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# **Creating a GIS Application for Health Services at Jeddah City**

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**GIS Introduction– CRP 514**

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### ***Abstract***

*This project focuses on the possibilities of using Geographic Information Systems (GIS) for private hospitals. A GIS is used for three main health planning issues which are distribution of health demand, classification of hospital patients and the definition of hospital service area. GIS has several functions and tools that can be used in health planning. One of these functions called network analysis that is used to produce drive-time hospital service area. Also another function, overlay analysis that is applied at the selected hospital to calculate the size of its served demand. Therefore, these functions are used to help health planners on evaluating the spatial distribution of hospital demand and for defining hospital service area. Jeddah city is a case study in this project so; all the produced models can be applied on any private or public hospital in Jeddah city. They can be used to build a spatial decision support system for hospitals in Jeddah city.*

***Keywords:*** *GIS; GIS functions; Hospital demand; Network analysis; Overlay analysis; drive time.*

## **1. INTRODUCTION**

Primary health centers and hospitals are two main types of health care facilities. Primary health centers provide basic health care services and hospitals provide services for specialist health treatment. Also, health authorities have aimed for providing the right service at the right time in the right place but there are many challenges that can be faced on health service to be implemented. These challenges are related to the following:

- The relationship between distances to health services the need for health care.
- Financial status
- Time constrains
- Social inconveniences
- Psychological stress of journey to health services

To explore these challenges, GIS are used by health planners for analyzing and manipulating health data. This project also covers some of health care planning issues that are not explored for Jeddah city which include defining the location and types of health demand and using GIS for manipulating and analyzing the collected demand data. There are several types of geographical analysis that can be made in health care studies. There are several types of geographical analysis that can be made in health care studies. All of these types of analysis can be covered using GIS tools and analytical functions.

### ***The Purpose***

- The purpose of this project is to create a GIS application that covers some of health issues related to hospitals at Jeddah city, Saudi Arabia. This application also includes several important factors related to hospital planning, distribution of health demand, classification of patients and defining hospital service area.
- This project also focuses on the advantages of using GIS in hospital planning and management.

## **2. METHODOLOGY**

### **2.1. Study Area**

A case study in this project is Jeddah city. It is located on the western coast of Saudi Arabia by the Red Sea. A population of this city is over 2.9 million people that represent about 14% of the total population in Saudi Arabia.

#### **Health facilities**

Health facilities at Jeddah city are divided into two main types. They are called public and private health facilities.

#### **Public Health Facilities**

Public health facilities are included the following:

- 72 health centers
- Seven hospitals

They are owned by the Ministry of Health and by other governmental authorities.

#### **Private Health Facilities**

Private health facilities are included the following:

- 29 hospitals with 2836 beds
- 151 clinics at different parts of the city

The two types of health facilities are faced different planning issues which include defining the spatial location of health demand, identifying health access, and service areas that can be cured with GIS techniques. Therefore, this project has selected one major private hospital. This hospital is selected by many factors. These include the following:

- Accessibility to health demand data
- The types of health services that are available at this hospital.
- All the planning issues are related to the remaining hospitals of Jeddah city.

This hospital includes:

- Capacity of 300 beds

- 120 doctors
- Difference department (family medicine, gynecology, pediatric department)

## **2.2. Research Issues and Analysis Techniques**

This project has focused on three major hospital planning issues. They are related to defining health demand location, classification of health demand and defining hospital service area. These issues are analyzed by using GIS because it has several techniques and functions that can be used for health service planning. These functions can be applied on different health related issues.

### **2.2.1. Defining Health Demand Location**

GIS has different tools that can be used for defining any location on the map. One of these tools is called on-screen digitizing which is used to define health demand location at Jeddah city. Therefore, ArcGIS software is used to define all hospital demands location. All these data are collected on city districts level.

### **2.2.2. Classification of Health Demand**

ArcGIS has several applications. One of these applications is called Arcmap which is used to digitize the GIS coverage which is using polygon-drawing tools that are located at the editor menu. It can be achieved in some steps. After creating the required city district polygons, the following step was to enter the collected attributes about hospital demand which include number of patients, age–sex and hospital utilization types (emergency clinics patients, specialized and general clinics patients and admitted patients).

### **2.2.3. Defining Hospital Service Area**

This issue includes two main GIS techniques which are network analysis and overlay analysis.

#### **2.2.3.1. Network Analysis**

This technique is the first main GIS tool that is considered to be very useful in health care studies. It can be used to determine the shortest path between location X and Y such as routing or path finding which determine the minimum cost path through a network between a given origin and destination. In this project, this function can be used in the health studies for defining the shortest path between patient location and health centre. This path can be presented to the ambulance driver together with the direction file that describes step by step the best routes for getting to such patient fast.

