

## A GIS Framework for Sites Selection of Health Care Services in Urban Areas

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### Abstract

The aim of this paper is to select sites for health care centers in urban areas using GIS by suggesting a framework for selecting the best locations proposed for new health care centers, also focuses on access to health care centers, geographical distribution, and managing various health care (HC) facilities in accordance to the criteria and standards of the Ministry of Health and Population (MOHP). This paper relied on program ArcGIS 10.6 to determine the geographical distribution, determine the nearest neighbor, the intermediate location, the standard distance and Inclination, the buffer zone and the intersection, and analysis the road map to discover the nearest health care center.

The proposed methodology involved many procedures, based on using satellite images, GIS, demographic, health data. The obtained results showed that there was shortage in PHC centers in the selected study area. As the research concluded that, there are many other governorate and private health service, which should be studied in details and from using this framework are finding the best locations for health care services centers by identifying the nearest access to health care centers and the geographical distribution of health care services.

**Keywords:** *Geographic Information System (GIS), Health Care Services (HCS), Sites Selection, Spatial Analysis.*

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### 1. Introduction

GIS is used in every aspect of our daily lives. Digital mapping has become an indispensable tool in solving many different problems. Digital maps help organizations achieve a great analytical and operational advantage. GIS experts help make use of the site to make appropriate decisions and extract and integrate large sets of spatial data into useful information that provides a new perspective and new problem-solving techniques, and plays a role in spatial analysis [1][2]. A GIS is a powerful tool in understanding and describing spatial relationships and behaviors of systems and organizations. It is commonly used for topological mapping, infrastructure network modelling, environmental and climatology, and other geo-location based activities [3].

### 2. Implications of GIS in Society and Related Issues

Public services are essential for residents of any city around the world in general, and in developing countries in particular. Governments begin to review the provision of public services to enhance their efficiency and quantity to meet the needs and expectations of the public. It recognized that improving the efficiency of basic public services for residents was one of the key ways to promote sound human settlements, good health and the provision of decent and decent living conditions[4].

Access to health care services is one of the main goals of any Ministry of Health in the world and is aimed at improving access to health care services and the ability of people to

access health care services, which is a prerequisite for effective participation in community activities [5].

Health care is one of the mandatory services provided to the population at the community level and targets better health outcomes and greater equity in health and health care, which are the key to shaping healthy communities, improving and maintaining people's health. The provision of quality health care services is important as it contributes to improving the development [6].

Some studies focused on the use of geographic information systems to evaluate the performance of urban transport systems of road design, highway mapping, accident data analysis and traffic as GIS provides transport planners and designers with a means to analyze, sort and use land [7]. One of the most reasons for the use of GIS in health care is the recognition of the factors of spatial health-related and limited resources that need to be addressed health needs in the spatial domain in order to determine what is required in a position to get rid of it instead of looking at the problem as a whole where the geographical information systems is a system to solve the problems of planning and Information Management [8].

The objective is to reveal current challenges in geographical information systems related to issues of access to urban areas in the context of health care. So, to understand how to use geographic information systems by policy makers and other decision makers in the field of health care and address health disparities to explore the health disparities of Geography, planning and evaluating health care services and strategic planning health care management [9].

## **2.1 Distribution and Accessibility Issues**

There are multiple problems with spatial distribution and access to health care facilities. There is a study have focused on the application of geographic information systems as a useful tool for solving these problems and decision-making. These studies aim at guiding the equitable and spatial distribution of health care facilities [10]. The application of GIS technology for the spatial distribution of some public services within the city of Makkah Al Mukarramah, Saudi Arabia. These include education, health, security, religion, commercial and sports services.

In addition, there is a study addresses the geographical access by varies depending on local transport conditions. Physical access is calculated as physical distance, in kilometers, access to health services is determined by demand, health services are provided, and inequalities in access to health services are determined by the unequal distribution of health care services and inadequate Health care resources, which determine the long distance in which patients travel to health care, suppliers and the poor quality of transport networks, which cause time to travel to health care [11]. Another study focused on the assessing and interpretation of the population's accessibility indicators to health services and health care needs an index inBotosani, in the period 2000-2013, in order to highlight the relationship between health care needs and the accessibility tohealth care services[12].

