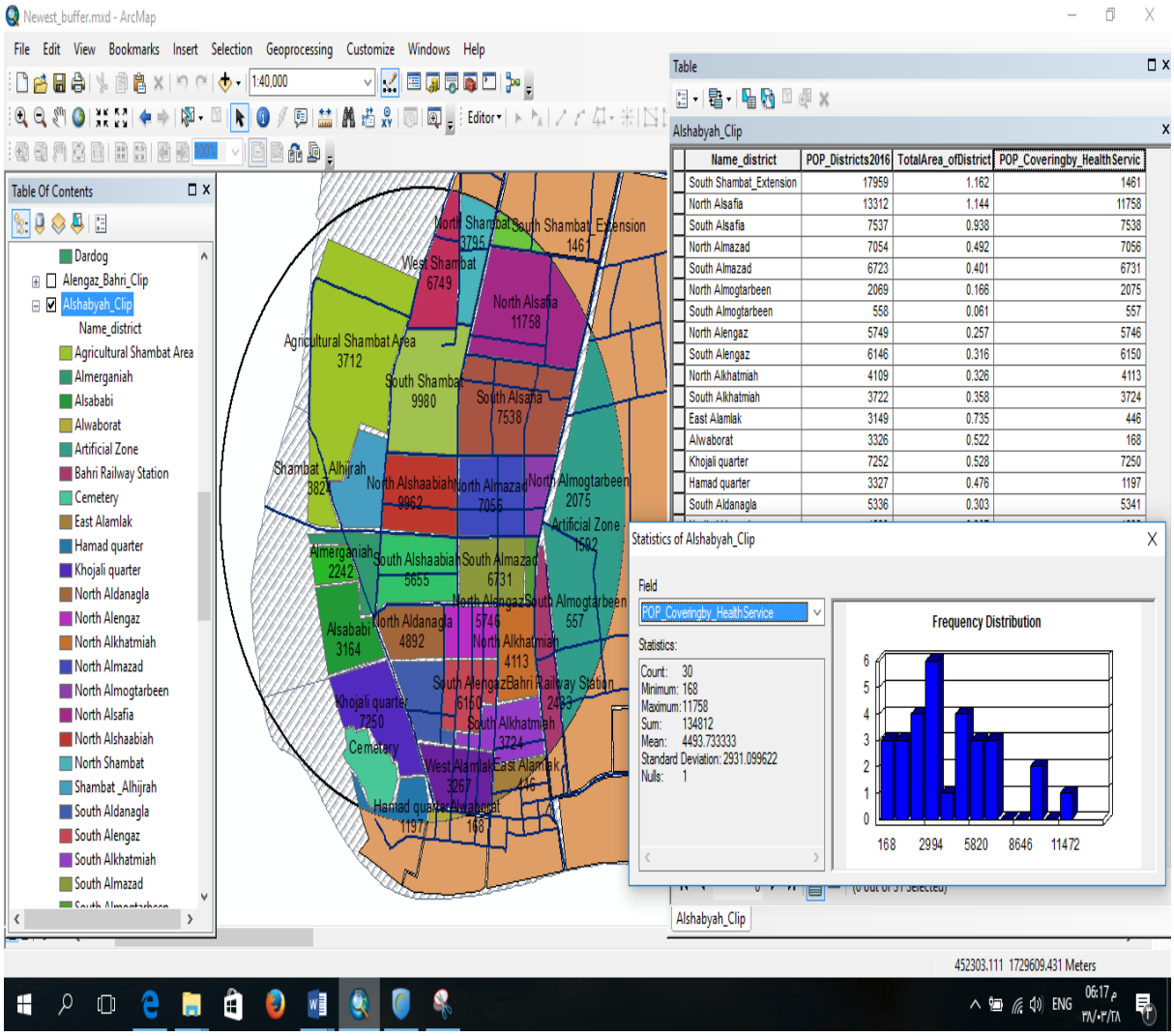


Fig (6.13) Attribute table of Alshabyah health center illustrate the number of population benefiting from health service.

Table (6.4) the population covered by health service and the shortage of Reference 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
Alkadaro Reference Family Health Center	60000	87707	27707	146.19	1
Alhalfaya charity Reference Family Health Center	60000	54693	0	91.16	0
Dardog Reference Family Health Center	60000	10471	0	17.45	0
Alshabyah Reference Family Health Center	60000	134812	74812	224.69	1
Shambat Reference Family Health Center	60000	123628	63628	206.05	1
Alengaz_Bahri Reference Family Health Center	60000	98069	38069	163.45	1
Total	360000	509380	149380	848.99	4

-The total percentage of the actual capacity of the population covered by health centers is equal approximately 141.49 %.