#### **2.2.3.2. Overlay Analysis**

This technique is used at different studies and for many purposes. It manipulates spatial data organized in different layers to create combined spatial features. This data will be stored by GIS that can be retrieved and overlaid one on another. Therefore it will be easy to determine which sites are most suitable for development of variety types. GIS software has several overlay analysis functions. This overlay function creates a new output coverage that has only city districts that falls inside hospital service area. Overlay analysis functions has several potential uses for. One of these uses is related to defining health demand of a selected service area and which is covered by the presented study.



### **3. RESULTS AND DISCUSSION**

The created application covers three main demand related issues which are spatial distribution of health demand, types and classes of health demand and accessibility of hospital location.

#### **3.1. Distribution of Hospital Demand**

Most hospitals used Management Information Systems (MIS) to save important information about patient number or recording file and to check the medical history of every patient. One of the main limitations of MIS is very weak to determine locations of these data. During collection data in Jeddah, author found that health administrators who are used to work with MIS are still not realize about the importance of using Spatial Information Systems (SIS) with their patient's data and did not realize the benefits of using GIS or SIS at their organizations. This project has created a GIS application that can be used as a guide for identifying some of the benefits. One of the main issues related to health demand is regarding defining its location within the city. GIS has many functions that can be used for identifying location of any feature. For example, Geocoding is a GIS function that can be used to create points features on a map from a table having  $x, y$  coordinates of any addresses. Also, On-screen digitizing is another GIS function that can be used to draw different tools such as point, line and polygon tools for identifying feature location. In this project On-Screen digitizing has been used for identifying hospital demand location. Therefore, GIS coverage is used to determine location of every city district. Then the attributes data of health demand are entered as records in the coverage table. After building the database of health demand, GIS graduated color function has been created to identify spatial distribution of patients. This function subdivides numerical data into a number of classes. There are five main methods for classifying numerical data in GIS. These are natural breaks classification, defined interval classification, equal interval classification, quintile classification and standard deviation classification. Each one of these classification methods can be applied on health demand data. For example, the natural break method has used in this project to minimize the variance within class and maximize the variance between classes.

- **Results**

- Hospital demand comes mainly from the northern city districts (which are close to hospital location)
- Very little demand for this hospital coming from the southern city districts. as shown in .Fig.1.