Some researchers have focused on the use of GIS as a decision support tool based on the capabilities of commercial intelligence and build spatial intelligence and predictive analytical approaches. The proposed approach will address the spatial problem facing decision-makers in the health sector. The proposed approach will cover three major health-planning issues [13]. Where some other researchers have taken up the issue and developed a new method to determining hospital selection criteria in an efficient and reliable way. It is based on

environmental indicators and multi-standard decision-making methods. The technique combines standards and sub-standards through the analytical process of the hierarchy and the interpretation of information obtained from experts during the decision-making process. (AHP)[14].

## **2.2 Disease Surveillance and Monitoring Issue**

GIS plays an important role in mapping epidemiological surveillance of disease management in health information and rapid epidemiological events of disease and infection, age, sex and disease used to determine spatial modeling and disease targeting, health monitoring, surveying, design, sampling and disease control programs, And disease prediction [15], [16].

Some researchers have focused on mapping trends and models by utilizing the basic mapping capabilities of GIS. Shows that with what GIS offers in health research services. It is possible to create spatial maps and explanations that are not complex and do not require Private data, personnel or systems. However, they provide a great insight into the investigation, evaluation, improvement and policy and planning issues in health [17].

Health geography is the field of research that integrates geographic techniques into the study of health and the spread of diseases such as the distribution of health services. To this end, it aims to provide an understanding of health problems and improve people's health based on the various geographical factors that affect them. As a result, mapping plays a major role in this area [18].

## **3. Guidelines and Standards of PHC Centers**

The selection of standards plays a critical role in health care service construction and management and helps to improve the allocation of medical resources, urban and rural health and services coordination, facilitate access to health care, reduce rescue time, and meet and promote quality of life [19].

Despite the advantages of GIS but facing challenges in their performance, for example, the lack of adequate and correct GIS data remains the main problem. GIS works more efficiently and helps to plan and make different decisions to solve various problems in all areas [20].

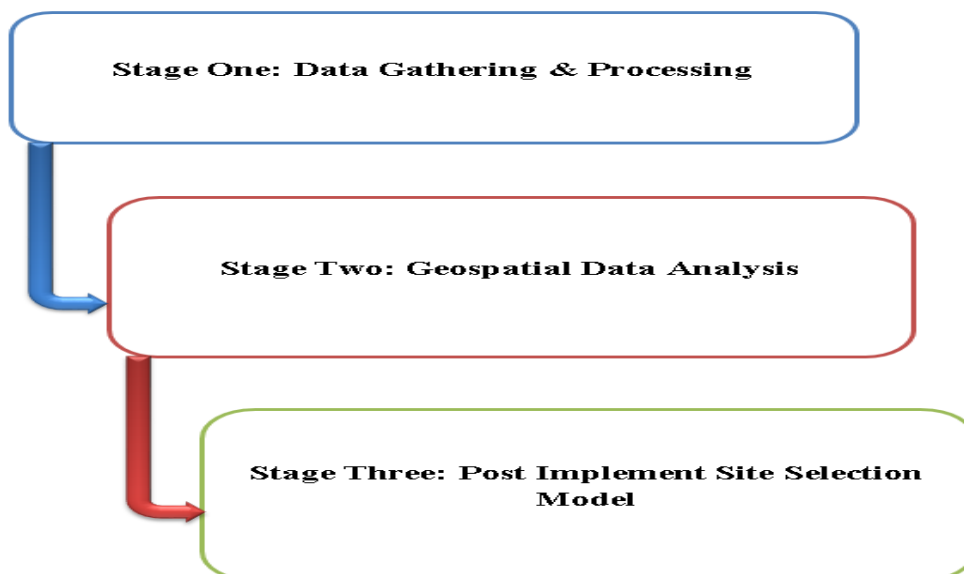
The challenge and problems of the user policies and strategies to improve urban life. About the increasingly important role of service activities in the urban system, where change is necessary new in the direction of Urban Planning in terms of distribution centers to urban services and how to access them [21].

Urban areas are an important issue in the delivery of humanitarian services to both public policy decision-makers and planners in urban areas where equitable access and easy access to health care facilities is considered to be one of the main goals of many health care systems[22], [23].

## **4. Initial Implementation and Model of Site Selection Framework**

The proposed framework begins with data collection as the first phase, data processing, data layer, and data analysis for the last phase. Tools, which are used in this paper, are ARC GIS 10.6 Google Earth 7.1, AutoCAD 2017, Microsoft Excel 2017, and KML2KML.

