

Planning Critical Infrastructure based on Population Growth and Environmental Constraints

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Abstract – This study explores the impact of public school location/distribution and surrounding build environment based on its distance from the main street, service road, petrol stations in Sohar, Oman using GIS. Data have been collected from various official sources to fulfil the requirements of this study, which helped in constructing the geodatabase for this project. The results of this study demonstrated that there is an apparent inconsistency in public schools distribution, as most public schools are concentrated in one location. The study concludes with suggestions and recommendations to use GIS and spatial planning by the decision makers to make future sound decisions of building public schools. It is desirable to build schools in areas with lower percentages of highways and commercial sectors.

Key Words: GIS, spatial planning, geospatial analysis, Sohar

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1. Introduction

Education is one of the critical sectors of any society and plays a vital role in the growth of any country. Schools are one of the leading community facilities, which are dedicated to the children's education, recreational and social activities. Sultanate of Oman is one of the countries in the Gulf region and a member of Gulf Corporation Council (GCC). It is situated on the southwest Asia, on the southeast coast of the Arabian Peninsula [1; 2]. Before 1970 in Oman, there were only three schools; Alsayidiyah School in Muscat, Alsayidiyah School in Matarh and Alsayidiyah School in Salalah, by 1985 the number of schools was increased to 588. The Ministry of Education (MoE) [3] has responsibility for the strategic planning for all the public and private schools and some of Early Childhood Education Schools. The location of school plays an essential role in creating a healthy and safe school, and this supports the high quality of education. To select an excellent site, the decision makers must identify the criteria that will be used to evaluate the location of both the existing schools and new schools that will be built in the future [4].



Figure 1. Sultanate of Oman Map [5]

Table 1. Total number of public schools in Oman

| Education Type | Schools | | | |
|-------------------------------------|---------|--------|------|-------|
| | Male | Female | Coed | Total |
| Basic Education | 260 | 147 | 484 | 891 |
| General Education and Grades(11-12) | 86 | 44 | 22 | 152 |
| Total of Public Education | 346 | 191 | 506 | 1043 |

The general length of education is twelve years, but since 1998/1999, the MOE has merged it into the basic education system. The basic education consists of two cycles, and the duration is ten years: the first four years being cycle one, and the last six years is cycle two. After basic education, there are two years, covering grade eleven and twelve. Special needs education was established in 1974/1975 and the beginning, the MOE sent the students to study abroad. In the same year, they opened classes for deaf students. Today there are three schools for these students. Also, the ministry began integrating children with special needs with other children in basic and general education school. Illiteracy and adult education centres divide into two stages; the first phase lasts for three years while the second phase starts from grade five to grade twelve.



Figure 2. Map of Al Batinah North

The main objective of this paper to investigate a Geographic Information System (GIS) [6,7] approach for spatial planning of school distribution in Sohar. To investigate the current locations of the public schools in Sohar and propose a framework using GIS for public school distribution and spatial planning in Sohar. Based on our findings, present an alternative solution for better school distribution and spatial planning that may help decision-makers to take appropriate steps to develop and improve the current distribution of schools. In section 2, we discussed the literature review related to our research; section 3 outlines the criteria for evaluating and selecting school location. Section 4 and 5 outline our analysis and suggestions respectively.

2. Literature Review

In [8] used remote sensing and GIS to identify vegetation in Dhofar Governorate. This study aims to evaluate three approaches; the Normalized Differences Vegetation Index, Supervised Classification and Unsupervised Classification to extract information about the vegetation from satellite images and examine each approach within the environment of GIS. The method of study is combined GIS and remote sensing. ER Mapper was used for preparing and extracting the images of vegetation, while the results are managed by using ArcGIS (ArcInfo level) [9].

In [10] used remote sensing and GIS for damage assessment after flooding in Muscat, Oman after the Gonu tropical cyclone in 2007. In this study, he used two IKONOS satellite images of Muscat, one of them before the cyclone and other after it. Many areas of interest were extracted from these images. The result of this study shows how the remote sensing and GIS are useful in the assessment of damage especially in mapping and updating the geographic database after the disaster. Moreover, remote sensing and GIS are considered as a phase of Disaster Management Planning.

[11] used GIS to evaluate and investigate the distribution of the existing police stations and rescue police points in Duhok city in Iraq. This study aims to compare the location of police stations with local and regional criteria according to population and area, to examine if they have been distributed equitably or not. This study used two techniques to achieve the aim; GPS to determine the points and locations and GIS to produce maps.

[12] studied the effects of Tropical Cyclone Gonu in the governorate of Muscat, Oman to determine the damage caused by the Cyclone in urban areas. The researcher used change detection techniques to identify and evaluate the damage. Principal Component Analysis (PCA) [13] method was used in the study to determine the variations between two different images at different times. There are two main parts to this study's methodology, which are; ER-Mapper (used to identify the damages), and ArcGIS (ArcMap) is used to manage the results. The study concluded that more than 37% of the areas changes have occurred because of the vulnerability of water and silt.