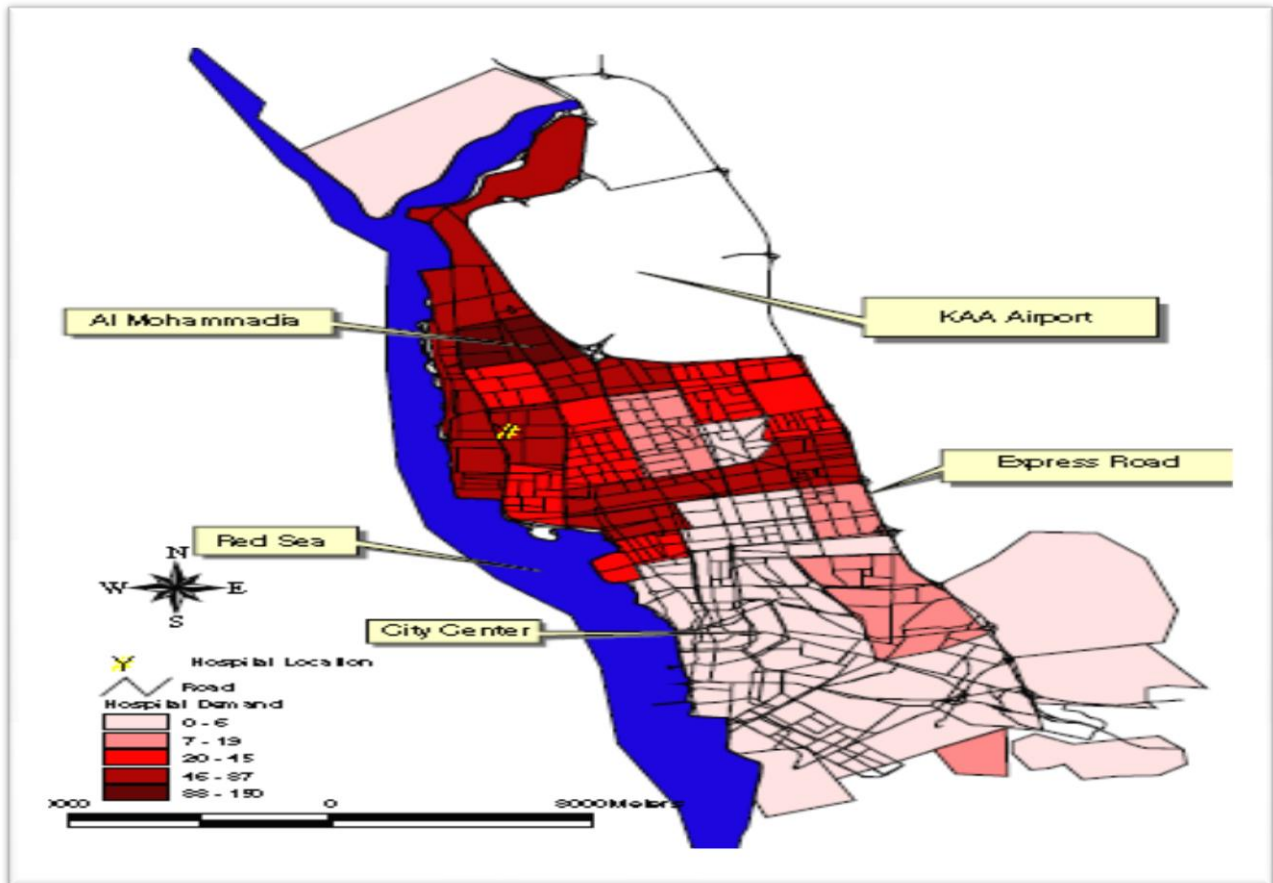


Fig.1. distribution of hospital demand

### 3.2. Types of Hospital Demand

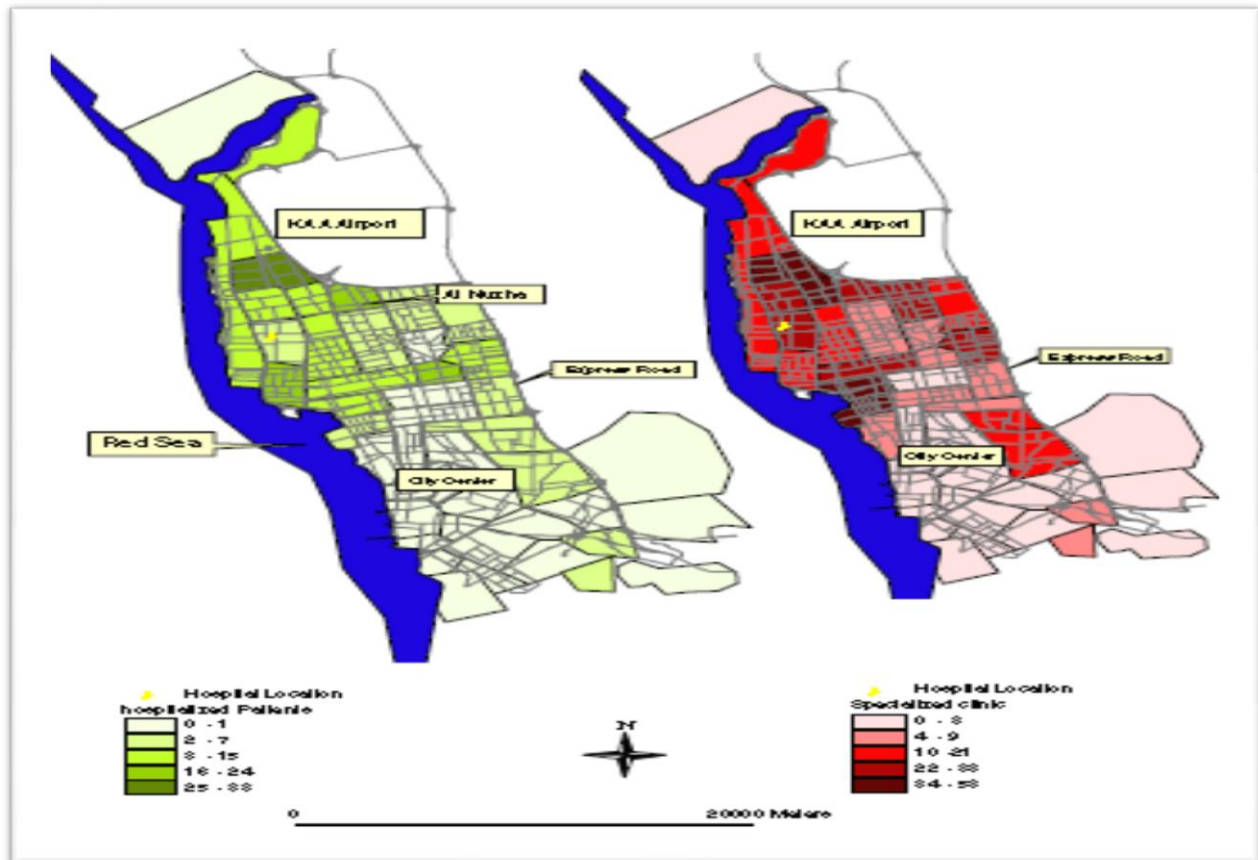
This section is related to having a clear idea about the classification or types of health demand. This will be very useful for health planners for relating demand types with health supply. For example, if the health demand is related about pediatric or diabetic clinics, then these clinics should match that demand. There are two types of hospital demand classification:

## ➤ Health Service Utilization

This type of hospital demand classification divides patients into three main hospital groups. These are called:

- General /specialized clinics patients
- Emergency clinic patients
- Hospitalized patients.

