Analysis of Site Suitability of Mosques Locations Using GIS: A Case Study of Khartoum State

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Abstract

The distribution of mosques needs to be assessed to help authorities to choose the appropriate location for the new mosques proposals, or to extend the existing mosques, the distribution and capacity of mosques is a serious problem in Islamic towns. This research aimed at finding appropriate planning standards, selection criteria for mosques locations and capacity by studying the current locations, distributions and capacities of the existing mosques. An aerial photograph was used as a source of spatial data. The distinctive orientation of the mosques to Gibla (Mecca holy mosque direction) facilitated their identification among other buildings. A layer of mosques was created in GIS. Each mosque area was calculated from the layer and saved in the attribute table. The actual capacity of each mosque (number of worshipers) was calculated by dividing the mosque area by 1 square meter. A buffer tool was applied, depending on the optimal distance for worshipers to access the mosques; the houses within the buffer area of each mosque were calculated to estimate the expected maximum number of worshipers for Friday prayer. The actual capacities of mosques were compared to the expected population. The results indicated that some mosques were found to be suitable; some needed to be extended within the existing location, while others could not be extended within the existing location and a new location must be determined for a new mosque within the buffer area to accommodate the expected number of worshipers.

Keywords

GIS, Mosques, Site Suitability, Planning Standards, Khartoum

1. Introduction

Choice of mosques locations together with the appropriate capacity sufficient for the number of worshipers is a serious problem in Islamic towns, added to non-observance of planning standards in the areas of mosques to cope with population growth and urban expansion. Site selection is a very important activity aimed at producing optimal mosques locations. Site selection for mosques involved combining large amounts of statistics, written narrative, questionnaires as well as some sample geographic methods. Probably the typical geographic was using Tisane polygon. Voronoi diagram is a process of decomposing a specific space in the basic distances of object. These objects are usually called sites. The principle of this diagram is to produce regions whose boundaries define the area in which the distance of any location to any given site is not greater than the distance to the other sites [1]. The purpose of the optimum site selection is to find the optimal location based on predefined criteria [2] [3] [4] [5] [6].

This research aims to find appropriate planning standards to solve this problem by studying the existing location, distribution, and capacity of the existing mosques, using Geographic Information System (GIS). GIS can enhance the accessibility and flexibility of information and improve the linkages and the understanding of relationship between different types of information [7]. The system can treat the spatial data (maps, aerial photos... etc.) and descriptive data (names, tables), and revision of the error, storage, retrieval, inquiry, spatial and statistical analysis, and display data on a computer screen or on paper in the form of maps, reports, charts, graphic or through the website [8]. The use of GIS and multi criteria analysis has helped planners to achieve desired and more accurate results [1]. GIS is used today in several planning applications including land use, health care, and transportation [9].

The distribution of mosques in residential areas must take into consideration their distance from each other and the number of mosques must be compatible with the number of houses around them. In previous studies, some hypotheses were introduced as the following example. In narration mosque should be built to cover forty houses in each direction. According to this narrative, for every 160 homes people could be built a mosque in the center [10].

2. Location of Mosque

The location and chosen mosque location and its relation to the other elements of the urban area to the main themes in the history of Muslim cities. Sometimes it was determined that the construction of the neighborhood or towns, the location of the mosque and then founded the establishment of urban spaces. The first example, the mosque of the Prophet in Medina is that its location was determined by divine inspiration [10]. The location of the mosques depend on multi criteria: Criteria are variables that justify or explain the environmental impact on making decision to select the most suitable site for a project. They are chosen depending on the characteristics of the alternative. It is necessary to have enough information about the chosen criteria to allow for comparison among

the alternative [11].

The planner should take into account some of the major planning considerations that raise a mosque and strengthen it in the hearts of Muslims. The researchers summarize the most important considerations for mosque planning according to [12].

1) The mosque's location should be away from noise, pollution, smoke and other environmental hazards.

2) Mosque site must be integrated with the built environment and urban fabric, and preferably in the center of public services.

3) The site must be found in a permissible location in Sharia, cannot be in graves, unclean, occupied, or public used land.

4) The selected land to establish a new mosque must not be adjacent to another mosque, which cause a dispersion of Muslims

5) The mosque location must be supported by good roads and pedestrian paths with possible shades and trees.

6) The exploitation of the mosque as an attraction point based on the visual aspect, and the minaret as a distinctive sign [8].

7) The location of the mosque must avoid high noise; activities such as industrial development project and traffic [13].

Many factors affect the choice of mosque locations. Some do not cope with planning criteria, and may be according to particular beliefs. Location of a mosque is a divine affair because "Divine guidance is for the houses which Allah has given permission to be raised and praised and the name of Allah is remembered in purity morning and nights and the mosque can be raised and built with grandeur only where God allows [14]".

