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Application of GIS for Population Analysis Case Study of Zwarah, Libya

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Abstract: In this study we have used a population project model to estimate the population growth for Zwarah city until the year 2050 and to calculate the current and future needs elements in urban planning of the city. Other objective was to guide development by studying the natural properties of the city boarder and to determine the suitable direction of city growth. For urban planning, we have employed GIS-ArcInfo to digitize the maps and GIS-ArcView to process the data combining with other analytical measurements to display the results. The average population growth rate of Zwarah city is 7.2% per year and the local migration growth rate is 131.13% into per year, total area of Zwarah city has increased from 3.55 km^2 in 1980 to 42.7 km^2 in 2000.

Key words: Population analysis, geographic information system, Zwarah (Libya)

INTRODUCTION

Libya is a large country on the Mediterranean coast of the North Africa, Libyan inhabitants is one of the smallest total in the African continent[1]. The average number of Libyan people km^2 is 3 persons[2]. Zwarah city is one of the biggest coastal plain in the north west of Libya, with very low population. At present, to assure the social stable is the key factor to keep and increase the economy development.

The cities like the trees, both of them grow under natural limits. The major elements of current urban planning (demographical studies) in Zwarah city are described by using a population project model to determine the population growth until the year 2050. In this model the population figures serve as a base for calculating the current and future needs elements for urban planning as well as for services. In urban planning, these elements should be available in a detailed spatial level (i.e. more information on age structure, household size, fertility, mortality rates and local migration). Geographic information system is a powerful tool to manage spatial data and database, widely using in different fields[3]. Both geographic information and population information are basic information although they can be used lonely. The integration of them will gain more important effects. GIS has abilities to create, store, edit, visualize, analyze and present the data, which is needed for carrying out the urban growth of the city.

MATERIALS AND METHODS

Study area: The study area, is located in the northwest of Libya and is about 110 km away from the capital city (Tripoli) and 60 km east of Libya-Tunis borders (Fig. 1). Geographically, it is located between the Latitude 32°56' N and the Mediterranean Sea and Longitudes (12° 04' - 12° 08') E[4]. This area covers about 42 $km.^2$

GIS dataset: The dataset was processed with Arcinfo and ArcView softwares. This data consists of a set of features represented by related files that can be manipulated by the data base management system .

A time series land use database is important to realize the existing land use structure and understand the process of land use change. In this study, three general landuse features were used as follows:

- Infrastructure change (transportation, communication, industry and utilities).
- Demographic change (population, residents, health and education).
- Other general changes (commerce, public, building, culture, religion, recreation and sports).

The land use maps for different years 1980,1990 and 2000 of Zwarah city were digitized into vector files (polygons) and the attributes were added using GIS-Arcinfo software.

In order to make an integrated analysis, the land use maps of different years were crossed to obtain the land

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Fig 1: Location map of the study area

use change. This process was easily completed by overlying the land use with the boundary maps of the different levels of spatial unit. By overlying the land use with the boundry maps of different levels of spatial units on intergrated analysis have been made to obtain land use changes.

Population project model: The term population growth refers to increases or decreases of a population with time. The birth and death rates are the main two factors that influence the size of the population[5]. With these basics we have considered a simple model to generate population projection growth. Which is based on the population projection method, which follows each cohort of people of the same age.

Elements of the model: The data used according to the last population census of Libya in 1980 as the actual population. To forecast the future population of an area data must available on the three major demographic variables; these that is Birth, Death and Migration. Growth can be explained through the following equation:

$$\text{Growth} = \text{Birth} - \text{Death} + (\text{Immigration}) - (\text{e-mmigration}) \quad (1)$$

The model used is based on age cohorts for both males and females throughout:

Fertility rate: Fertility rate is the average number of babies that women will have during their lifetime. Birth rates are commonly measured as the number of the births per thousand in a year. Birth rate depends on the fertility rate as well as the age distribution of the population. The general fertility rate is more refined than crude birth rate[6].

$$\text{General Fertility Rate} = \frac{\text{Live birth in a calender year}}{\text{Women aged } 15-45} \times 1000 \quad (2)$$

- Calculating the average number of deaths.
- Calculating the net migration.

In this model, we have used the estimated migration from the works of Poliservice Consulting Office (1978 to 1980) to format the projection should follow to apply this model following steps:

- Apply formula to find the Fertility rate: for example when the fertility rate equals two, that means a woman or a group of women would be excepted to have two children on average.
- Multiply the factor (CBRG) by the different women groups (15 - 45)
- Multiply death rate factor by different male and female groups.

Table 1: Forecast of household and land supply

Years	Dwelling demand	Residential area by Hectare
1980	3271	110
1990	10434	424
2000	23929	957
2010	30385	1215
2020	38128	1525
2020	50547	1856
2050	104939	4200

Housing forecasting: The aggregate method is the simplest method used to forecast household numbers (1). The forecast Population (P) is divided by the forecast of average household Size (S) to produce the forecast number of Household (H).

$$H = P/S \quad (3)$$

$$A = H^* Ha \quad (4)$$

Where:

A: is the area required
H: is the number of houses
Ha: is average housing size

By applying the formulas (3) and (4) and according to the population model, determine the housing numbers and the areas required for the residential planning. (Table 1).