The general and specialized clinic patient group is related to those patients that use this hospital for specific health treatment. The hospitalized patient group is referred to patients who were admitted for health care treatment in the same hospital. Also GIS aids to show more than one attribute data in one view. This tool is called multiple data classification method that allows using two renders at once on a feature layer as shown in Figs. 2 and 3. For example, Alnuzha or Almohammadia that located north of the city have high-hospitalized patients and also have the same high figures about emergency clinics and general specialized.



Figs.2. Classification of hospitalized and specialized clinic patients

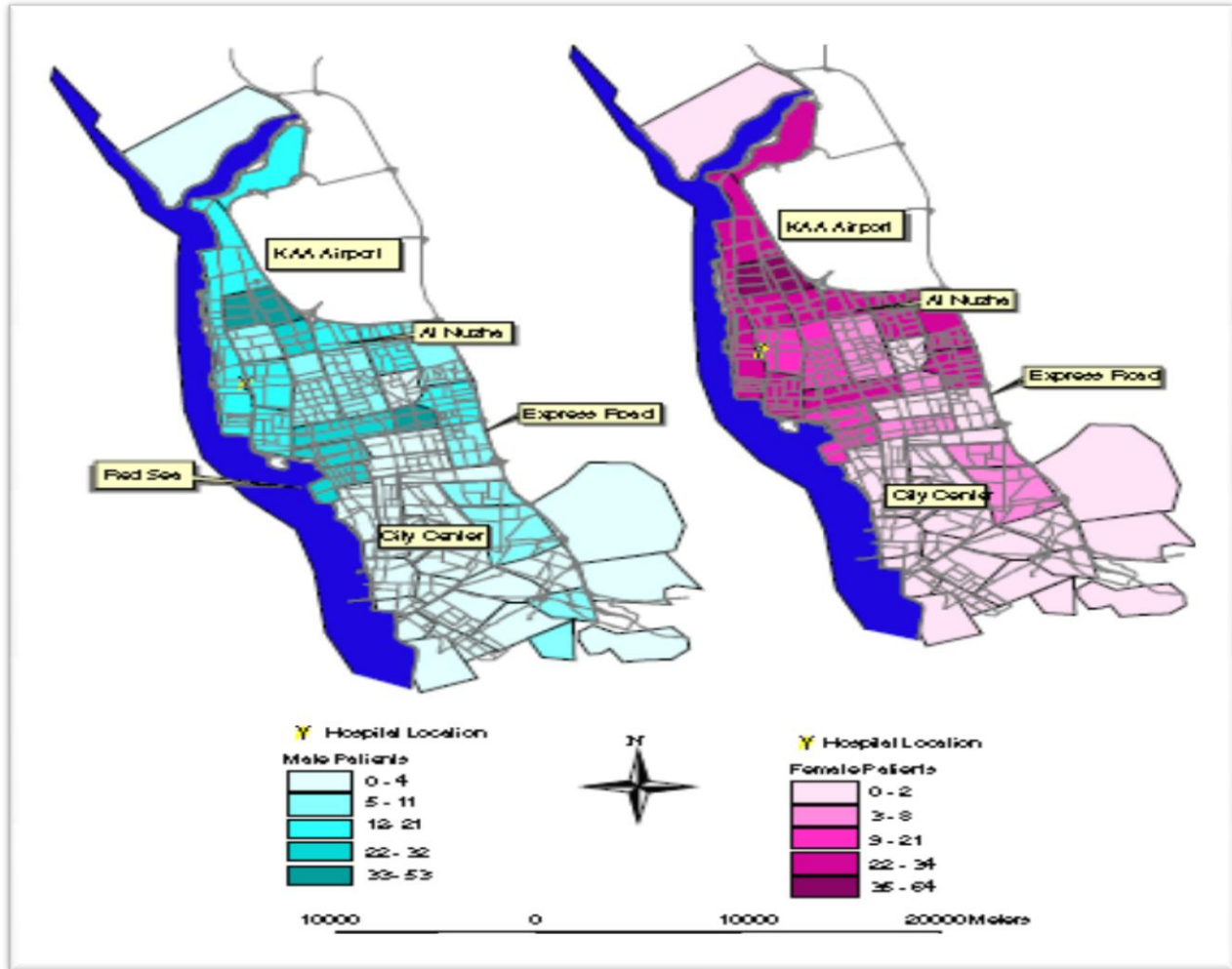


Fig.3. Classification of hospitalized and emergency clinic patients

### ➤ Demand Gender

This type of hospital demand classification is concerned on patient gender (male and female). These data can be used by health planners to identify the required health services for male and for female patients. For example, female patients who originated from the western Jeddah city districts and male patients are distributed at different districts with different amounts as shown in Fig. 4. In the other words, the areas that are located near the hospital site have more female than male patients. This means that hospitals that have female patients should be provided with more staff, health services and facilities than male.

