Research Article   **Open Access**

The Geographic Information Systems (GIS) Application in the Evaluation of Sanitary Services in the Big Algerian Cities Empirical Study on the City of Annaba

Foued Benghadbane[*]

Institute of the Urban Techniques Management, University of Oum El Bouaghi, Algeria

[*]**Corresponding author:** Foued Benghadbane, Institute of the Urban Techniques Management, University of Oum El Bouaghi, Algeria, Tel: 030 34 87 40; E-mail: fouad.benghadbane@gmail.com

Abstract

The GIS is one of the empirical scientific methods that are applied in many studies related to the infrastructure. Particularly the distribution of services whether in terms of spatial distribution or ways of present and future work. Moreover, it helps to provide a real picture about distribution and the nature of its connection with the residents' distribution, density, road network and the existing imbalance in these relations.

The present intervention provides an applied study about the GIS upon the sanitary services in the city of Annaba (the fourth Algerian city) to illustrate the reality of the sanitary equipments distribution and to know the deficiencies by determining their adequacy and efficiency in presenting the sanitary services. This is done by mapping maps (Digital ones) in order to clarify the distribution of sanitary equipments according to its ordinal system (hospitals, clinics, treatment rooms). In addition, there are maps for densities' distribution, road network, the prominent distances between sanitary equipments with certain dimensions by specifying a service area for each category of sanitary services, by which it can be analysed to reach the perception of new sites that are considered for the sanitary equipments. This perception is based on the program of ArcGIS10.3.

Hence, the applied studies of Geographic Information Systems on the sanitary services have unlimited potentials to reach the exact scientific results, so that, it can obtain the necessary information for enhancing and developing that kind of services in the city of Annaba (Algeria).

Keywords: Sanitary services; Geographic information systems; Management; Distribution; Annaba

Introduction

The sanitary services are considered as the most necessary services that affect persons and society's health. Strategies vary from one country to another to provide people with health services, and one of the important elements of this strategy consists in the widespread of the sanitary services' network over the urban space.

The importance of the sanitary services reflects the economic and social development of the country considering its necessity for the residents; this sector has been taken great importance in many countries because it is a criterion of the country's economic and social development in order to allow a better function of the urban system. This requires a balanced spatial distribution for these services in the way it can line with the population density over the urban sectors [1-3].

The importance to study the sanitary equipments is linked the resident's life due to the offered services which respond to their real needs.

The geographical knowledge especially the applied one has noticed great improvement in different sectors, and with the appearance of the GIS technology on the geographical field, with its great capability of spatial analysis. It calls many researchers to inter deeply into this technology, from this, the importance of employing this technology has come in analyzing the fact of the spatial distribution to the sanitary equipments which are presented to this kind of services and its connection with the residents' distribution, their density, roads network in order to clarify the Imbalance relationships and to appear its spatial distribution efficiency in the city of Annaba, containing its (measuring geographic distribution). Through the program of Arc GIS 9 that is used for current study, it should have the convenience of the researcher with the importance of the GPS to manage the sanitary services in the big Algerian cities and its capacity in studying the spatial distributions also to know its efficiency to meet the residents' needs.

The city of Annaba which has been chosen for this study is considered as one of the big Algerian cities occupying the fourth place in the national urban network because of the high population growth, and the importance of the sanitary services distributed over the urban tissue as a part of the public urban services, and its relationship with the residents due to the provided curative and preventive services for a wide geographical space and for different age groups as well as its connection with the state as the first responsible for providing its services for the different categories of the society and the need of the city to a scientific study of the spatial distribution reality relying on the technique of the GIS as an efficient instrument for applied geographic research.

The city of Annaba is suffering from the deficiency of the spatial distribution of the sanitary equipments over its urban sectors in line with the density in the sense of reflecting low level of efficiency in the city 's sanitary equipment, and to find the imbalance in its Variables by the development of a base of numeric geographic knowledge on the sanitary equipment and its variables and to analyze the static and analytic data, to provide accurate information for the decision makers in the urban management.

The Situation of the City of Annaba with Industrial and Service Importance for its Region

The city of Annaba is situated in 7.45° long and 36.55° large, in the eastern side of the Algerian coast (Figure 1).

The city is bounded from the East and the West, by the Edough Mountain (1008 m), from the East, the Mediterranean Sea, from the South, the Annaba plains. The El daheb and Sibouse valleys are poured in the eastern south side.

