Spatio Temporal Analysis in Land Use and Land Cover Using GIS Case Study: Gaza City (Period 1999 – 2007)

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Abstract— In recent years, Gaza City is exposed to a large amount of land use and land cover changes, as a result of lack of planning and monitoring programs. This leads to complex serious problems such as: lack of storm water infiltration, impact of global warming, potential agricultural failures, soil erosion, etc. Due to increasing changes of land use, mainly by human activities, detection of such changes, assessment of their trends and environmental effects are necessary for future planning and resource management. This study aims to detect changes occurred in Gaza City for land use and land cover during the interval between 1999 and 2007using GIS techniques. It shows that within the period from 1999 to 2007, the built up areas have been reached the highest increase (8.06%). On the other hand, both of green and dry lands have been decreased. Certainty, the green lands is transformed from 41.79% in 1999 to 38.80% and the dry lands become 18.80% in 2007 while it is 24.16% in 1999. For the wet lands, the area of this category has been increased with a percent of 0.96% as a total in 2007. Depending on those numbers, the study expects that the built up areas will be the dominance at the expense of other categories as a result of the continuous population growth and in accordance to the proposed master plan of 2025 of Gaza City. The study strongly recommends giving real opportunity for the local community in sharing in the awareness campaigns to introduce the scope of this study for all community sectors to be aware about LULC for upcoming generations.

Index Terms— Change detection, Gaza City, Land use and land cover, GIS.

I INTRODUCTION

Change detection is the process of identifying differences in the state of an object or occurrence by observing it at different periods [1]. Reference [2] defines change detection as the comparison and difference of multi temporal images of the same geographical area. This is achieved by using image-handling techniques to analyze the changed areas of the landscape over different times. Change detection is a key for monitoring the globe natural resources through analysis to spatial distribution of the population of attention. Aspects of change detection that are necessary for monitoring natural resources are; detecting changes that have occurred, identifying the nature of the change, and measuring the size of the change [3].

The change of land use and land cover (LULC) is a result of complex relations between some biophysical and socio-economic situations that may occur at different temporal and spatial scales [4]. Land cover refers to physical conditions on the ground or natural cover of the land for example forests, grasslands, etc. while land use refers to the human actions such as residential areas, industrial areas, and agricultural fields [5]. LULC change detection is required for updating LULC maps and the management of natural resource.

Change detection for land use and land cover is an active topic and provides varieties of new techniques constantly developed over the last years. It is not easy to choose a suitable technique for specific change detection,. In general, a good change detection research should give information like the area of change and change rate, the spatial distribution of changed types, the change trajectories of land cover types and the accuracy assessment of change detection results [6]. For this reason, a review of change detection techniques used in previous researches is useful to understand how these techniques can be best use.

Reference [7] classifies change detection techniques for land use and land cover into the following seven categories: (1) Algebra, (2) Transformation, (3) Classification, (4) Advanced models, (5) Geographic Information Systems (GIS), (6) Visual analysis and (7) other techniques.

II THE STUDY AREA

Gaza City is a Palestinian City in the Gaza Strip. It is considered as the second capital of Palestine because of its strategic location, its economic importance and the presence of most of the headquarters of the Palestinian National Authority [8].

After the establishmentl of the Palestinian National Au-

thority in 1994, Gaza City has witnessed extraordinary expansion, growth and developmental activities such as construction of buildings, roads and many other human activities. This lead to increase land employs and rapidly making changes in the status of its land use and land cover over time without any action to monitor and evaluate this status. The area of the City is estimated to be 55.6 square Kilometers [9]. Figure 1 shows the geographic location of Gaza City.

Gaza City is located on a low-hill with an elevation about

Figure 1 The Geographic Location of Gaza City

45 meters above sea level. Much of the urban expansion of the City is parallel to the coast in addition below the hill especially to the north and east to form Gaza neighborhoods and border of the City. At three kilometers distance west of the City core, the port of Gaza is located [9].

Gaza City participates border with border towns of Jabalya, Beit Lahiya and Beit Hanoun in the north while it's enclosed by the Mediterranean Sea in the west, in the south the al-Zahra City while the remaining border of 1978 are the restrictions of the City from eastern border. Gaza City is divided into seventeen neighborhoods as follow: El Daraj, Sheikh Radwan, El Awda City, Northern Remal, Southern Remal, Sabra, Nassr, Tuffah, Ijdaida, East Ijdaida, Old City, Shiekh Ejleen, Zaytoon, Tal El-Hawa, Beach Camp, Turkman and East Turkman (see Figure 2).