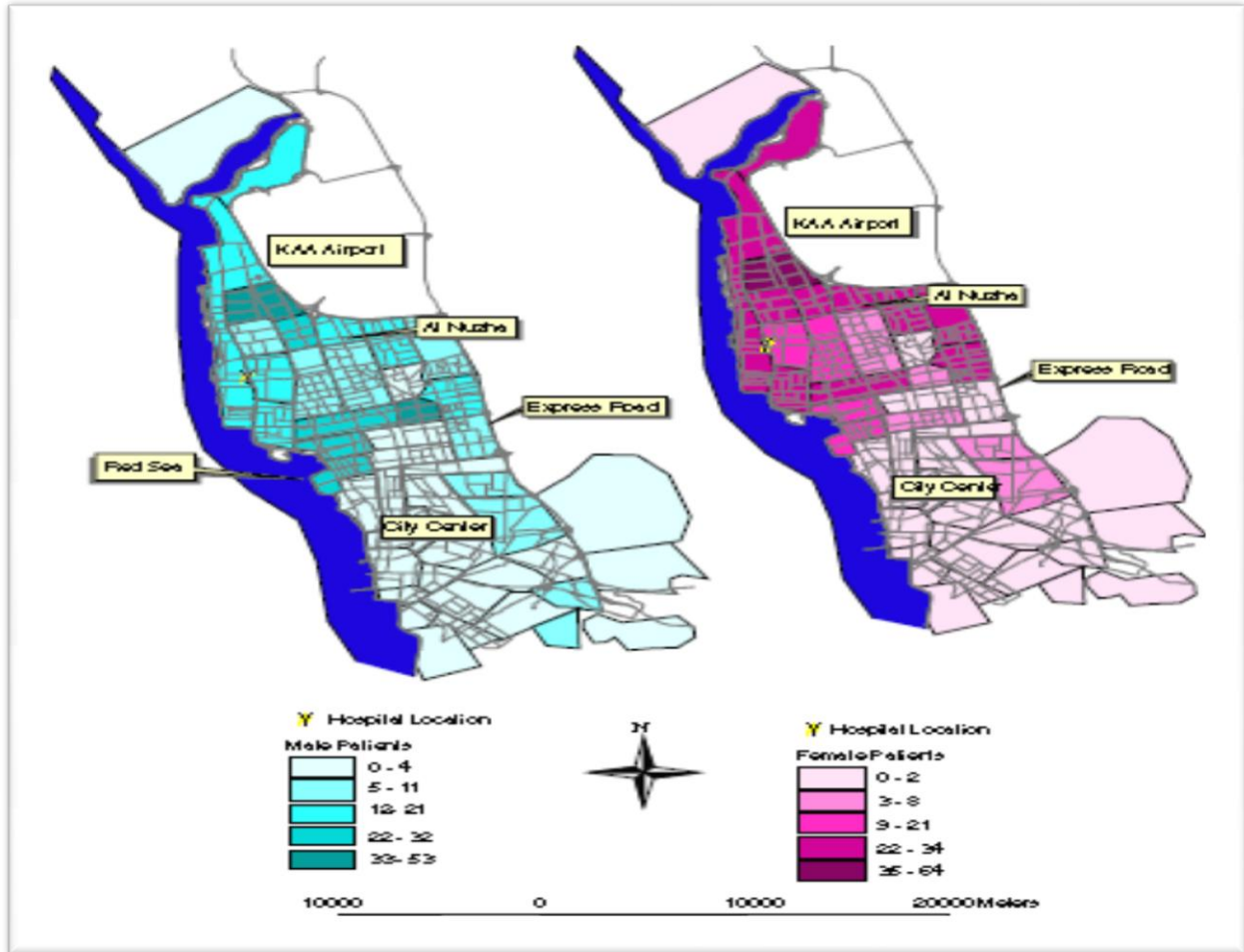


Fig.4. Classification of male and female patients

### 3.3. Hospital Service Area

Health service area has several methods that can be describe by several health studies such as travel time method. These studies have concluded that distance to health location is the main factor for identifying health service area. For example, to select hospital service area for all Jeddah roads, travel time is used for producing a 15-min drive-time area. By using ArcGIS software, it will be easy to select all cities that occur within the 15-min service area of the selected hospital. So that all districts which are selected should be studied and monitored for the purpose of hospital marketing and utilization. Fig. 5 presents districts like Alzahra and Alnahda are the main demand zones for hospital service Area.