The administrative area map gathered from the Central Agency for Public Mobilization and Statistics as the base map, which contains information about the number and addresses of the health care centers. The proposed framework has three phases shown that in fig 1



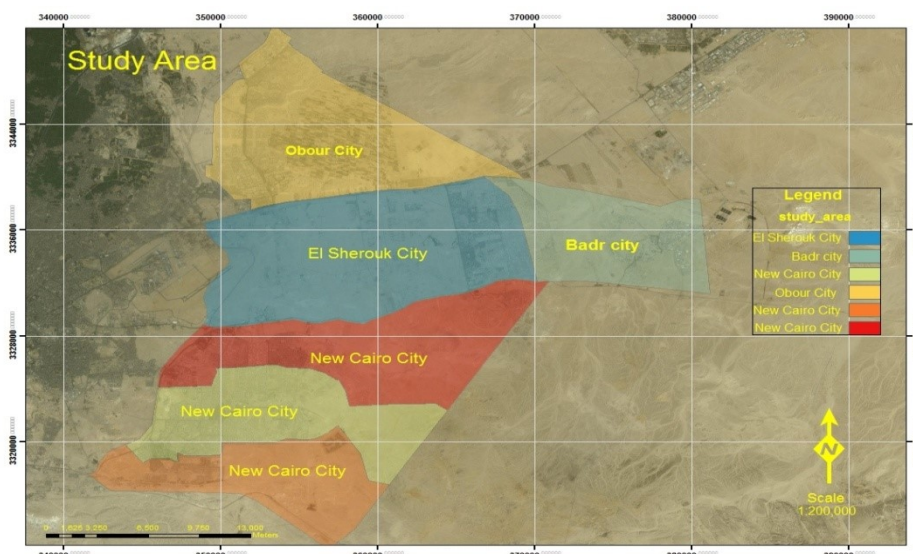
**Fig.1**The proposed Framework for Site Selection of Health Care Services

**4.1 Stage One: Data Gathering and Processing**

In this stage, this paper provided what data is collected and what is useful data. Data collection is the most important stage in the framework process that researchers collect data to help study. It is the main source, which forms the starting point of any scientific research effort. The stage of data collection is a stage that depends on the other stages.

A) Study Area: The geography of Egypt relates to two regions: North Africa and Southwest Asia the below figure, shown the study area by using Google Earth program.in fig 2.

- El Sherouk.
- Obour.
- New Cairo.
- Badr

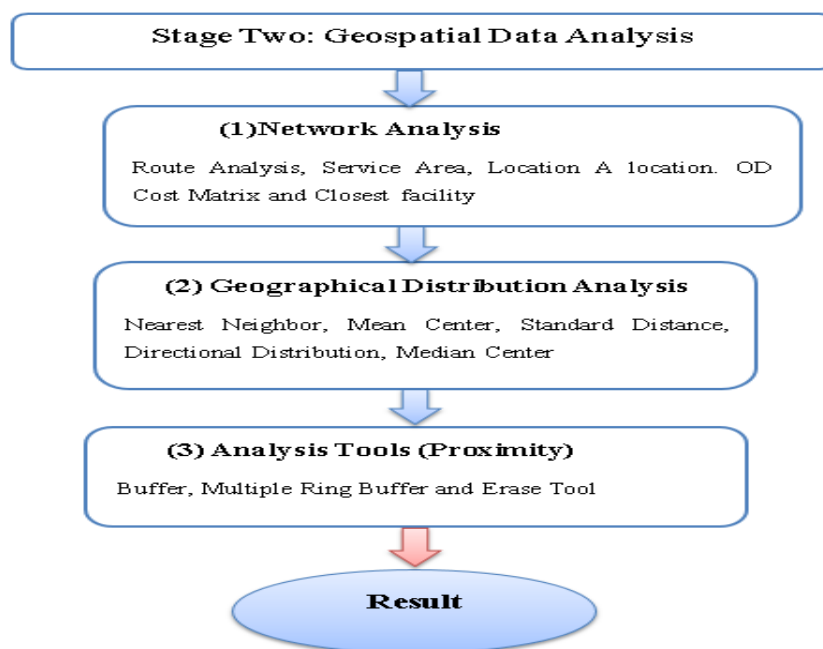


**Fig.2.**Study Area in Google Earth

**B) Data Processing:** In this step, the spatial data and descriptive data are merged together and form new GIS database. This information will be used in next step i.e. data analysis. The data processing includes five operations, defined building geodatabase, Coordinate Systems, Transformation data, convert AutoCAD to Geodatabase and convert from KML to layer in program Google earth, and define Map projections, and Topology Spatial Adjustment.