CHAPTER SEVEN

Conclusion and recommendations

7.1 Conclusion:

Geographic information system (GIS) Techniques has proved a valuable aid in this study by analyzing health centers' sites and the population benefiting from those centers.

The study had found that the locations of governmental health centers about (20 centers) in the study area were not related to the sites of populations, from (6.3) it can be seen that there are five governmental family health canters' health services covering a wide area is non-residential area, regardless of the geographical distribution.

It had found been that the distribution of Family health centers (14 centers) focused in the northern regions of study area about10 centers from (Fig (6.1)), while lacking in the central, eastern and western regions, thus need the establishment of new governmental Family health centers. Re-distribution of health cadres in areas crowded with health centers (northern areas) which close to each other to avoid the loss of health resources, and an extension of some governmental health centers' buildings in the southern regions in order to accommodate the largest number of patients.

The high density of Reference Family health centers (6 centers) is in the northwest, southwest and the eastern parts of study area from (Fig (6.5)), while it is weak in southeast and the central parts, so it is necessity to construct a new Reference health centers near to the existed governmental health centers to accommodate the excess number of population, to provide health service in the best form.

7.2 Recommendations:

1- Use of geographic information system (GIS) as integrated tool to measure the distribution of health services' sites according to the population distribution and their density, as required to provide for the effort, time and money.

2- Add Other Criterions which have direct impact on Health service such as roads network, that means new standards should be adopted for the distribution of health services to respond to the necessity of rationalizing and allocation of resources and capabilities in the study area.

7.3 References:

1) ADAY, L. A. & ANDERSEN, R. M, 1981, Equity of access to medical care: a conceptual and empirical overview, *Medical care***,** 4-27.
2) ANSARI, Z, 2007, A review of literature on access to primary health care, *Australian Journal of Primary Health,* 13**,** 80-95.
3) ARONOFF, S, 1989, Geographic information systems: a management perspective.
4) BACHELET, M. & OFFICE, I. L, 2012, *Social protection floor for a fair and inclusive globalization*, International Labour Office.
5) BAGHERI, N., BENWELL, G. L. & HOLT, A, 2006, Primary Health Care Accessibility for Rural Otago:'A Spatial Analysis', *HIC 2006 and HINZ 2006: Proceedings***,** 365.
6) BELL, S., WILSON, K., BISSONNETTE, L. & SHAH, T, 2013, Access to primary health care: does neighborhood of residence matter? *Annals of the Association of American Geographers,* 103**,** 85-105.
7) BISSONNETTE, L., WILSON, K., BELL, S. & SHAH, T. I, 2012, Neighbourhoods and potential access to health care: The role of spatial and aspatial factors, *Health & place,* 18**,** 841-853.
8) BURKEY, M. L, 2012, Decomposing geographic accessibility into component parts: methods and an application to hospitals, *The Annals of Regional Science,* 48**,** 783-800.
9) BUSSE, R., SCHREYöGG, J. & GERICKE, C, 2007, Analyzing changes in health financing arrangements in high-income countries, *Health, Nutrition and Population Discussion Paper. Washington, DC, World Bank.*
10) CARVER, S., KINGSTON, R. & TURTON, 1998, Accessing GIS over the web: An aid to Public Participation in environmental Decision-Making, *GISRUK'98*.
11) CRAGLIA, M. & MAHESWARAN, R, 2016, *GIS in public health practice*, CRC press.
12) CROMLEY, E. & MCLAFFERTY, S, 2002, GIS and public health, 2002, *New York: Guilford Press Google Scholar*.
13) CULLINAN, J., GILLESPIE, P., OWENS, L., DUNNE, F. & COLLABORATORS, A. D, 2012, Accessibility and screening uptake rates for gestational diabetes mellitus in Ireland, *Health & place,* 18**,** 339-348.
14) DYE, C., REEDER, J. C. & TERRY, R. F, 2013, Research for universal health coverage, *Science translational medicine,* 5**,** 199ed13-199ed13.
15) FLOWERDEW, R. & GREEN, M, 1989, Statistical methods for inference between incompatible zonal systems, *Accuracy of spatial databases***,** 239-247.
16) FUNCTION, G.-B. C. O. I. I. T. F. D. O. T. P. H, 1988, *Public health in England: the report of the Committee of Inquiry into the Future Development of the Public Health Function*, HM Stationery Office.
17) GOODMAN, D. C., FISHER, E., STUKEL, T. A. & CHANG, C.-H, 1997, The distance to community medical care and the likelihood of hospitalization: is closer always better?, *American Journal of Public Health,* 87**,** 1144-1150.
18) GOODMAN, D. C., MICK, S. S., BOTT, D., STUKEL, T., CHANG, C. H., MARTH, N., POAGE, J. & CARRETTA, H. J, 2003, Primary care service areas:

a new tool for the evaluation of primary care services, *Health services research,* 38**,** 287-309.
19) GUAGLIARDO, M. F, 2004, Spatial accessibility of primary care: concepts, methods and challenges, *International journal of health geographics,* 3**,** 1.
20) GUAGLIARDO, M. F., RONZIO, C. R., CHEUNG, I., CHACKO, E. & JOSEPH, J. G,2004, Physician accessibility: an urban case study of pediatric providers, *Health & place,* 10**,** 273-283.
21) GUTHE, W. G., TUCKER, R. K., MURPHY, E. A., ENGLAND, R., STEVENSON, E. & LUCKHARDT, J. C, 1992, Reassessment of lead exposure in New Jersey using GIS technology, *Environmental research,* 59**,** 318-325.
22) HANCHETTE, C. GIS implementation of 1997 CDC guidelines for childhood lead screening in North Carolina, GIS in Public Health, 3rd Natl. Conf. Abstr, 1998.
23) HAYNES, R., BENTHAM, G., LOVETT, A. & GALE, S, 1999, Effects of distances to hospital and GP surgery on hospital inpatient episodes controlling for needs and provision. *Social science & medicine,* 49**,** 425-433.
24) HEWKO, J., SMOYER-TOMIC, K. E. & HODGSON, M. J, 2002,Measuring neighbourhood spatial accessibility to urban amenities: does aggregation error matter?, *Environment and Planning A,* 34**,** 1185-1206.
25) HIGGS, G, 2004, A literature review of the use of GIS-based measures of access to health care services, *Health Services and Outcomes Research Methodology,* 5**,** 119-139.
26) HUMPHREYS, J. S., WAKERMAN, J., WELLS, R., KUIPERS, P., JONES, J. A. & ENTWISTLE, P, 2008, " Beyond workforce": a systemic solution for health service provision in small rural and remote communities, *Medical Journal of Australia,* 188**,** S77.
27) HYNDMAN, J. C. & HOLMAN, C. A. J, 2001, Accessibility and spatial distribution of general practice services in an Australian city by levels of social disadvantage, *Social Science & Medicine,* 53**,** 1599-1609.
28) JOSEPH, A. E. & PHILLIPS, D. R, 1984, *Accessibility and utilization: geographical perspectives on health care delivery*, Sage.
29) LOVETT, A., HAYNES, R. N. & BENTHAM, G, 1998, 1mproving Health Needs Assessment using Patient Register 1nformation in aG1S, *GIS and Health,* 6**,** 191.
30) LUO, W, 2004, Using a GIS-based floating catchment method to assess areas with shortage of physicians, *Health & place,* 10**,** 1-11.
31) LUO, W. & QI, Y, 2009, An enhanced two-step floating catchment area (E2SFCA) method for measuring spatial accessibility to primary care physicians, *Health & place,* 15**,** 1100-1107.
32) LUO, W. & WANG, F, 2003, Measures of spatial accessibility to health care in a GIS environment: synthesis and a case study in the Chicago region, *Environment and Planning B: Planning and Design,* 30**,** 865-884.
33) LUO, W. & WHIPPO, T, 2012, Variable catchment sizes for the two-step floating catchment area (2SFCA) method, *Health & place,* 18**,** 789-795.
34) MASOODI, M. & RAHIMZADEH, M, 2015, Measuring access to urban health services using Geographical Information System (GIS): a case study of health