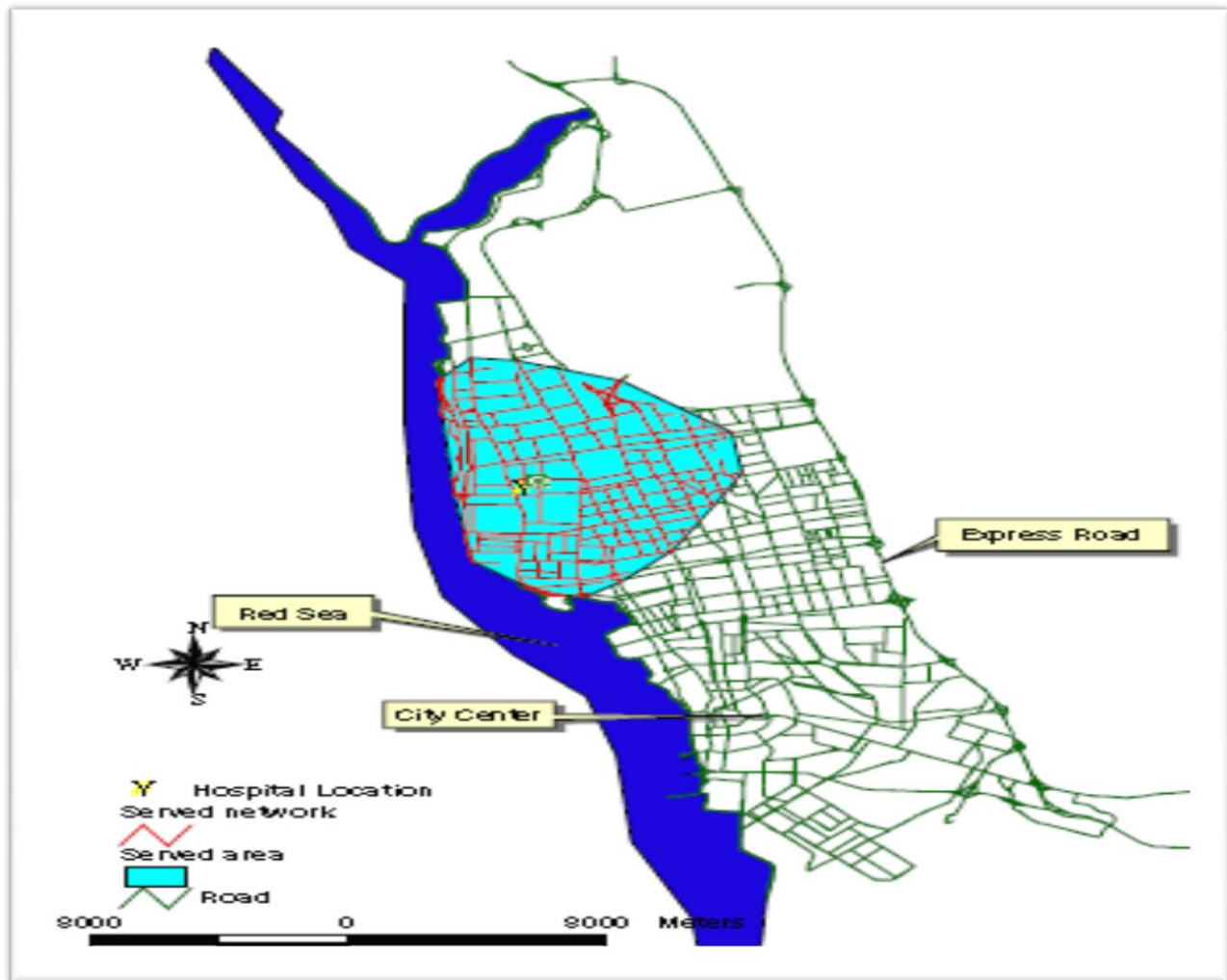


Fig. 5. 15-min drive-time service area

Overlay functions of GIS software can be used to discover the amount of population that lives inside the resulted service area. By the way to apply these functions input coverage and the overlay coverage should be created. Input coverage presents census data and overlay coverage represents the area of interest such as service area. Using these functions, portions of the input coverage that occur inside the overlay coverage will be saved as new output coverage. Fig. 6 shows two main coverages were used to produce these outputs which are:

- Hospital demand shows all hospital patients within Jeddah city.
- The 15-min drive-time service area.