The city of Annaba is presented as an administrative region since the French colonial, which qualified it to be an important industrial area during the Constantine plan (1958).

Annaba is connected with an important road network (National Road no 44, national road no 16), besides to the railways that relate different regions.

The importance of this situation is related to the port that is considered as one the most important eastern ports, in addition to the international airport in the eastern south along the national road no 44. All those make it a point of capitals, functions and flux pole.
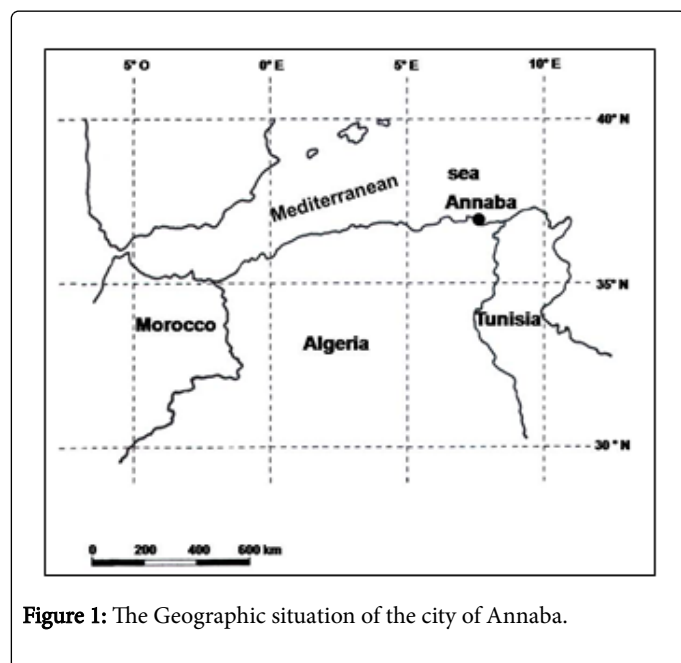

Figure 1: The Geographic situation of the city of Annaba.

Collecting, Developing Data and Constructing the Geographic Data

The first step consists in the collection and development of data, the second step structuring the geographic data basis as follows:

Collecting and developing data

It includes the spatial and descriptive data related to the sanitary services in the city of Annaba:

The spatial data and its various resources

Mapping data: It is necessary in all analytical phases of this study, which is the basis of the success of geographic information systems (GIS), and is considered as a set of maps with different scales are:

Urban structure plan for the city of Annaba (1/7.500) is derived from the master plan of Annaba urban group, which serves as the essential map on which the sanitary equipment are determined according to their location and also the rest of other services, as well as the clarification of the structural road network and adopted in the division of the city into 24 urban sectors, the shortage has been completed by its updating through work field.

Topographic map of the area of study-scale (1/50.000) with the coordinates (UTM), which illustrate the different slopes as well as mountain passes and valleys that cut the site of the city of Annaba [4,5].

Remote sensing data: It is relying on the analysis of 4 satellite images LANDSAT : ETM 2000, TM 1987, MSS 1973 combines medium and high precision that allows to know the pace of urban growth of the city and its trends and its stages and understand the various mechanisms of urban city dynamic, and then realize history of the emergence and the completion and signing of health services equipment especially in the urban extension areas, plus 4 other satellite images: ASTER for the years: 2001 and 2006 to find out the status of the surface and forms of constructing health services equipment.

These data are reinforced by aerial photographs to determine the location of health services equipment in urban areas, which are difficult to detect (especially traditional Arab and chaotic modes of urban tissues and some tissues European modes) at this level of distinctive precision using aerial photos for different years and scales, namely: 1957 (1/20.000), 1967 (1/20.000) 1992 (1/27.000), besides carved images from Google Earth.

Field work data: It has been relying on field work to complete the rest of the data in order to sign equipment health services according to their locations on the map depending on their names and addresses as stated in the data obtained from the Directorate of Health and Population of the WILAYA of Annaba, in this context was used device Global Positioning (GPS) of Product Type 80 by GERMIN firm and adjust the coordinates within a kilometer coordinates (UTM) system being used in the search maps.

The following step is to introduce urban structure plan to the computer and turn it into information network (pixel) numbered map using scanner size A0 and accuracy not less than (High resolution DPI 600), after the conservation of the numbered map in file format Tief, the map is returned to its real geographic origin on the earth's surface, using geographic coordinates (UTM) taken with a GPS.