RESULTS AND DISCUSSION

Forecasting population: The local population of Zwarah increased by 75% from 1969 to 1980[7]. According to the results of this model we can estimate that the population of Zwarah has increased by 550% from 1980 to 2000 with expected figure of 263605 in 2030. Table 2 describe the birth rate, death rate and growth changes.

In Table 2 there is the average population growth from high birth and death rates to low birth and death rates and from zero out-migration to high in-migration. This process of change from rapid population growth to slow population growth is called demographic transition.

Gross population density: The population density that measures the total residents per unit area, is a useful indicator for the density of drivers, potential transportation users, workers, available streets, parks, other recreation sites, offices, manufacturing, commerce and the undeveloped areas as well (Table 3).

The high value of the population density was mainly in 1980. This indicates that at that time there was a high net population density (Total population/Total residential area) or high ratio of the residential area. Comparing the land use structures in 1980 with that in 1990 and 2000 it is clear that decrease of population densities because the

Table 2: Demographic data

Population, crude birth rate, crude death rate, natural increase rate, total increase rate and total fertility rate in Zwarah City from 1973 to 2030

Year	Total pop	Crude birth rate	Crude death rate	Natural increase rate	Increase rate	Fertility
1973	14100	57.8	10.1	4.17	4.17	8.71
1980	20000	58	7.88	5.01	10	9.87
1985	30000	54.9	7.31	4.76	23.25	9.2
1990	60000	50.85	6.21	4.46	11.11	8.47
1995	90000	47.33	6.13	4.13	9.48	7.81
2000	130000	43.95	6	3.79	3.79	7.16
2005	144573	43.95	6	3.79	3.79	7.16
2010	161912	43.95	6	3.79	3.79	6.94
2015	177540	43.95	6	3.79	3.79	6.94
2020	202081	42.67	5.96	3.67	3.67	6.94
2025	230248	42.67	5.96	3.67	3.67	6.94
2030	263605	42.67	5.96	3.67	3.67	6.94

Table 3: Distribution of the population ages in Zwarah city from 1980 to 2030

		Age period and population percentage												
Years	Age	0-5	6-11	12-17	18-22	23-27	28-32	33-37	38-42	43-47	48-52	53-57	58-62	63+
1980	%	23	19.7	8.3	6.0	5.9	5.2	5.0	4.9	1.8	3.1	2.9	2.2	1.9
1990	%	21.2	20.0	8.8	6.1	6.1	5.3	5.1	4.9	2.0	3.1	2.8	2.2	2.0
2000	%	17.5	20.9	8.9	6.2	6.2	5.8	5.2	5.0	2.1	3.1	3.0	2.9	2.9
2010	%	17.4	20.6	8.9	6.3	6.2	5.8	5.2	5.0	2.1	3.1	3.0	2.9	2.9
2020	%	16.4	20.4	8.7	6.1	6.0	5.9	5.3	5.0	2.1	3.1	3.2	3.1	3.0
2030	%	16.5	20.2	8.6	6.1	6.1	5.8	5.3	5.0	2.1	3.1	3.2	3.1	2.9

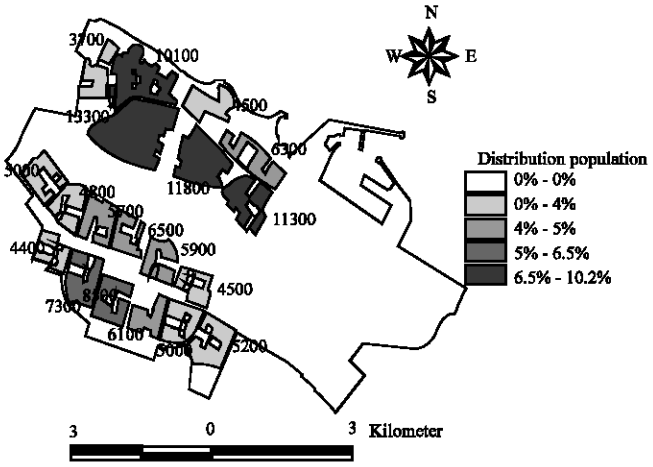

Fig. 2: Distribution of the population of Zwarah city in 2000

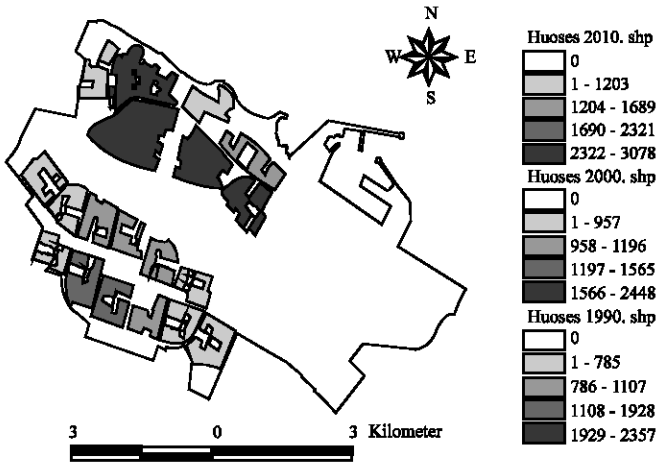

Fig. 3: The residential area of Zwarah city in 2000

ratio of the residential area is higher than the increase in population. From 2010 to 2050, the population density should be increased.