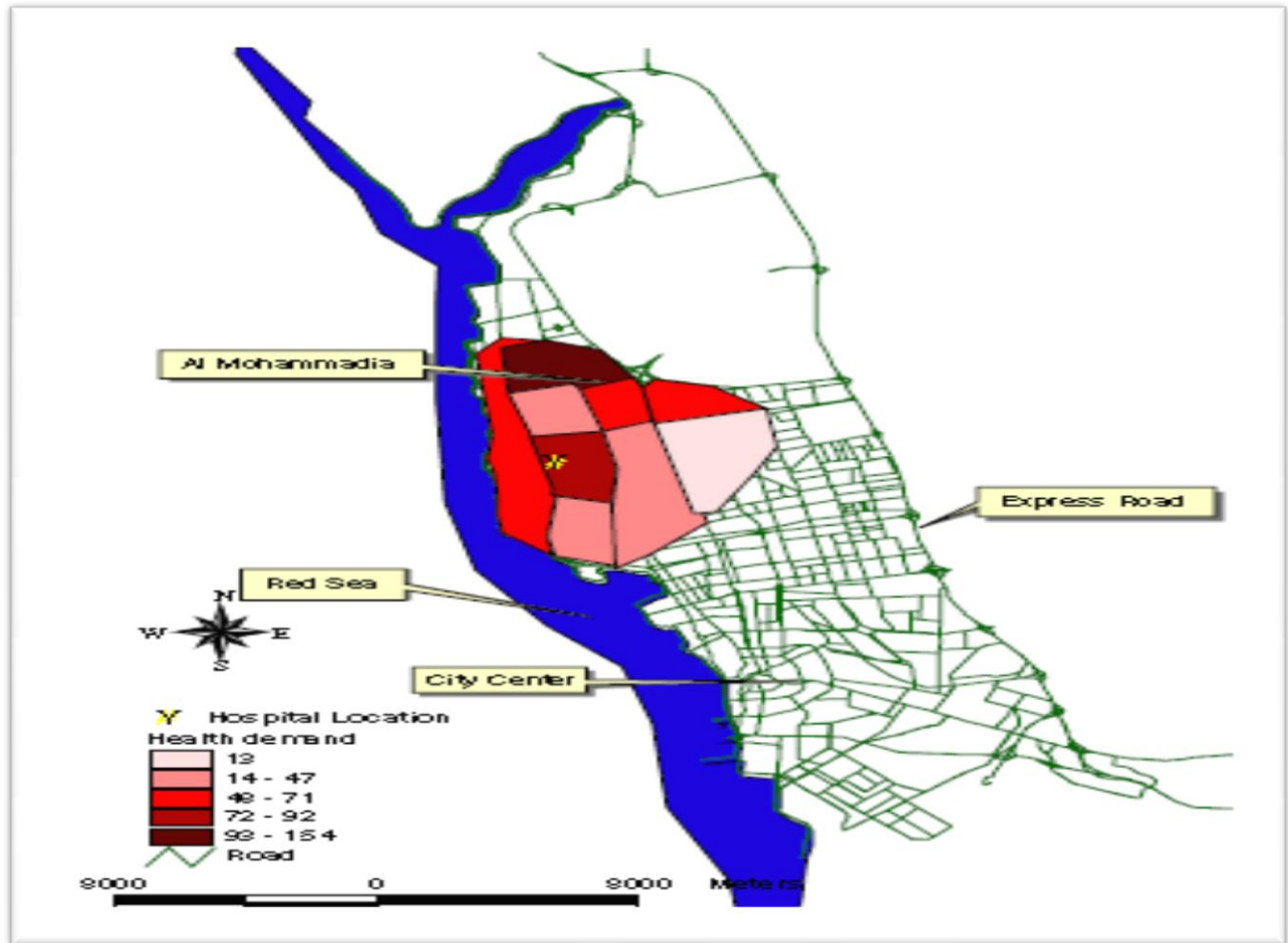


Fig. 6. Distribution of served health demand

The results are 580 patients who use the selected hospital and live 15 min away from the hospital where these patients represent about 60% of all hospital demand. It can be seen that most of health demand to the selected hospital come from the nearest residential areas around the hospital location. Also,

One of the other possible usages of the resulted travel time service area is related to evaluating the share of hospital demand and the market values of hospital. This is called the market penetration of health services.

This project also focuses on evaluating the share of hospital demand and the market values of hospital. This is called the market penetration of health services. We can get the penetration index by dividing existing size of patients over number of households living inside hospital service area and multiplying the result by 100. Fig. 7 presents the distribution of hospital market

value. The result of the distribution of hospital market views some districts located inside hospital service area but are not producing high demand such as Alsalmah, Albawadi and Alrawdah districts.