Descriptive data: The provision of descriptive data by using all the theoretical references and sources related to the subject of services in general and health services in particular, as well as geographic information systems and their applications in contemporary urban and geographic studies especially those associated with urban management in terms of services.

Also the provision of official statistics related to the sizes and population densities for the year 2008 by direct contact of the National Statistics office, as well as data related to the number of health services equipment by its categories and numbers of nursing staff, and the number of families, according to their addresses by contacting the Directorate of Health and Population of the wilaya of Annaba (2013-2014), as well as the Directorate of Construction and urbanism of the wilaya of Annaba to get an idea on the numbers of the city's neighborhoods and their sectoral division and area and other urban functions scattered across the urban fabric [6-8].

Building geographic database

The process of building geographic database is necessary for any geographic system are basic rules, and by designing a database is where the link between sites equipment health services and schedules quantity and descriptive, is the selection of items that have a relationship to health services between sites equipment health services to become valid for analytical and statistical treatment until is displayed in maps and graphs allow to realize the efficiency of health services in Annaba, in order to visualize the elaborate system of control, which is evident from Figure 2.
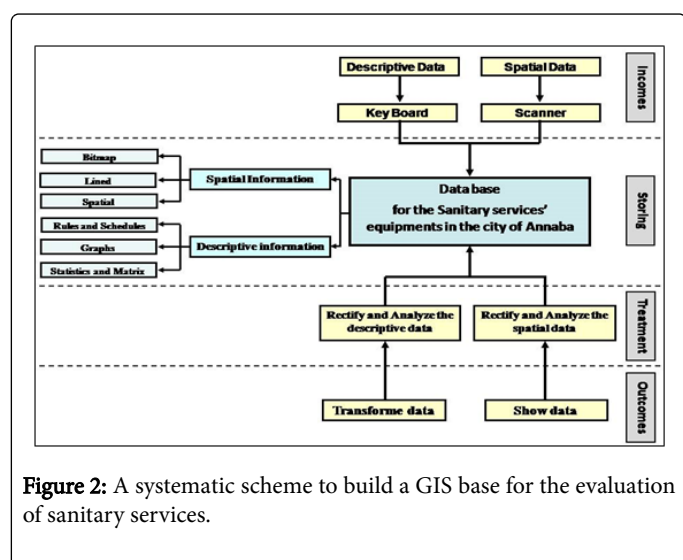

Figure 2: A systematic scheme to build a GIS base for the evaluation of sanitary services.

Components of Health Services in Annaba and Spatial Distribution

The sanitary equipment related to the population size and the degree of economic and social development, this combines public and private health equipment, which know variation in their potential and service ability according to a pyramid scheme ordinal that would reflect the efficiency of Sanitary services provided, and are:

Public sector's health facilities

Figure 3 shows the spatial distribution of public sector's sanitary equipment, and through which we find that hospitals occupy the top of the pyramid among health components which offer services of quality and central nature and this impose imperative nature and concentration in Annaba, which represents the capital of the wilaya compared to the rest neighboring municipalities, all gathered within what is known as " University Hospital Center ", which includes the following health facilities:

- Hospital "Ibn Rushd" with 470 bed capacity provides health services surgery.
- Hospital "Ibn Sina" with 269 bed capacity and provides health services specialist.
- Hospital "Durban" with 190 bed capacity and provides health services specialist along with specialty of ear surgery.
- Clinic of St. Teresa with 94 bed capacity includes health services in pediatrics.
- Square March clinic with 50 bed capacity and providing health services specialist in ophthalmology.
- Saint Augustine clinic to provide health services specialist in dental surgery.
- Elisa clinic provides health services in the dental surgery.