Nowadays, Gaza City is the biggest population center with about 496,410 inhabitants and the average population density is almost 6913 person/km^2 [10].

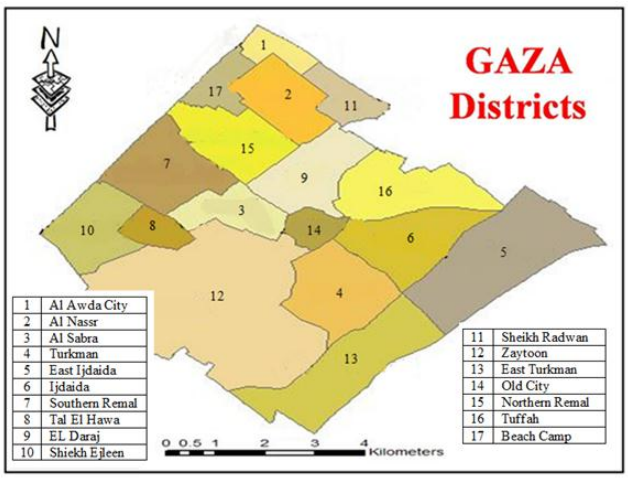

Figure 2 Neighborhoods in Gaza City

Table 1 shows the Gaza's population for each neighborhood in 2009 [9].

TABLE 1
The Population in neighborhoods of Gaza City

SN	Neighborhood	Population	(%)	SN	Neighborhood	Population	(%)
1	Al Awda City	8250	1.40	10	Shiekh Ejleen	20350	3.46
2	Al Nassr	33000	5.61	11	Sheikh Radwan	36000	6.12
3	Al Sabra	27500	4.68	12	Zaytoon	66000	11.23
4	Turkman	48000	8.16	13	East Turkman	42000	7.14
5	East Ijdaida	1000	0.17	14	Old City	27500	4.68
6	Ijdaida	35750	6.08	15	Northern Remal	22000	3.74
7	Southern Remal	30250	5.15	16	Tuffah	41500	7.06
8	Tal El Hawa	8800	1.50	17	Beach Camp	90000	15.31
9	EL Daraj	50000	8.50				

The Landsat satellite images of Gaza City are acquired for two epochs, 1999 and 2007. Both images have a resolution of 50 cm and 20 cm respectively. Unfortunately, only these two images are available. However, studying the change of LULC may express the required needs since there is no significant changes have been occured after 2007 due to the siege of the Gaza Strip up to now. Figure 3 and Figure 4 show the aerial photographs of Gaza City as well as the city neighbourhoods.

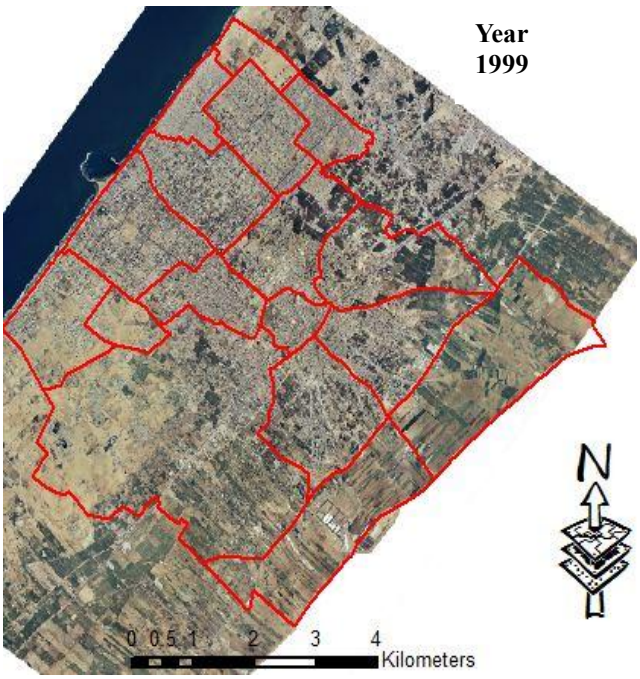

Figure 3 Aerial Image (1999)