service management in Bandar Abbas, Iran, *International journal of health policy and management,* 4**,** 439.
35) MCGRAIL, M. R, 2012, Spatial accessibility of primary health care utilising the two step floating catchment area method: an assessment of recent improvements, *International journal of health geographics,* 11**,** 1.
36) MCGRAIL, M. R. & HUMPHREYS, J. S, 2009a, Measuring spatial accessibility to primary care in rural areas: improving the effectiveness of the two-step floating catchment area method, *Applied Geography,* 29**,** 533-541.
37) MCGRAIL, M. R. & HUMPHREYS, J. S, 2009b, A new index of access to primary care services in rural areas, *Australian and New Zealand journal of public health,* 33**,** 418-423.
38) MCLAFFERTY, S., WANG, F., LUO, L. & BUTLER, J, 2011, Rural—urban inequalities in late-stage breast cancer: spatial and social dimensions of risk and access, *Environment and Planning B: Planning and Design,* 38**,** 726-740.
39) MCLAFFERTY, S. L, 2003, GIS and health care, *Annual review of public health,* 24**,** 25-42.
40) MELNICK, A. L. & FLEMING, D. W, 1999, Modern Geographic Information Systems-Promise and Pitfalls, *Journal of Public Health Management and Practice,* 5**,** viii&hyhen; x.
41) MOHAN, J, 1993, Healthy indications? Applications of census data in health care planning, *Population Matters: the local Dimension, Paul Chapman, London***,** 136-149.
42) NAYAK, S., THORAT, S. & KALYANKAR, N, 2010, GIS: Geographic Information System An application for socio-economical data collection for rural area, *arXiv preprint arXiv:1004.1793*.
43) ORGANIZATION, W. H,1978a, Declaration of Alma-Ata: International Conference on Primary Health Care, Alma-Ata, USSR, 6–12 September 1978. *Retrieved February,* 14**,** 2006.
44) ORGANIZATION, W. H, 1978b, Report of the International Conference on Primary Health Care, Alma-Ata, USSR, 6–12 September 1978. *Geneva: WHO*.
45) ORGANIZATION, W. H, 2010, *The world health report: health systems financing: the path to universal coverage,* Geneva: World Health Organization.
46) PETERS, J. & HALL, G. B, 1999, Assessment of ambulance response performance using a geographic information system, *Social Science & Medicine,* 49**,** 1551-1566.
47) PFEIFFER, D., ROBINSON, T. P., STEVENSON, M., STEVENS, K. B., ROGERS, D. J. & CLEMENTS, A. C, 2008, Spatial analysis in epidemiology.
48) PHILLIPS JR, R. L., KINMAN, E. L., SCHNITZER, P. G., LINDBLOOM, E. J. & EWIGMAN, B, 2000, Using geographic information systems to understand health care access, *Archives of Family Medicine,* 9**,** 971.
49) RADKE, J. & MU, L, 2000, Spatial decompositions, modeling and mapping service regions to predict access to social programs, *Geographic Information Sciences,* 6**,** 105-112.
50) ROEGER, L. S., REED, R. L. & SMITH, B. P, 2010, Equity of access in the spatial distribution of GPs within an Australian metropolitan city, *Australian journal of primary health,* 16**,** 284-290.

51) SCHEFFLER, R. M., LIU, J. X., KINFU, Y. & DAL POZ, M. R, 2008, Forecasting the global shortage of physicians: an economic-and needs-based approach, *Bulletin of the World Health Organization,* 86**,** 516-523B.
52) SCHUURMAN, N., BERUBE, M. & CROOKS, V. A, 2010, Measuring potential spatial access to primary health care physicians using a modified gravity model, *The Canadian Geographer/Le Geographe canadien,* 54**,** 29-45.
53) SHOBA, B. & RASAPPAN, K, 2013, Application of GIS in solid waste management for Coimbatore City, *International Journal of Scientific and Research Publications,* 3**,** 1-4.
54) TALEN, E, 2003, Neighborhoods as service providers: a methodology for evaluating pedestrian access, *Environment and Planning B: Planning and Design,* 30**,** 181-200.
55) TEACH, S. J., GUAGLIARDO, M. F., CRAIN, E. F., MCCARTER, R. J., QUINT, D. M., SHAO, C. & JOSEPH, J. G, 2006, Spatial accessibility of primary care pediatric services in an urban environment: association with asthma management and outcome, *Pediatrics,* 117**,** S78-S85.
56) TERRY, M. & TERRY, D, 2013, The Shortage-Surplus Paradox: A Literature Review of Primary Health Care Accessibility, *Universal Journal of Public Health,* 1**,** 40-50.
57) TOOSI, A., DELAVAR, M. & REZAYAN, H, 2005, Spatial Development Infrastructure Linkages with urban planningand Infrastructure management. April.
58) WAN, N., ZOU, B. & STERNBERG, T, 2012, A three-step floating catchment area method for analyzing spatial access to health services, *International Journal of Geographical Information Science,* 26**,** 1073-1089.
59) WANG, F. & LUO, W, 2005, Assessing spatial and nonspatial factors for healthcare access: towards an integrated app
60) roach to defining health professional shortage areas, *Health & place,* 11**,** 131-146.
61) WONG, L. Y., HENG, B. H., CHEAH, J. T. S. & TAN, C. B, 2012, Using spatial accessibility to identify polyclinic service gaps and volume of under-served population in Singapore using Geographic Information System, *The International journal of health planning and management,* 27**,** e173-e185.
62) YANG, D.-H., GOERGE, R. & MULLNER, R, 2006, Comparing GIS-based methods of measuring spatial accessibility to health services, *Journal of medical systems,* 30**,** 23-32.