#### 4.2 Stage Two: Geospatial Data Analysis

The processing of data within GIS depends mainly on the tools for spatial analysis in Arc GIS 10.3. The data analysis phase is an important stage and includes analysis that helps us reach the objectives of the paper such as Network Analysis, Analysis Tools (Proximity) and Geographical Distribution Analysis. Shown in below fig3.



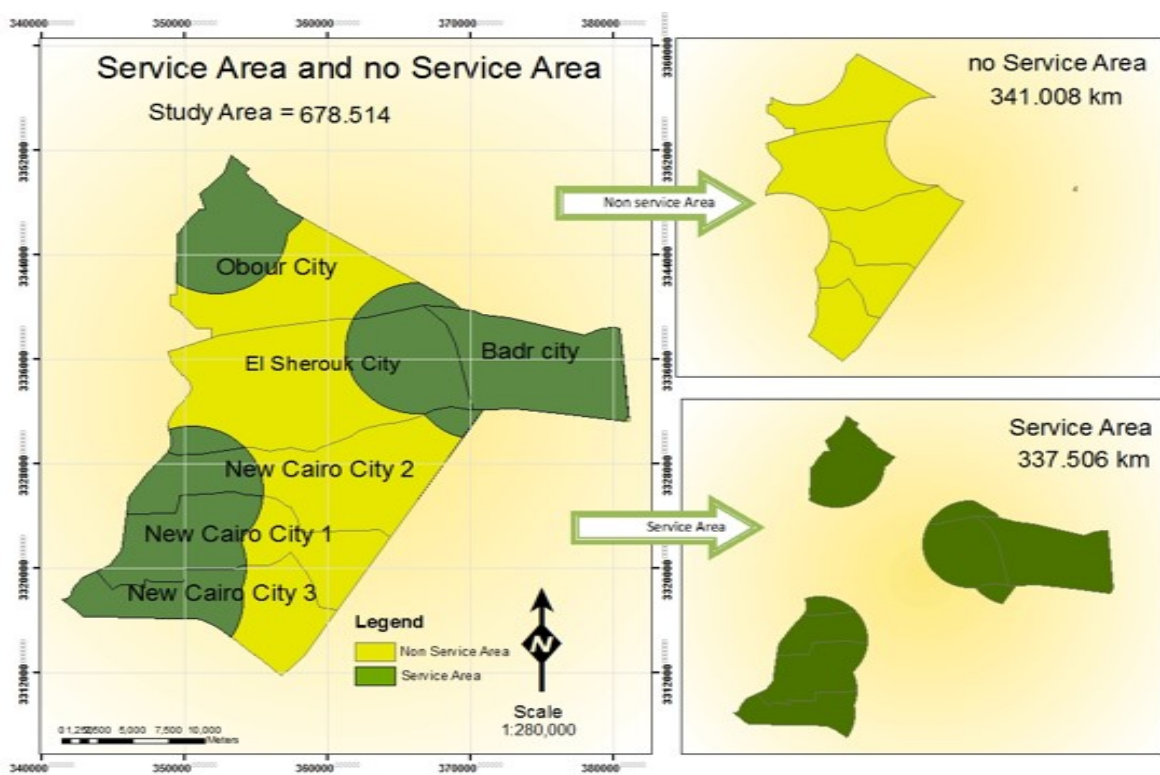
**Fig.3 Stage Two: Geospatial Data Analysis**

- A) Network Analysis:** The main objective of the network analysis is to know the reality of the roads in the study area as it will help us to choose sites for health care services. The road network is one of the infrastructure services of which the state is most concerned. It is the most important factor in the development of countries and the provision of security and strength to it.
- B) Geographical Distribution Analysis:** Measuring the distribution of a set of features allows you to calculate a value that represents a characteristic of the distribution, such as the center, compactness, or orientation. You can use this value to track changes in the distribution over time or compare distributions of different features. In geographical distribution, in this paper adopted the following methods: 1. Average nearest Neighbor Analysis (ANN), mean center, and standard distance.