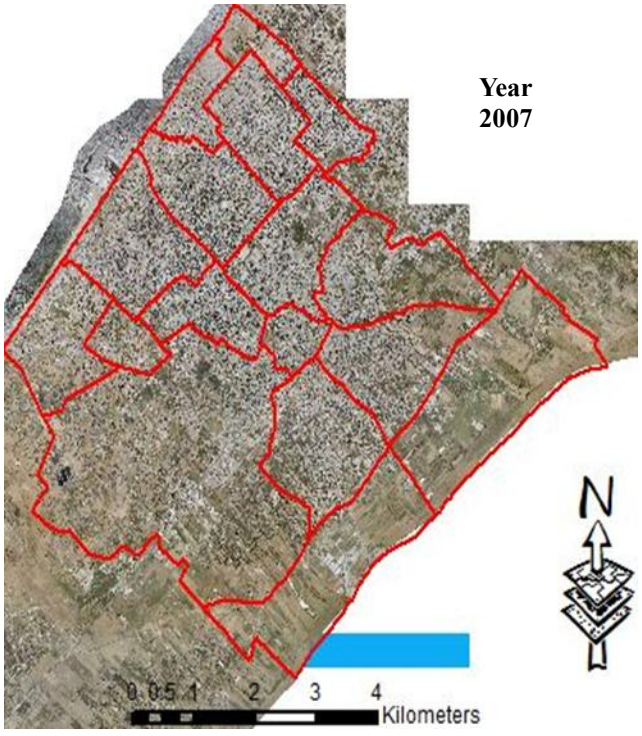

Figure 4 Aerial Image (2007)

III LULC CLASSIFICATION

There are many land use and land cover classification systems that are used in many countries of the world, such as Classification of the U.S. Geological Survey and Ecological Land Classification System. That is noted; these systems containing the ratings are not presented or used in Palestine or in the Gaza Strip in particular, such as forests and wetlands.

Palestinian Central Bureau of Statistics (PCBS) [10] in 2007 has developed a classification system for land use based on the classification system of the Economic Commission for Europe (ECE). This classification contains thirteen different patterns of land uses, but it contains some classifications that do not exist in the Gaza Strip, such as jungle, the territory of the settlements and natural reserves, although they exist in the West Bank. In addition, that is not comprehensive for all land uses and land cover [11].

In 1997, the Municipality of Gaza in cooperation with the Ministry of Local Government developed a structural plan of the City consisting of the following classifications (Figure 5): residential zone class A,B,C, freeze development zone , agriculture residential zone , beach zone, main commercial center, old town, commercial facades, tourism and recreation zone, public buildings, green area, archeological site, public cemeteries, sport zone, existing roads, ring roads, railway land, storm water collection area, regional transportation center, industrial area, and agricultural area.