Besides institutions of Health which combines 07 polyclinics and 12 treatment rooms and clinic births, which are unevenly distributed across urban sectors of the city as illustrated in Figure 3.
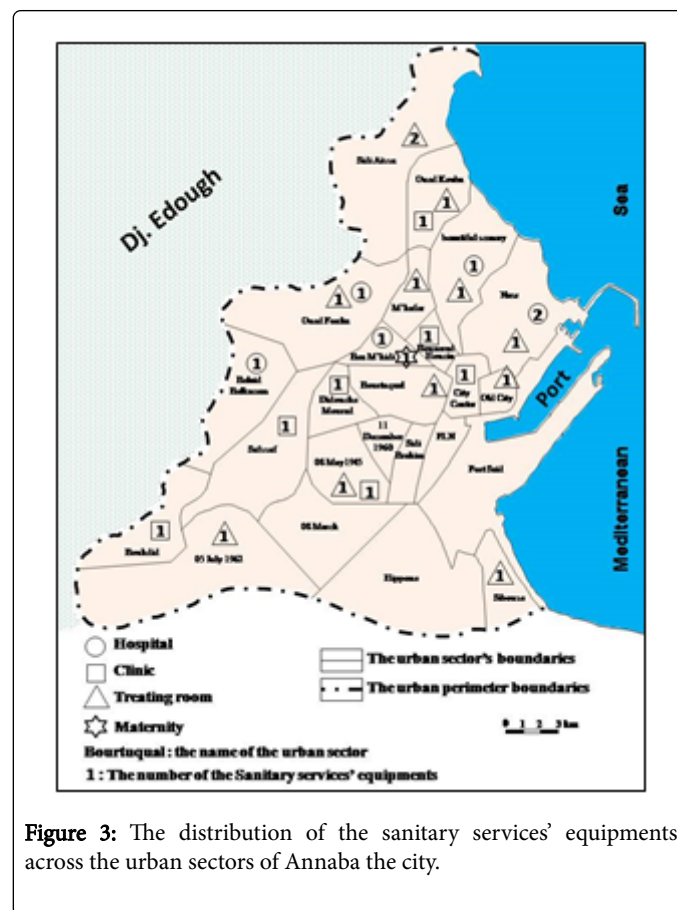

Figure 3: The distribution of the sanitary services' equipments across the urban sectors of Annaba the city.

Health facilities belonging to the private sector

It is contributed to the private sector in the provision of health services in Annaba through 08 surgical clinics with total capacity of 305 beds as shown in Table 1.

Clinic Name	Capacity (Bed)
Al Awrasi Clinic	24

Saidani Clinic	50
Jasmine Clinic	30
The white Bridge Clinic	32
Abou Marwan Clinic	66
Algeria Clinic	49
Al Farabi Clinic	36
Sibouss Clinic	18

Table 1: The distribution of the private clinics in the city of Annaba. Source: The directorate of Health and residents Annaba 2013.

In addition, we find that the private sector that contributes to health care through the following health facilities:

- 05 hemodialysis centers and equipped with 87 generators.
- Two (02) medical imaging centers.
- 08 medical scanning clinics available on 06 Scanner devices and two devices to detect the magnetic resonance.
- 08 laboratories for medical analysis.
- 167 specialized medical clinics.
- 13 a competent dental surgery clinic.
- 120 general medical clinics.
- 104 public dental surgery clinics.
- 214 Pharmacy.

Spatial and Statistical Analysis of Geographic Data Related to Health Services in Annaba

The evaluation of health services in Annaba is based on the analysis of data related to the location of sanitary services and treats them by using spatial and static analysis means provided by GIS software ArcGIS 10.3, and is the most important of these methods.

Function of making border on the phenomenon

This phenomenon helps to evaluate the location of each equipment for sanitary services separately, through the function range "Buffer" on the list of "Proximity" and listed under the Tools menu analysis "Analysis tools" in the program that has been selected, which allowed to draw three bands around each equipment according to the distances specified for each criterion by giving each range a value representing the degree of risk, to cover all the criteria taken into account and collect them to know the degree of appropriation for each equipment separately, and the closer the output from zero the more the location is appropriate, and therefore index to assess the health services provided.

Function of closest neighbor

This function within statistical analysis tools "Spatial Statistics Tools", based on measuring the distance between the location of a particular health equipment and another nearby it, this function allows to clarify the distribution pattern of equipment health services in Annaba, when it is a regular pattern, this means that there are factors that affect it, or if the pattern is chaotic, it refers to the factor of chance.

Function of the average center and distance criteria: This function under the list of "Measuring Geographic Distribution" and interested

to the urbanized area in each urban without considering empty area to realize the tendency of sanitary equipment to centralization (geometric centralization) inside the urbanized area of the Urban sector and becoming closer from residential areas.

Analysis of Sanitary Equipment Efficiency and Ensure their Role in the Urban Management

The used methodology and use of congruence of information between various spatial data and descriptive data allow to know how suitable are the sites of sanitary services (It has been relied in this research on the public sanitary fittings because it is featured by a hierarchal system in presenting the different sanitary services for various population classes) in Annaba and efficiency in providing this type of service by applying GIS as a tool to ensure its efficient management and contribute to the lifting of its the adequacy and efficiency.