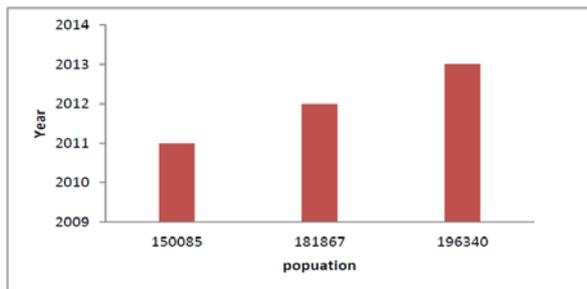
Authors in [14] focused on the spatial distributions of 11 existing neighbourhood parks in Sheikhpura city in Pakistan, assessing them by using GIS techniques. The result of this study showed that the existing parks do not serve most of the population in Union Councils. The study concluded that according to their calculations, the pattern of spatial distribution of the existing parks meant that more than 80% of the

population remained un-served. The study recommended using advanced GIS to determine the location for new neighbourhood parks that will serve more people.



Figure 3. Map of study area (Sohar)

Figure 3 represents the map of the study area (Sohar). Sohar is one of the oldest cities in Sultanate of Oman. It is situated in Al-Batinah North governorate. It is a third largest city after Muscat and Salalah. The size area of Sohar is about 1728 km². The area is divided into coastal area and mountains area. It includes 144 villages. According to the census, in 2014 Sohar has population of 196,340 as shown the graph in Figure 4 [15]. The population has grown from 401,242 since



the census in 2003.

Figure 4. Population of Sohar

3. Criteria for Evaluating and Selecting Location of School

This section includes the criteria for evaluating and selecting the location of the school. The requirements varies from one country to another, because each one has its own economic, social and physical conditions. The location of schools plays a vital role in adhering to health and safety guidelines, which support a high quality of education. To achieve these aims, the decision maker must identify the criteria that will be used to evaluate the location of both the current schools and schools that will be built in the future. Building a new school is a critical decision made by MOE. The selection of school site involves a complex set of decision factors involving social, health and environmental issues. GIS is one of the most common tools employed to solve sitting problems.

In this case, we did not find clear criteria that the MOE's decision makers could use to select the location for building a school. Within a series of interviews held with different employees at planning and project departments in the ministry of education, the employee at planning department said, "still no definite criteria to build public schools in the ministry, as everything depend on the "Absolute Growth" and needs ". For that reason, we have stated criteria that are used by neighboring countries, as there are similar features between Oman and neighboring countries. In addition, we also obtained the criteria from an official source, like Urban Planning Guide and The Annual Educational Statistics Book. Table 2, shows the criteria that we used to analyze the location of schools in Sohar city.

The number of public schools that are distributed in Sohar is forty-one. These schools were built in twenty-two villages as seen in Figure 5. Al-Hambar village has seven schools representing the highest total number of schools in the study area. According to unpublished statistics, Al-winat village represents the highest total population in Sohar followed in second by Al-Hambar, although it just has two public schools. The highest percentage of students is in Al-Hambar, as students come from neighbouring villages. Most of directorates of ministries are located in Al-Hambar that contributes to making it noisy and crowded. In addition, some schools are accumulated in certain areas that can lead to traffic jams.

Table 2. Criteria for evaluating and selecting location of school

| Criteria | Cycle one | Cycle two | I 1-12 School |
|---|----------------------------------|-------------------------------|-------------------------------|
| Proximity to street | Proximity to service road (150m) | Proximity to main road (50 m) | Proximity to main road (50 m) |
| The school should away from petrol station | 300 m | 300 m | 300 m |
| The school should away from stream of wadi | 300 m | 300 m | 300 m |
| The distance between the existing public school and another at the same level | No less than 500 m | No less than 1000m | No less than 2000m |
| The maximum travelling school | 60 min | 60 min | 60 min |
| The area size of school | 12000-25000 m ² | 25000-35000 m ² | 25000-35000 m ² |
| Proximity to other facility like health services, parks | | | |

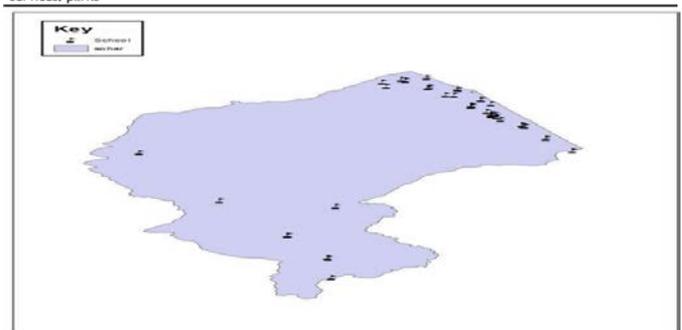


Figure 5. Public School's Distribution in Sohar

4. Findings and Results

By using Spatial Analysis Tool in ArcMap 10.2, we got the following results:

- The number of students in Sohar area is 23857, 51% Male and 49 % Female. The percentages of students in villages that have public schools are ordered from highest as following: Al-Humbar 23 %, Al-Tiraf 12%, Al-Siwhrah and Al- Multaque 14% (each one has 7%),
- Al-Awinat 6%, Falag Al-Qabail and AlAfifa 10% (each one has 5%), Majaz and Silan 8% (each one has 4%), AlGhushbah, Hibi, Falag Al-Oohi and Harh Al-Shik 18% (each one has 3%), Al-Hadhira, Mejes, Sayh Al-Birayr, Wadi Algzy, Ghail Al-Shibol and Al Khuwayriyah 12% (each one has 2%),
- Al-Khadd, Al-Mitarsha, and AlShibaybat 3% (each one has 1%).
- The type pattern of distribution of public schools in Sohar is "clustered" as seen in Figure 6. It discovered by using "Average Nearest Neighbor" tool in ArcGIS Desktop 10.2. Some villages in Sohar have schools and the others have not. In addition, some villages have more than one school at the same education level.

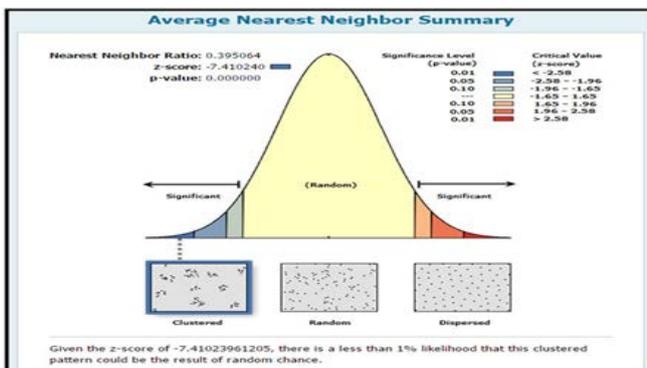


Figure 6. The type pattern of distribution of public schools in Sohar

- Thirteen schools that were built in proximity to the wadi's. For example, Abu Hamza Al-Shari Basic School was built proximity to wadi, and the distance between school and wadi is 79m, which represents the minimum distance as shown in Figure 7 & 8. The measure that is used to measure the distance between schools and wadi is 300m.

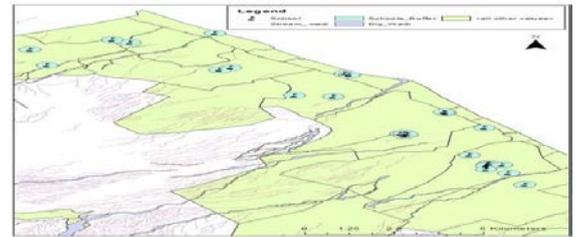


Figure 7: Buffer around school (Distance between school & wadi)

- Al- Hikma and Al-Humbar schools are in the same level of education which is cycle one. These were built beside each other in Al-Humbar. The distance between these schools is less than 10 m as shown in Figure 8.

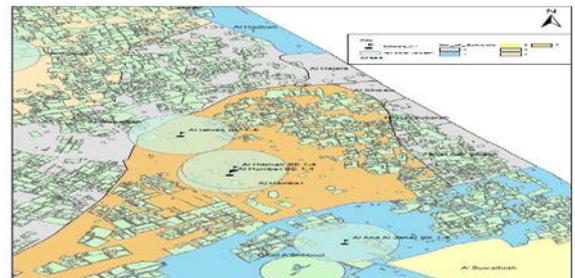


Figure 8: Distance between Al Hikma and Al Humbar's Schools (Buffer)

- The distance that we have used to evaluate the distance between existing schools and petrol station is 300 m. By using buffer tool, the result is all existing schools in Sohar away from petrol station as shown in Figure 9. The shortest distance that generated by ArcMap 10.2 between school and petrol station is 302 m.
- The location of school should be approximate to an existing road network (Schools, 2015) that will help to easily access to school and supportive to an efficient transportation system. The measure that is used to measure the distance between schools of Cycle 1 and service road is 150m. On the other hand, the distance that is used to measure the distance between Cycle 2 and Post basic education grades (11-12) schools according to the main road is 50 m.



Figure 9: Suggested new location for Al-Imam Ahmed bin Said school

5. Conclusion and suggestions

Our findings suggest some issues:

- Replace the location of Al-Imam Ahmed bin Said School (5-10) which was built beside Al-Hikma school (1-4) to location of Al-Safa Basic School (510). Because as we know the age of students at schools of cycle two is between (10-15 years), and some of boys at this period of age often display bad behavior and try to create problems. In addition, when moving the location of Al-Imam Ahmed bin Said school to the location of Al-Safa school it will be near to Sohar Sport Complex, which is better for them as shown in Figure 9.
- Build a new school of grade (11-12) or add new classrooms in an existing school in Al-Awinat, as it has a high population but is lacking in this type of school. That school will serve neighbouring villages like A'suwaihrah, Owtab, Khour Al-Seyabi, Al-Fatik and Majaz Al-Kubra.
- Build a new school in Seeh Al- Makarem village as more people are moving to live there. Figure 10 shows our suggested location to build a new school in Seeh Al-Makarem.



Figure 10: Suggested Location for new school

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