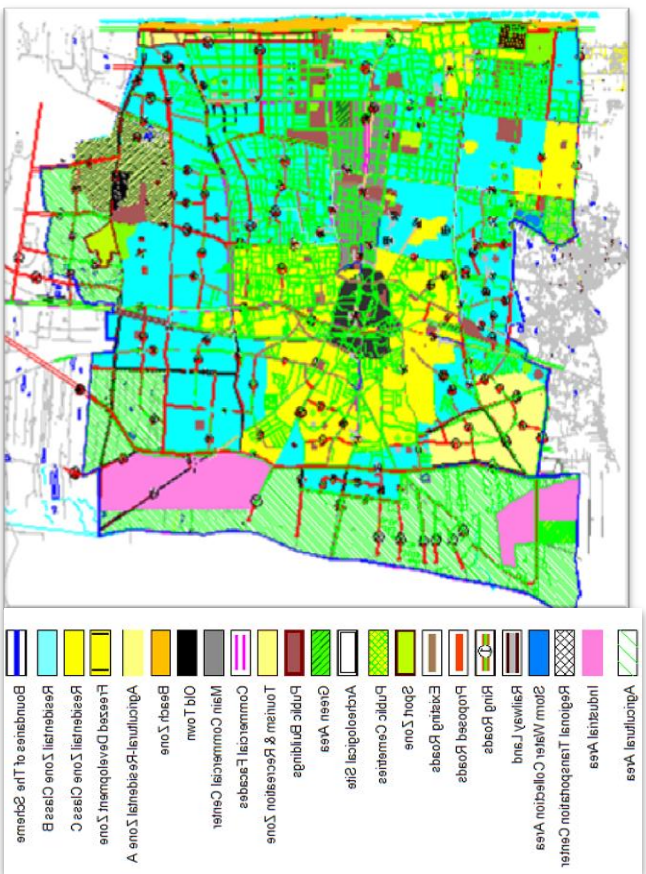

Figure 5 Structural Plan of Gaza City

Because of the difficulty of obtaining maps with high accuracy and providing maps with low resolution from multiple sources, it is difficult to use the technology of remote sensing. In addition, GIS technology is used because of the small size of the study area for classification of land use and land cover. For these reasons, it is recommended to establish a special classification in this research to reflect the variance of the categories on the LULC so that it contains all categories.

It was observed that this classification can be collected into groups so that commensurate with the nature of the research as well as it covers all land uses and land cover in the City. Therefore, in this research, the established land use and land cover in Gaza City categories are listed below:

- Built Up Land: which consists of residential, main commercial center, old town, commercial facades, tourism and recreation zone public buildings, public cemeteries, existing roads, ring roads, railway land, regiona transportation center, sport zone, and industrial areas.
- Green Land: which consists of green and agricultural areas.
- Wet Land: which consists of storm water collection areas.
- Dry Land: which consists of all areas that do not fall under the categories of the three previous (This is an area of land covered with gravels).

IV METHODOLOGY

In this research, GIS is used as a technique of change detection. It is considered as an effective technique in studying the LULC change as it helps in trialing, analyzing, surveying lands and calculating averages for studying categories. In addition, this technique is recognized with its ability to view two stages of the study categories on maps.

A Data Preprocessing

Aerial images of Gaza City taken in 1999 and 2007 are used to detect changes of LULC. Many steps have been done to prepare needed data. It starts by preparing the required layers for many processes in the study, making ready the database using Arc Catalog software, exporting of different extensions of data files and modifying them with extensions of required data files. The next step is to update files to Arc Map software, and preparing of all statistical data by Microsoft Excel software in order to simplify dealing with them through this study.

Georeferencing is the first and fundamental to build of vector spatial model, where this process has been applied to overlaying aerial images of 1999 with 2007 using the local coordinate system (Palestine Grid). The process was needed to reach high accuracy during implementation to achieve the greatest possible congruence between the two images and align distortion ratio in aerial images. Twenty control points are used to rectify and georeference the two images. Points selection considers the distribution of neighbors of Gaza City including its border to reach maximum degree of comply between the two aerial maps. This is necessary in order to achieve accuracy in results for the areas to prevent any losses or repetition/ duplication of any area during the study completion. RMS is noted to equal ± 0.005 m.

B Digitizing Process

For process applications during the project, it was based mainly on the existing classification of the LULC of Gaza City. The process is to build vector spatial model that describes the type of spatial data for the LULC because the following operations will depend upon the use of spatial database for this process. All issues that have been mentioned previously have been taken into account during implementation. It has been the primary goal of this process for spatial representation to LULC items in Gaza City for years 1999 and 2007 separately in order to apply change detection process using these data.

Digitizing has been done for each neighborhood and its database was built by ArcCataloge to be easier in handling with data for any application following the digitizing process. To guarantee there is no any mistakes as decreasing or increasing in areas during the digitizing process, snapping function has been used for all points (start, end, and vertex) between polygons during the process.

C Topologic Model

Topology process is one of the most important audited processes for data accuracy which will be built among many of the analytical processes of the project, especially for digitizing stage. In addition, through them there is modification for all the problems of overlaps and intersections between vector spatial data. The amounts of large areas that have been implemented during the digitizing stage require topology process to check for errors resulting from each district.

D Editing Functions

Editing functions are used through all project phases to add, delete, or manipulate the geographic position of features. Sliver or splinter polygons are thin polygons that occur along the borders of polygons following digitizing and the topological overlay of two or more coverage's. In other words, Editing is the detection of errors in text records or spatial database features and the implementation of the needed correction. Corrections can include additions, deletions, and rearrangements, as well as changing size, font, style, color, orientation, alignment, scale, and rotation. Editing techniques are exclusive to spatial features and include changing elevation, thickness, and width, attribute assignments, surface textures, dimensioning and others [8].