Functional efficiency of the sanitary service

The spatial distribution of health service equipment in the city of Annaba is characterize by the contrast across (Figure 3), the most equipment is concentrated in the El nasr urban sector two hospitals (2) and 1 treatment Hall. This sector has extended during the French colonial and has embraced this type of services in the city, the reason why it serves not only its inhabitants but the residents coming from other urban sectors as well so the health services provided and also those arriving from neighboring municipalities and other wilaya as Taref, Guelma, and Skikda, this is what makes population density reach 24 people/hectare, however the number of sanitary equipment diminish gradually in other urban sectors, reaching one equipment in each sector. Number of these sectors are especially mentioned: "Belaid Belkacem," "Bouhdid", "05 July 1962", "Safsaf-Willow", "Didouche Mourad", "Sibouse", and "M'hafer" where we find only multiple clinic services or treatment hall.
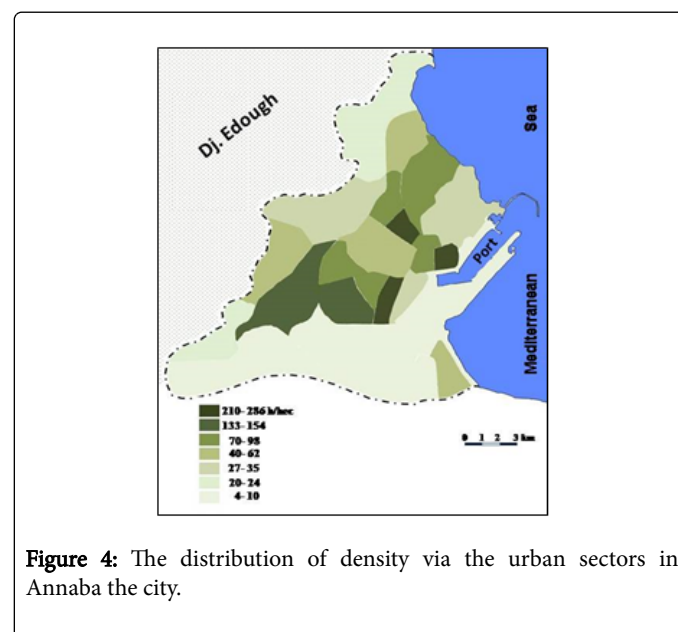

Figure 4: The distribution of density via the urban sectors in Annaba the city.

These sectors are situated in the western side of the city where we find the new urban residential extension and the current extensions in the western plain they are residential neighborhoods primarily and

include buildings still under construction this makes the population density being between 24-154 people/ha, which is reflected in the low functional efficiency of health facilities compared to the rise in the size of the population, many urban sectors are characterized by the total absence of these equipment we can mention here the following sectors: "Jabhat El tahriri El Watani FLN," Sidi Brahim, "" Port Said "," Hippone ", and" March 08 ", forcing the inhabitants of these sectors to move to other sectors, regardless of their population density (Figures 4 and 5).
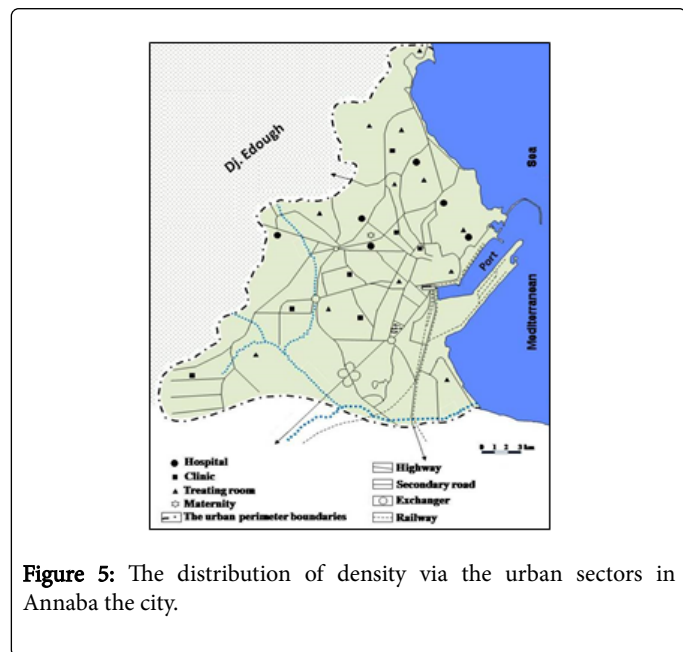

Figure 5: The distribution of density via the urban sectors in Annaba the city.