**C) Analysis Tools (Proximity):** For feature data, the tools found in the Proximity toolset can be used to discover proximity relationships. These tools output information with buffer features or tables. Buffers are usually used to delineate protected zones around features or to show areas of influence. Buffer and Multiple Ring Buffer create area features at a specified distance (or several specified distances) around the input features. The benefits of GIS in this process is that it allowed for generating the buffers required for each health care center and identification of the different roads located inside the impact area

The map shows the serviced areas and the underserved areas. It shows that the areas that are not serviced are much larger than the areas served shown in fig4.

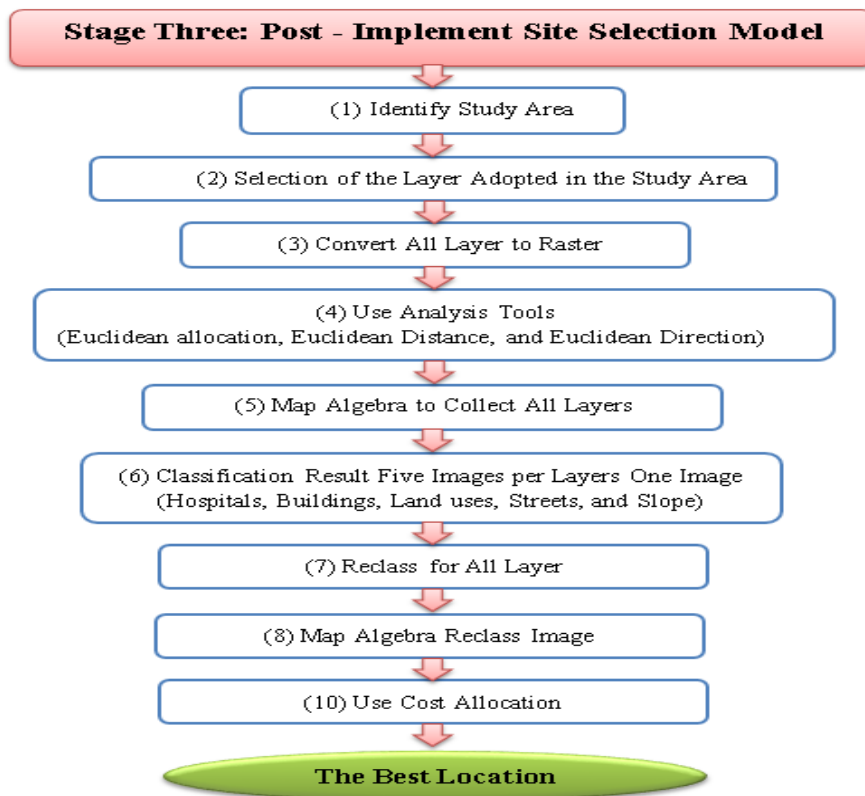
- Study area = 678.514
- No service area = 341.008km
- Service area =337.506km



**Fig.4 Service Area Vs. No Service Area**

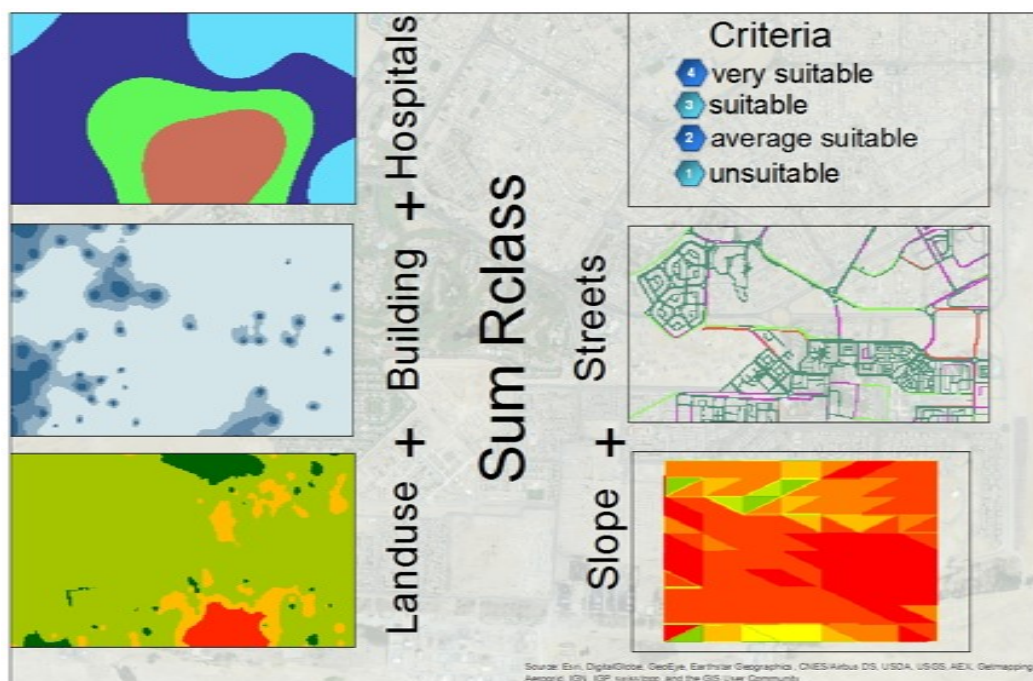
### 4.3 Stage Three: Post Implementation Site Selection Model