D Development of a Classification Scheme

Based on the classification of Gaza Municipality of main classification for LULC in Gaza City (Built Up, Dry Land, Green Land and Wet Land), a classification scheme was setting to develop the study approaches. It is necessary where identifying and interpretation of LULC by attribute data with spatial data for each area. Figure 6 shows the classification method:

E Change Detection Tools

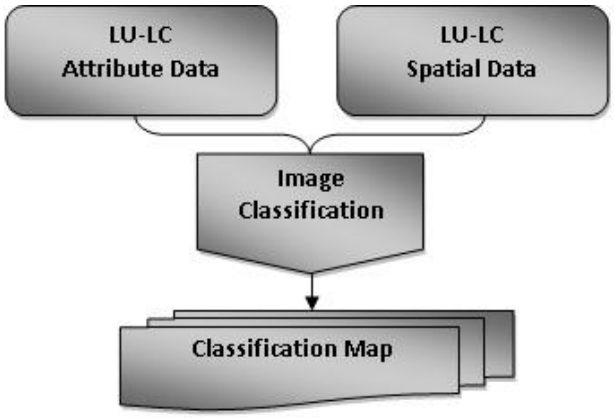

Figure 6 Classification Scheme

GIS software provides an Erase Tool which is useful in showing change of places and areas in general. To know the directions of any increasing or decreasing which could be occurred in classification study, the intersect tool can be used. Figure 7 illustrates an example of using intersect tool.

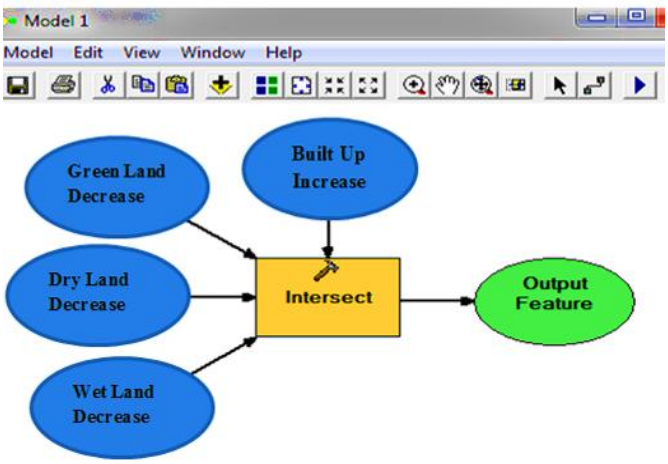

Figure 7 Example for use of intersect tool

V Results and Analysis

The gained results, after the digitizing process has been completed, were mainly the calculated areas for classified regions of LULC and the representative percentage for each one in the both 1999 and 2007 years. The built up class during 1999 to 2007 increases from 33.38% to 41.44%, while the areas of dry land decreases from 11075.75 Dunom in 1999 to reach 8617.43 Dunom in 2007. Table 2 presents the areas and study classification percentage in 1999 and 2007. In general, there is an increasing in built up class, decreasing of dry land class and green land class, and little increasing in wet land class.

TABLE 2
Control Rule Base for MPPT Fuzzy Controller.

Classification	1999		2007	
	Area (Dunom)	% of Area	Area (Dunom)	% of Area
Built Up	15303.9912	33.38%	18998.6425	41.44%
Dry Land	11075.7577	24.16%	8617.4293	18.80%
Green Land	19158.6333	41.79%	17784.6436	38.80%
Wet Land	303.2133	0.66%	440.8802	0.96%
Total Area	45841.5955	100%	45841.5955	100%

The percentage of changes between different LULC classes for the period 1999 to 2007 can be derived from Table 3. According to the results, the higher increasing of change detection in built up class of the City is estimated as 8.06% almost annual increase rate is estimated at 1%. In addition, about 0.30% increasing in wet land class has been noticed. Otherwise, there is a decreasing of change in dry land class as -5.36% and about -3.00% decreasing for green land class. In addition, Table 3 presents a summary of the area change for LULC types by dunom.