Health equipment efficiency using the criterion of distance

By analyzing the values of the closest neighbor that is limited between 0.37 and 0.78 over the city of Annaba urban sectors were detected the pattern of health services equipment distribution, this pattern, does not take a similar situation in some urban sectors and even between types of sanitary equipment.
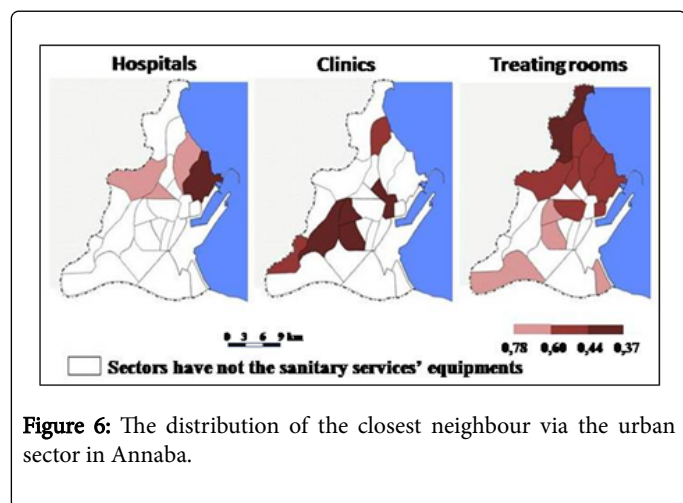

Figure 6: The distribution of the closest neighbour via the urban sector in Annaba.

For the distribudion of treatment hall they are characterized by a concentrated pattern in some urban sectors such sectors are : "old city" and "beautiful view" and "Nasr" and "Bourtuqal" and pattern random as sectors "July 5" and "Oued forcha", and in other sectors we find a

structured pattern such sectors "Sidi Aïssa" and "Oued Kouba" and "Sibouse" (Figure 6). This situation is due to the road network structure which vary from one sector to another depending on the characteristics of the urban fabric and the date of construction and also to the pattern of distribution of the rest of the other services (Figure 5), as for multiple services clinics and hospitals, urban distributed across sectors takes a random pattern in some of them, while others have a regular pattern.

Spatial location efficiency of health services

To build a model for selecting the best suitable locations for health services equipment in Annaba, it needs to turn all the criteria that are established previously to algebraic maps (Algebra Maps) (zero - mono areas suitable and unsuitable), using the spatial analysis tools "Spatial Analysis Tools" the operation started by bringing all the data that has been processed previously in its linear and retina, "cellular", then find the straight distance of all criteria that were in its linear state "Vector" the result is areas with equal distances are divided into six sections covering all the urban fabric of the city of Annaba, and then have been subject for requalification into six categories. Where the suitable categories are given number six despite the fact that they occupy the first rank in the classification as the highest degree, the unsuitable areas are given number one as the minimum degree without considering its location in the sixth place in the classification, then are doing arithmetic enables tool analyst spatial do by Raster Calculator for all resulting layers in its retina after giving a relative weight to each layer, based on their importance in determining the site of the health equipment and the degree of risk expected of them (Table 2), here the layers are collected it after multiplying them by their weights producing a new layer which reveals the best suitable sites for locating health services equipment in Annaba.

S. No	Variable	Weight
1	Valleys	4
2	Water Catchment Areas	7
3	The degree of sloping	4
4	Close to the protecting centers of the city	5
5	Close to the highways	4
6	Close to the principle roads	4
7	Close to the secondary roads	2
8	Close to the treatment rooms	2
9	Close to the clinics	2
10	Close to the hospitals	2
11	Close to the agglomerations	10
12	The distribution feature for other services	8
13	The density	3
14	The network circulation	5

Table 2: Final Exit weights criteria for assistance to the appropriate map. Source: Personal Address from the researcher, Depending on the study of the professor Besma Bint Salama Ben Salem Arrahili.