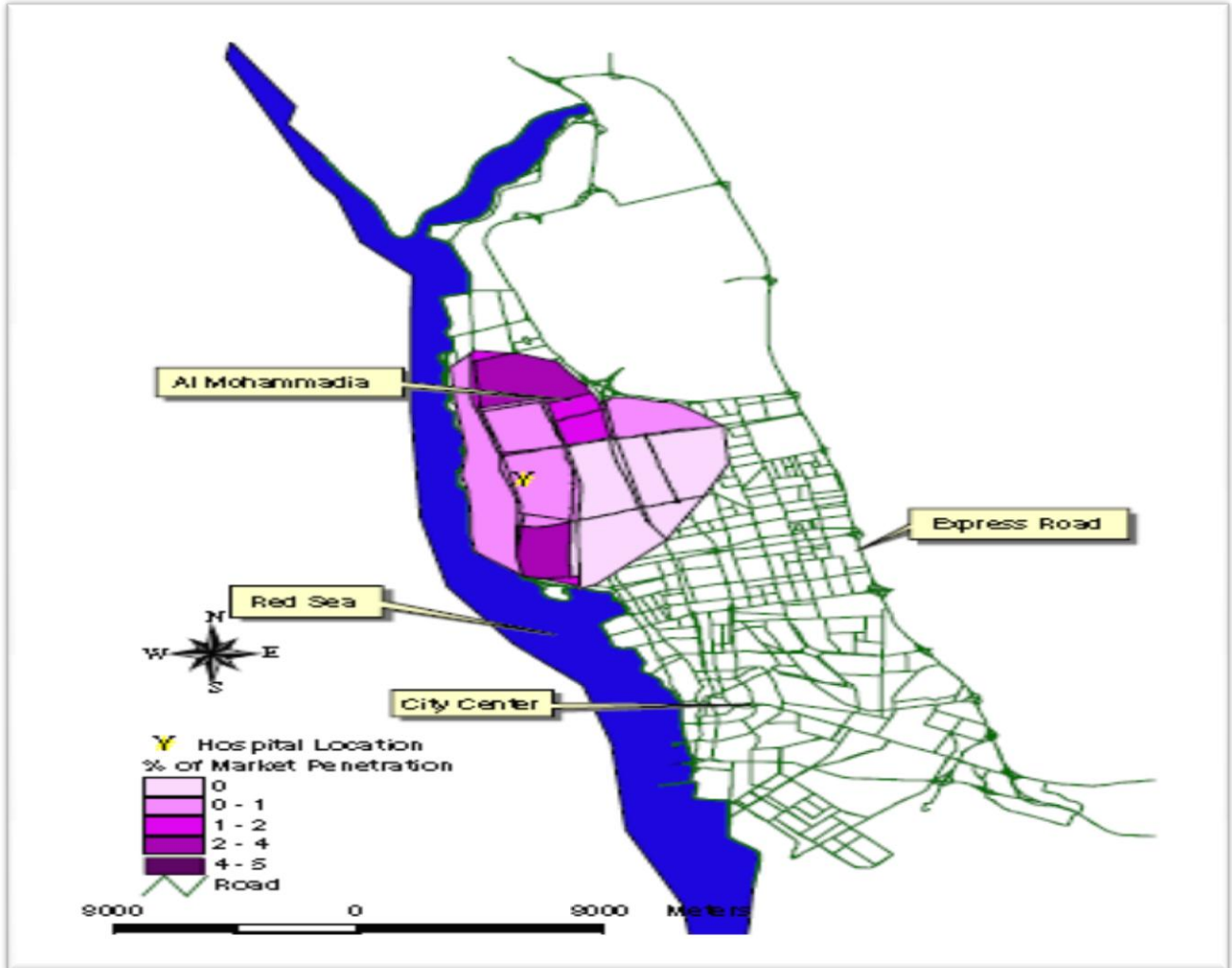


Fig. 7. Market penetration of private hospital



## **4. Conclusions**

This project explains application of GIS for hospital facility planning in Jeddah city. This study includes three main hospital issues that are location of health demand, types of patients and the extent of hospital service area. Each one of these issues is covered using several GIS functions. All of these functions are used to define all hospital demand location and produces an output. This output can present all districts of city that are producing remarkable demand to the selected hospital. Another important issue is classification of health demand that is described by several health studies. Therefore, Patients are classified based on their usages for the selected hospital. For example, Alzahra and Alnahda districts have high hospitalization rates. These result based on health demand classification. The last main issue is related to defining hospital service area. ArcGIS software is used to produce a 15-min drive-time service area for the selected hospital. Also, these results are used to define patients living inside hospital service area.

### ***References***

1. Murad, A. A. (2007). Creating a GIS application for health services at Jeddah city. *Computers in Biology and Medicine* 37(6): 879-889.
2. A. Murad, Creating a GIS application for local health care planning in Saudi Arabia, *Int. J. Environ. Health Res.* 14 (3) (2004) 185–199.
3. A. Murad, Using GIS for planning public general hospitals at Jeddah City, *J. King Abdulaziz Univ.—Environ. Sci.* 2004, in-press.
4. L. Roovali, R. Kiivet, Geographical variations in hospital use in Estonia, *Health & Place*, 2006.
5. H. Jordan, P. Roderick, D. Martin, S. Barnett, Distance, rurality, and the need for care: access to health services in South West England, *Int. J. Health Geograph.* 3 (21) (2004) 1–9.
6. A GATRELL & M SENIOR, Health and health care applications