TABLE 3
Summary of LULC Change Detection

Classification	Change Detection (Dunom)				
	Increase	Decrease	Change	Area 2007 (Dunom)	% of change
Built Up	3963.7120	269.0608	3694.6512	18998.6425	8.06%
Dry Land	2042.5844	4500.9129	-2458.3285	8617.4293	-5.36%
Green Land	1682.5316	3056.5213	-1373.9896	17784.6436	-3.00%
Wet Land	137.6669	0.0000	137.6669	440.8802	0.30%
Total Change	7826.4949	7826.4949	0.0000	45841.5955	0.00%

It is very important to evaluate the current situation for land use, to know any increasing or decreasing direction of classification of LULC. Generally, in the study area, a change has been noticed cross of the classification classes. Intersect tool has been used to get these results as shown in Figure 8 and Figure 9. They explain the location of all increases and decreases for built up, green land, dry land and wet land.

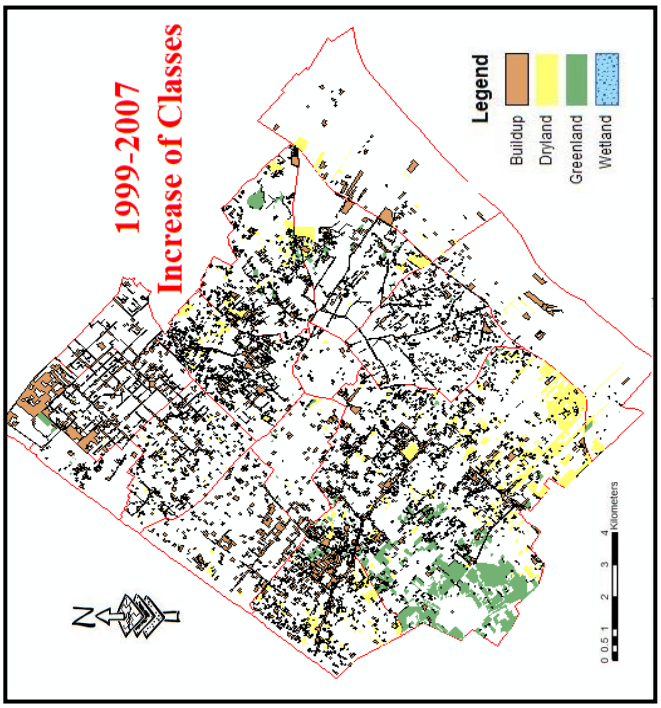

Figure 8 LULC increases of classes (1999-2007)

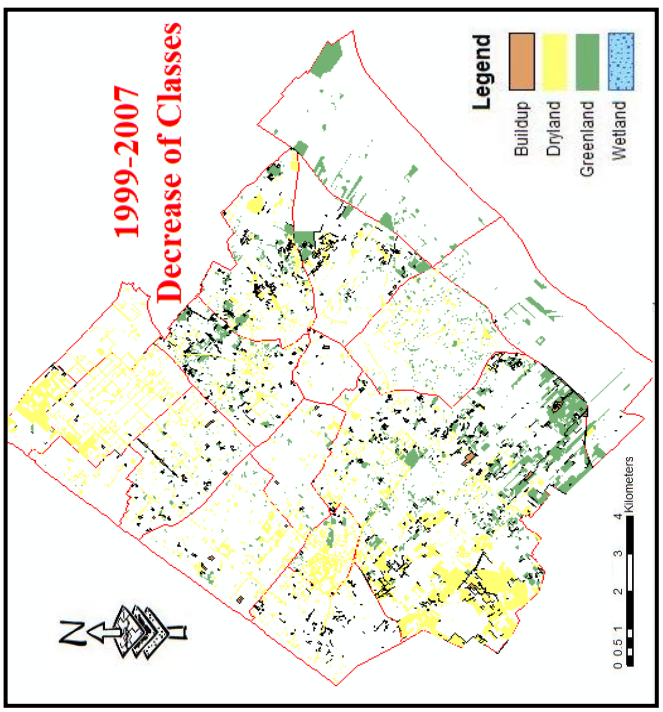

Figure 9 LULC decreases of classes (1999-2007)

It is noticed that the built up of the north western of the City increased because the existence of Al Awda City which was constructed at the expense of the dry land. The south of the City, the dry land is also decreased because it is transformed to green land. In addition, the built up class is increased in "Tal El hawa" neighborhood to face the extension of Netsareem Settlement during that time. The political situation in the Gaza Strip affected the decreasing of green land in the east of the City where this area becomes dry land because the army frequent attacks of this region and make damages to its agricultural area.