Basing on what has been approved as criteria in the in the model of appropriation, it was found that highways in Annaba has ranked first in the application, due to its small number and its proximity to a small number of treatment halls rate of 0.32% we specify here sector "Sidi Aïssa" and "Oued Kouba" and "08 May 1945". The second place was occupied by branches of the civil protection rate of 0.76% for its proximity to some of the multi-service clinics, then come the degree of slope by 4.25% due to the city's growth and expansion on flat areas to avoid severe sloped areas which are exploited as zones for entertainment, recreation and rest, while we find water areas rafting a ratio of 9.21% as representing the less higher regions, and they are extended on limited area in the western side"Belaid Belkacem", "Safssaf", "Bouhdid", and "05 July 1962", which belongs to health services and then we find the proximity of the treatment rooms by 11.15% and multi-service clinics by 13,65%, as well as hospitals 15.44%, largely due to the urban plan and urban fabric properties located therein, The valleys represent 19.04% due to the multiplicity of mountain passes and valleys emitted from Edough Mount most important: "Oued Kouba", "Oued Forcha", "Oued Bouhdid", "Oued Edeheb" and sweeping most of the urban fabric to pour into the Eastern side of the sea.

Category	The degree of appropriateness	The Sanitary services' equipments							
		Treatment room		Clinic		Hospitals		Total	
		Number	%	Number	%	Number	%	Number	%
0	Appropriate	5	41,67	2	28,57	2	33,33	16	64,00
01-Apr	Acceptable	4	33,33	2	28,57	1	16,67		
04-Aug	Non appropriate	3	25,00	3	42,86	3	50,00	9	36,00
Total		12	100	7	100	6	100	25	100

Table 3: The distribution of the sites of the sanitary services equipments according to its suitability in Annaba. Source: The results of the spatial Analysis+The personal address of the researcher.

So we find most sanitary equipments juxtapose the with different distances, while the criterion of the middle situation of health services occupy the highest percentage of 28.50% because it is not takes into consideration in the location of health services and their situation on the edges of the urban fabric especially for hospitals and multi-services clinics.

Basing on the spatial analysis we have evaluated locations of health services equipments in Annaba, which are divided into three categories depending on the degree of suitability, the results and represented in the Table 3.

It is clear from Table 3 and Figure 7 that treatment rooms are characterized by an acceptable degree of suitability that is reflected in the average of total grades estimated at 4.60 while multi-service clinics and hospitals have increased their proportion of the site with class "inappropriate" with an estimated average of 6.60 degrees, and thus we find to 64.00% of health services have fulfilled certain or all criteria considered in this model, and this situation can be explained that the sanitary services are not characterized by the location of suitable degree" are located in the following urban sectors "beautiful scenery" "Oued Kouba" and "Sidi Aïssa," they are sectors of planned neighborhoods mainly European neighborhoods which occupy the central area of the city of Annaba.

While chaotic sectors urban are characterized by the existence of health equipment of "unsuitable sites" "like Urban sectors "M'hafer", "Safssaf", "Bouhdid", and "05 July 1962" because their location were not studied and did not take into consideration the necessary criteria, because the completion of this type of equipments was done in urgent state in service urgency to cover the significant delay after the housing delivery, this phenomenon exist also in the sector of "old city" this sector includes ancient and traditional residential neighborhoods which have been degraded and most of its residents have left it.
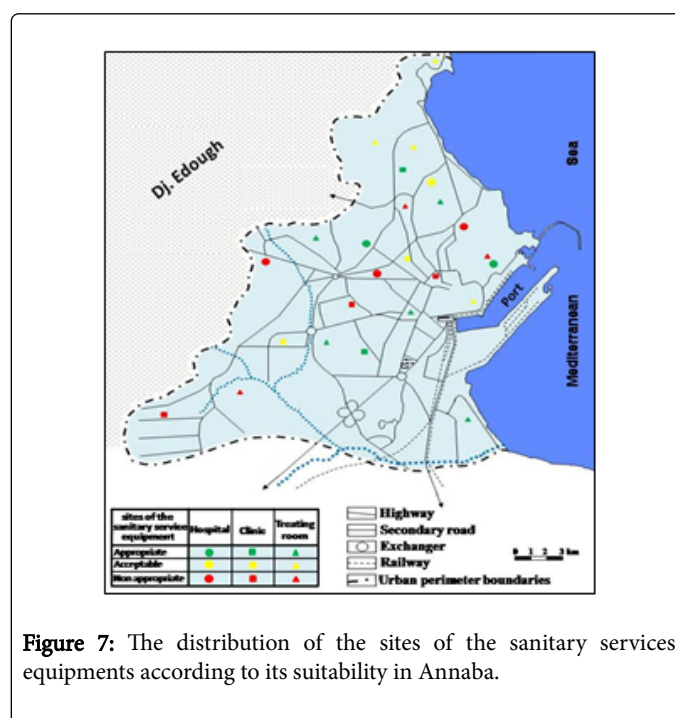

Figure 7: The distribution of the sites of the sanitary services equipments according to its suitability in Annaba.