In the third stage, in this paper began by selecting the site analysis for the study area (new Cairo section III) in Egypt and using the tools spatial analysis of GIS based on the necessary standards to the choice of sites for health care services. And In this paper offered 10 basic steps for selecting sites for health care services as each step contains spatial analysis tools in the GIS environment based on the Arc GIS 10.6 program in below figure.5



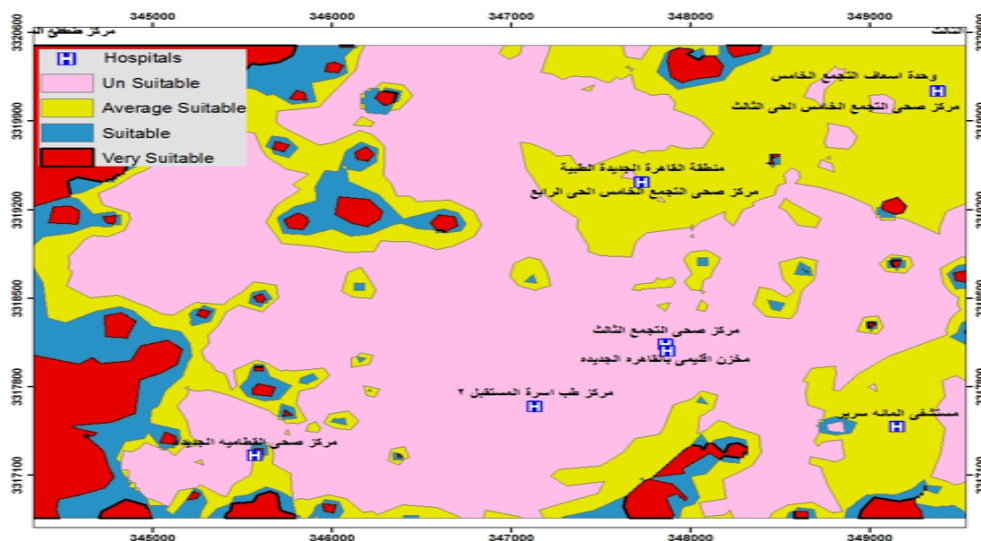
**Fig.5 Stage of Site Selection Model**

In this paper collected the data from different layers, each layer had its own data and gave each layer that own importance data such as, land use layer, street layer, hospital layer, building layer and slope layer in fig .6.