The choice of mosque location must consider optimal distance for worshipers to access the mosques, and should not be built in the areas far from houses. Accessibility is the ease of entry to and exit from a particular site in a residential area. The variables that should be considered when measuring accessibility include the number of traffic lanes, traffic speed and congestion, and traffic control devices [15]. Physical accessibility is a measure of the capacity of a location to be reached by, or to reach different location [16].

In this paper some mosques are built inside companies and inaccessible to worshipers outside this company to pray, and also the companies do not have the available space to extend the mosque for their labors. Extension of mosques using temporary material such as zinc is not a good solution. Some mosques are very close to each other according to the existence of different doctrines, regardless of the need of the population. Mosques names can be according to the doctrine's name, name of districts, name of donors, or name of one of the Prophet's first followers (Sahabi).

3. Materials and Methods

3.1. Study Area

The position of the study area in Khartoum state located between blue Nile, white

Nile and Khartoum-Gezira expressway, located between Easting [446182.92E and 457691.42E] and Northing [172555.22N and 1718022.86N], the study area is 82241673 square meters approximately (**Figure 1**).

An aerial photograph was used to facilitate the Identification of mosques among other buildings by distinctive orientation of them to Gable (**Figure 2**).

3.2. Research Method

Arc GIS 10.3 was used to determine the location of the mosques in the aerial Photograph and in the map as indicated in **Figure 3** and **Figure 4**.
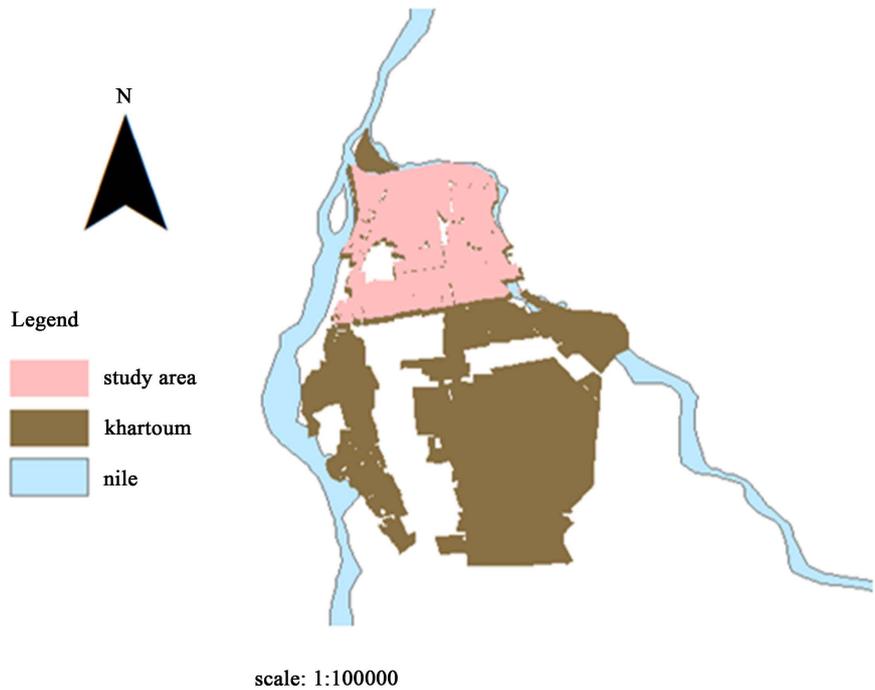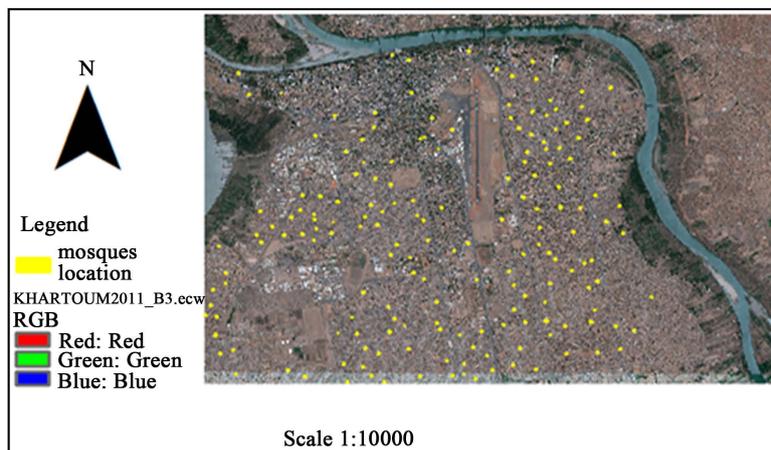

scale: 1:100000

Figure 1. Study area in map of Khartoum state.

Figure 2. An aerial photograph of the study area.

Figure 3. Location of mosques in aerial photograph.


Figure 4. Map of the location of the mosques.