The research gets to suitable maps for health services equipments (Figure 8) by adjusting the unsuitable sites of equipment "and directing it to convenient locations and by taking into account all criteria of optimal location for health services equipments through Geographic Information Systems Technology.

Figure 8: The distribution of the sites adjusting of the sanitary services equipments in Annaba.
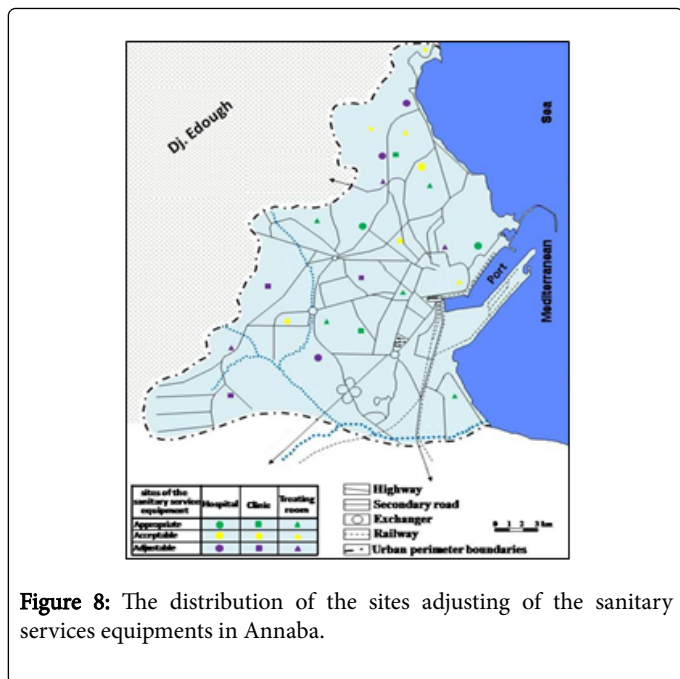
Conclusion

The GIS has become one of the most important tools which enforce the sanitary services' equipments. It is considered as one of the most important services sectors in the city. This technology allows to treat the various data in a collective picture using spatial and statistic analysis to get efficient results which tolerate spatial practice.

This research has taken the spatial distribution efficiency for the sanitary services' equipments (public) in Annaba to use GIS through the field of spatial distributions in the program of "Arc GIS" in order to analyze the spatial data using criteria distance, the closest neighbor, the real rectified center and the middle geographic centers.

The practice of this technology on the sanitary services in Annaba shows the existence of clear spatial disparities in distributing the sanitary services' equipments across the urban sectors of the city. This has an impact on the efficiency and sufficiency of the service presented to people. Moreover, these equipments are characterized by their regular and centralized mode of distribution treatment hall and chaotic and irregular distribution for the clinics and hospitals. This has been confirmed by the closest neighbors

In addition, the model of appropriation reveals the choice of the selective sites depending in the most variable way between highways however the sanitary equipments are situated in the centre of the urban sector this makes the sites of these equipments distributed between the appropriate sites, accepted and inappropriate.

Hence, it is necessary to put appropriate maps to maintain public sanitary services in Annaba and to establish its sites and data in automatic system to get digital maps able to be adjusted and offer efficient solutions and help for urban management in the field of sanitary equipment by using GIS.

References

1. Alföldi TT (1978) Introduction to digital images and digital analysis techniques. Canada Center for Remote Sensing, Department of Energy, Mines and Resources, Paris.

2. Bordin P (2002) GIS: concepts, tools and data. Hermes Science Publications, Paris.

3. Denègre J, Salgé F (1996) Geographical Information Systems. University Press of France, Paris.

4. Essevaz-Roulet M, Iratchet B (2008) The implementation of a geographical information system in local authorities. Territorial Editions.

5. Gilliot M (2000) Introduction to Geographical Information System (GIS). Department AGER, INA, Grignon, Paris.

6. Glasson W (1987) An introduction to regional planning. Macmillan, London.

7. Price DG, Blair A (1989) The changing geography of the service sector. Blharen Press, London.

8. Ravalet S, Panet I (2001) Vade-mecum of the GIS project manager. National School of Geographical Sciences, Paris.