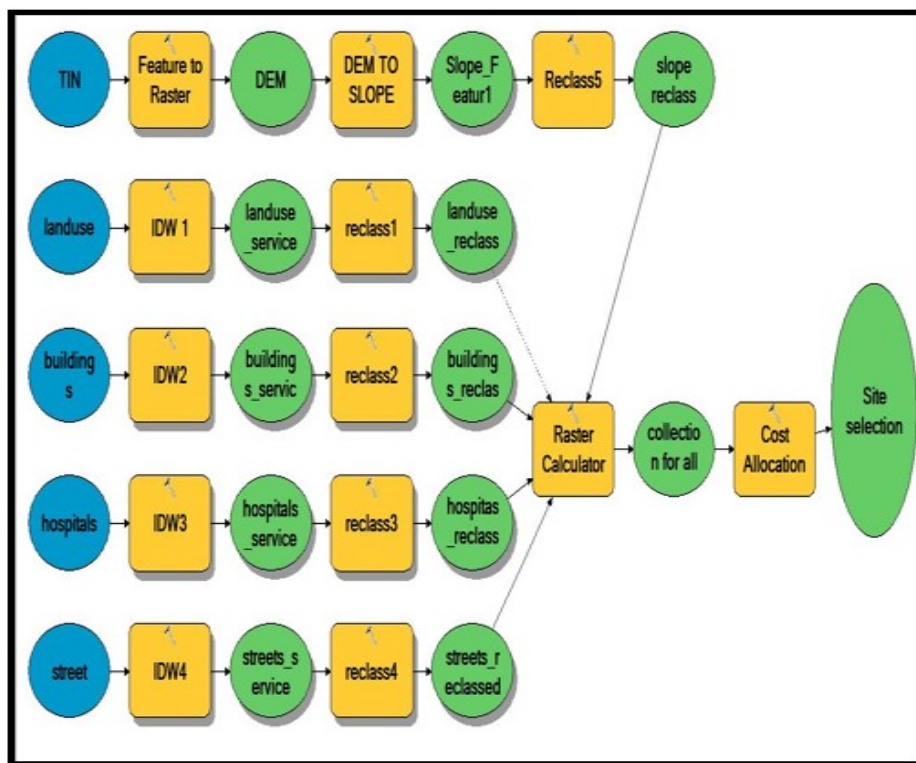
**Fig.6 Sum Reclass Layers Tool**

The map shows us the choice of the best sites for health care services in study area and the map identifies the unsuitable areas, average suitable areas, suitable areas and very suitable area shown that in fig .7.



**Fig.7 Best Health Care Services Sites in Study Area**

This model builder is based on this paper, a model builder tool is GIS-based methodology for sites selection of health care services, and it is a visual programming language for building geoprocessing workflows. Geoprocessing models automate and document your spatial analysis and data management processes. In addition, makes these tasks faster, easier, accurate and automated in fig 8.



**Fig.8 Model Builder for Sites Selection of Health Care Services in program ARCGIS 10.3**



## 5. Results

In this paper, we showed the access to a spatial GIS information, land-suitability analysis, buffer-zone analysis, and location-allocation analysis. These analyses will provide a unique platform to identify and measure accessibility to health care facilities in Egypt, which would help the planners to make better quicker decisions with cost much less than all other methods, and it will make the health care facilities database more reliable, and data can be retrieved for analysis at any time.

The most important results of this study were the bad distribution of health services, which led to the difficulty to manage these services. As there are areas in urban regions, which have health care services and others do not have, so that health care facility should be provided to those deprived areas.

This paper has applied the GIS techniques to analyse the geographical distribution and found that the distribution is random irregular and serves few citizens and this resulted that there are no balance between the administrations of the services; the planners and decision makers should consider the obtained results to achieve fair and better distribution of public services.

The study showed that the non-serviced areas in the study areas are larger than the areas served. Therefore, we need new health services centers in the underserved areas where the study area is 678.514 km and the areas served 337.506km and the un-serviced areas 341.008km

## 6. Recommendations

- Re-Consideration of the distribution of health care services and construction a new hospital in non-serviced areas.
- Using the framework as a model of planning for future in all sectors as it helps to choose the best sites, and can be used in the health, education, industry, transportation, and new urban communities, where they can provide a wide range of conveniences to urban geographers and planners.
- Using of GIS as integrated tool to measure the distribution of health services sites according to the population distribution and their density as required providing for the effort, time and money.

## 7. Conclusion

GIS have also become an essential tool in the mapping of epidemiological information, disease surveillance, health monitoring, surveying, sample design, disease control programs, disease prediction and, more importantly, an important decision-making tool for monitoring public health diseases and monitoring disease control programs providing a set of guidelines for decision-making and planning towards the achievements of the health care management.

In this paper, we showed the access to a spatial GIS information, land-suitability analysis, buffer-zone analysis, and location-allocation analysis. "These analyses will provide an unique platform to identify and measure accessibility to health care facilities in Egypt, which would help the planners to make better quicker decisions with cost much less than all other methods, and it will make the health care facilities database more reliable, and data can be retrieved for analysis at any time.

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