According to the characteristics of the city, it can be seen that physiographical features have not any impact on the population density. The highest fractions of land area were in 1990 and 2000 and the lowest fractions were in 1980 because in 1990 and 2000 the urban land area ratio had increased higher than the increase of the residential ratio. In 2010, the residential ratio is the same as in 2000 but the population will be increased.

Age distribution and sex ratio: In demographic analysis, data related to age and sex distributions is important for the analysis of the population dynamics[8]. From a geographical perspective, the interest is in the spatial variation of age and sex distributions as shown in Table 4.

Figure 2 indicates that the city's male and female populations are almost equal in number. The populations of Zwarah are relatively young, with 53.8% of the population are of 0-24 years age. The percentage of the students in the city is very high and potential labor force is about 33.6% of the population.

Residential sector: In Zwarah the residential area comprises 1.1 km^2, which is 32.4% of the urban land in 1980 and 9.55 km^2 and is 29% of the urban land in 2000, therefore the housing location is important for its own position as well as a means of access to other facilities.

Figure 3 shows that the physiographic features have not any impact on the distribution of the population. The present plan of Zwarah city is directed to the south, which has a big effect on the settlement of the foundation and concrete to steel reinforcement because most of the

Table 4: Gross population densities in Zwarah city from 1980 to 2050

Years	Gross Population density (persons ha^{-1})
1980	59
1990	43.6
2000	39.4
2010	49
2020	61
2030	79
2050	158

Table 5: Net residential densities in Zwarah city

Year	Total dwelling units	Residential area by Hectare	Net residential density (dwelling ha^{-1})
1980	3264	110	30
1990	10601	450	24
2000	23927	960	25
2010	30385	960	32

Table 6: Net household densities in Zwarah city

Year	Net household density (persons ha^{-1})
1980	181
1990	133
2000	134
2010	168

southern areas are marshy, so the urban plan should change the residential planning towards the west, where the hard sand is suitable for construction.

Net residential density: Depending on 1980 census, the population projection model and Arcview analysis have been used to calculate the residential area and according to formula (3) we can estimate households and the net residential densities, which represent the densities of dwelling units in the residential areas Table 5.

In 1990 the residential density decreased because the construction growth was higher than the population growth. From 1990 to 2000 the residential density increased, which indicated the construction in the city was less than before.

The net household density Table 6 represents the density of households in the residential areas.

By a comparison of the net population density with the net households density it is concluded. Net households density is equal to the net population density.

Location of hospitals: Maintaining the balance of the demand and supply of health service is a problem in health service planning because of insuffeciant information. For example, many small towns and villages depend on the health facilities of Zwarah city. According to this situation, it is very difficult to decide if the health services are adequate or not for the population.

The second step in the analysis of the demand health Services is to combine the population number with the health services in different years, by using a polygon overlay technique create a new GIS map that contains the boundaries and the attributes of input maps.

The simplest approach to a real analysis is to assume that only people of this city being serviced by a health facility.

Education: The buildings for education purpose represent 6.2 and 5.6% of the urban land in 1980 and 2000 respectively. By using a polygon overlay technique to combine the population number with the distribution of the schools in the city we can find that the city has a fair distribution of the schools and the educational buildings are expedient with the population number.

CONCLUSIONS

According to the population census in Libya in 1980 and the result from the population project model the average population growth rate of Zwarah city is 7.2% per year. The local migration growth rate has changed during the years 1985-2000, with zero local migration in 1980, 4189 in 1985 and 86588 in 2000, so there is an average local migration growth rate of 131.13% per year, which is due to the decreasing people from neighboring towns and regions who seek employment and livelihood opportunities as well as higher education in the city.

The city area was increased from 3.55 km^2 in 1980 to 42.7 km^2 in 2000. This situation was reflected on the city's population density, which rose by almost (59.6%) persons km^2 in 1980 to (39%) 2000. The net households density was greater than the net population density; therefore the residential area was adequate for the people at that time. However, if the migration will continue then the population will exceed the capacity of the city.

The total number of dwellings in the city based on 1980 data was 3271 and the number of dwellings in 2000 was 23929 as shown in Table 1. The populations of Zwarah are relatively young, with 53.8% of the population belonging to the 0-24 years age. This places the potential labor force at 34.5 % of the population.

The overlay technique is useful. It can demonstrate if there is any inadequate health facilities and educational buildings or unfair distribution.

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