The mosques had been added to the map and total area of mosques had been calculated, together with the main built up area, extended buildings areas and empty spaces. Calculated areas were recorded in the attribute tables in Table 1. Attribute table includes information such as id number for mosque, mosque name, interior areas, total areas, extra areas of any mosque, locality of the mosque, district of the mosque, material of extra areas, wc, worshiper number, needed areas to expand.

A buffer tool of 300 meters around any mosque had been applied, depending on the optimal distance for worshipers to access the mosque within 10 minutes by walking speed of 2 kilometer per hour (Figure 5). It is assumed that 10 minutes is the sufficient time for the worshiper to reach the mosque after prayer call time (Azan) and prayer starting time.

The buffer area had been used to clip the area around each mosque. The following criterions were designed to extract the number of worshipers based on the expert's opinion from the Ministry of Planning:

Table 1. Attributes of mosques.

FID	area	mosque_nam	district	total_area	extra_area	material	w_c	worshipers
0	386	burri allamab mosque	burri allamab	2859	46	zincs	yes	430
1	589	omak street mosque	al riyadh	2997	107	zincs	yes	362
2	314	al taif mosque	al taif	1635	534	zincs	yes	378
3	419	alferdawes mosque	alferdawes	2398	0		yes	560
4	385	alemarat collage mosque	aljeraif west al sheta	2432	68	zincs	yes	6066
5	412	Martyr Haj Nour Mosque	al mamora	2763	393	zincs	yes	400
6	434	street no 33 mosque	aljeraif west al sheta	2747	139	bricks	yes	352
7	365	burri allamab mosque	burri allamab	1607	102	zincs	yes	760
8	400	alharaa altaltaa mosque	aljeraif west al galaa	2712	183	zincs	yes	126
9	427	aljeraif west al sheta mosque	aljeraif west al sheta	3039	0		yes	326
10	468	dawhat al eman mosque	aljeraif west al galaa	1880	0		yes	274
11	549	almamoraa mosque	almamoraa	3728	152	zincs	yes	532
12	305	block 63 mosque	block 63	1414	0		yes	654
13	625	arkaweet mosque	arkaweet	4460	0		yes	570
14	386	alferdawes north mosque	alferdawes north	2098	0		yes	734
15	521	alferdawes north mosque	alferdawes north	3585	0		no	578
16	474	al nakheel street mosque	arkaweet	1551	0		yes	722
17	353	Rayyan Mosque	arkaweet	1298	0		yes	730
18	274	badar st mosque	al riyadh	647	0		no	618
19	542	al salam mosque	al taife	3814	0		yes	488
20	340	gis office road mosqe	al taife	2212	0		yes	572
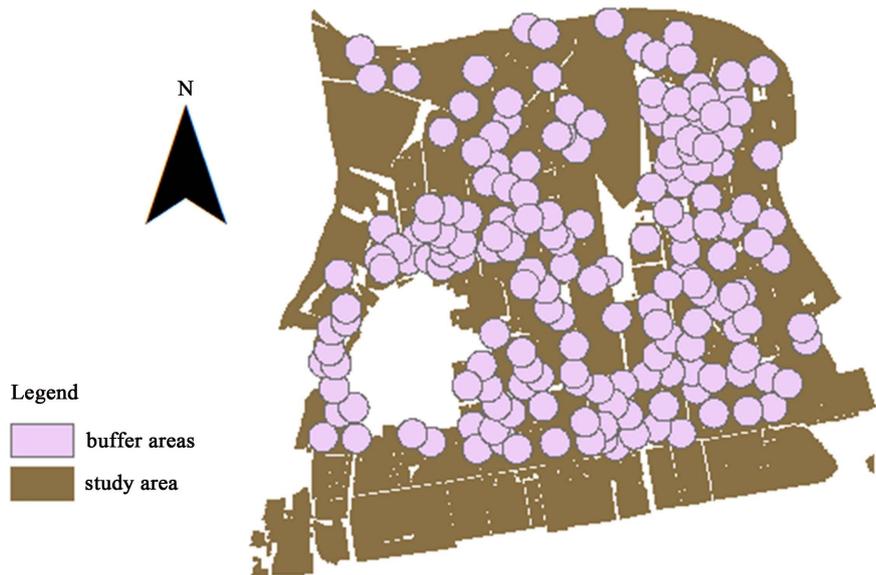
Figure 5. Map of the buffer around mosques.

1) Assume an area of each worshiper at the mosque is equal to 1 square meter.

2) Assume the number of worshipers is equal to 2 in every house.

3) Expected worshiper number in the buffer area around the mosque = number of houses in the buffer area multiplied by 2.

4) Actual capacity of the mosque is equal to mosque built area divided by 1 square meters (1.25 × 0.83).

To assess the suitability of each mosque a comparison between expected number of worshipers and actual capacity of the mosque was conducted; if the expected number of worshipers is less than the actual capacity of the mosque, then this mosque is sufficient for worshipers; if the expected number of worshipers is greater than the actual capacity of the mosque then this mosque need to be extended within the existing location; if it is feasible otherwise a new location must be selected to accommodate the excess number of worshipers.

4. Result and Discussion

Applying GIS in the analysis of mosques locations and capacity indicated that some mosques are suitable, some need to be extended within the existing location, some cannot be extended within the existing location and selection of new location is needed to accommodate the excess number of worshipers

Mosques were classified a corroding to their capacity and the classification map was produced (Figure 6).

1) Mosques shown by yellow color have sufficient space for worshipers.

2) Mosques shown by light green color include extensions outside the main building.

3) Mosques shown by red color do not have sufficient capacity and can be extended within the existing location.

4) Mosques shown by solid green color do not have sufficient space for worshipers and cannot be extended, so new mosques are suggested within the area.

The result found that 22% of mosques have sufficient capacity for worshipers while, 50% need to be extend in the existing location. On the other hand 16% have sufficient space if the outdoor area were considered. By contrast, 12% of mosques do not have sufficient capacity and cannot be extending (see Figure 7).
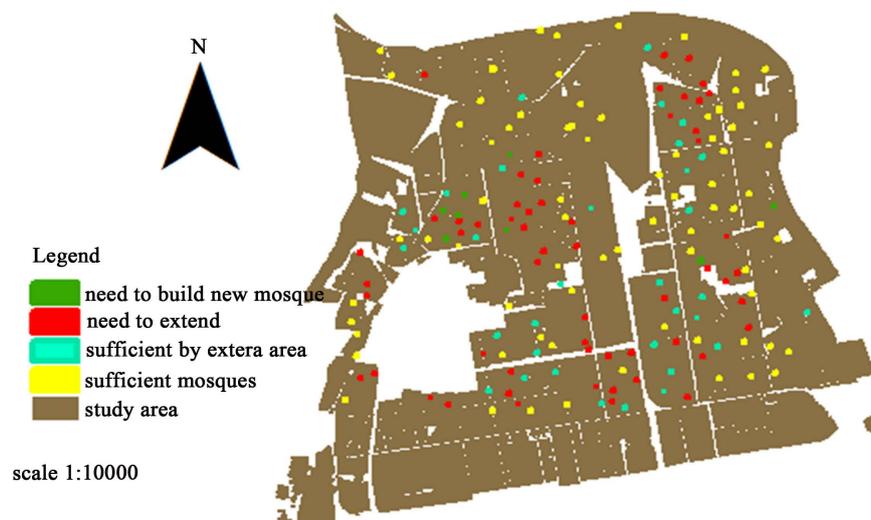
Figure 6. Map of the mosques classification according to their capacity.

Statistical Summery
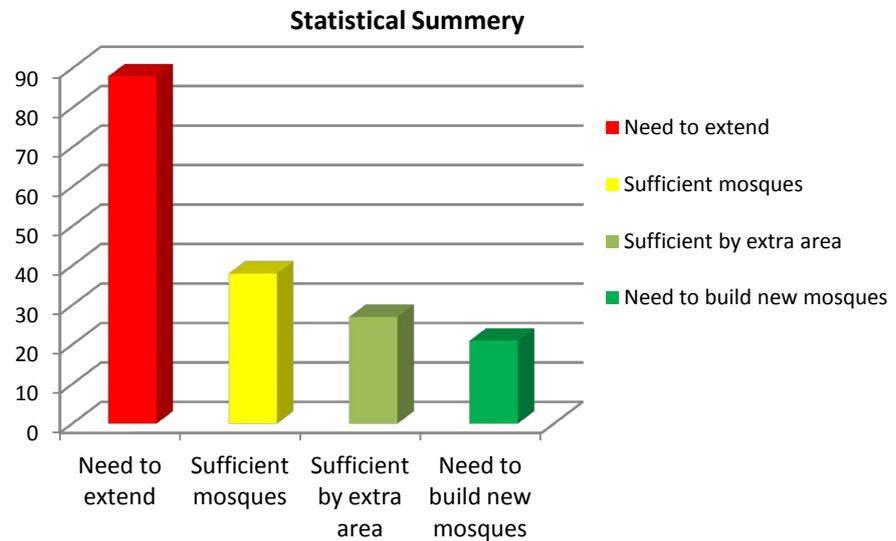
Figure 7. Statistical summary.

5. Conclusion

Analysis of results for the location, distribution, and capacity of the existing mosques, had shown that: some mosques have met all conditions, some need to be extended within the existing location, some are not capable for extension within the existing location and new location must be selected to cope with actual number of worshipers, and it is highly recommended to design mosques as multi stories for vertical extension.

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