The changes in the LULC over Gaza City neighborhoods can be observed from Table 4 which displays the proportion of representing area as structural plan, population and the change detection happened in built up, green land, dry land, wet land classes.

TABLE 4
Percent Change in LULC of Neighborhoods of Gaza City

SN	Neighborhood	Area as structural plan (%)	Population (2009) (%)	Change Detection of Study Classification (%)			
				Built Up	Dry Land	Green Land	Wet Land
1	Al Awda City	1.40	1.40	40.91	-43.61	2.70	0.00
2	Al Nassr	4.46	5.61	21.06	-21.06	0.00	0.00
3	Al Sabra	3.31	4.68	5.33	-4.49	-0.84	0.00
4	Turkman	6.33	8.16	8.92	-4.58	-4.34	0.00
5	East Ijdaida	10.78	0.17	2.74	1.45	-6.98	2.79
6	Ijdaida	6.01	6.08	6.79	-1.34	-5.44	0.00
7	Southern Remal	5.53	5.15	10.58	-9.27	-1.31	0.00
8	Tal El Hawa	1.73	1.50	26.32	-28.55	2.23	0.00
9	EL Daraj	5.30	8.50	11.77	-4.45	-7.31	0.00
10	Shiekh Ejleen	4.62	3.46	10.73	3.94	-14.68	0.00
11	Sheikh Radwan	2.24	6.12	8.85	-8.85	0.00	0.00
12	Zaytoon	24.72	11.23	6.02	-6.18	0.16	0.00
13	East Turkman	8.66	7.14	2.34	1.32	-3.66	0.00
14	Old City	1.53	4.68	2.07	-1.81	-0.26	0.00
15	Northern Remal	5.09	3.74	8.38	-5.98	-2.39	0.00
16	Tuffah	6.33	7.06	7.99	-5.42	-2.57	0.00
17	Beach Camp	1.96	15.31	4.42	-5.03	0.61	0.00

In general, all classifications of LULC in neighborhoods have been decreased except the built up class. In addition, green land class increases with about 2.7% in Al Awda City neighborhood and 2.23% in Tal El Hawa basically because of good planning. Otherwise, there is a notable increasing in dry land regions in the southern and eastern of the City, particularly, increasing in East Ijdaida and East Turkman neighborhoods, Shiekh Ejleen district which is specially referring

to the security status and the continuation of Israeli invasions during the study period which led to convert many green land regions into dry land. Moreover, no increasing in wet land area has been noticed excluding East Ijdaida where a sewage treatment station was constructed to cause 2.79% change detection.

According to the results illustrated on the Table 4, realizing that the higher increasing changes detection in built up class in Al Awda City is estimated as 40.91% which can be considered as new neighborhood. Another rising on the area is estimated as 1.4% as a residential tower to accommodate 1.4% of the population. Tal El Hawa residential Also represents 1.5% of the population and constitutes 1.73% of the total area City. Tal El Hawa becomes after Al Awda City in change detection increasing in built up to constitute 26.32%.

On the other hand, Al Nassr neighborhood is the third largest one in terms of change detection within 21.06% and occupying 4.46% of the City area, which is a high rate area comparing to northern Remal neighborhood areas which constitute 5.06% and change detection in built up 8.38% while southern Remal within 5.53% of the total area of the City and increasing change in built up estimated 10.58%. Noticing that the population percentage is nearly close in the three neighborhoods and with no big differences (Al Nassr 5.61%, Southern Remal 5.15%, and Northern Remal 3.74%) due to the high proportion of land purchasing price in Southern Remal and Northern Remal than Al Nassr. It is to be the most prestigious squares and many governmental buildings, educational institutions are including in those neighborhoods in addition to many commercial lands.

The Structure Plan of Gaza City which is to be adapted to residential and tourist town is clearly observed in the ratio of built up, which constitutes 81.98% of the original City area. While, green land covers up 17.79%, the dry land 0.00%, and wet land 0.23% as a sewage basin and treatment station.

TABLE 5

Percent of area classes as in structural plan and image 2007

Classes	Area as in Structural Plan	Area as in Image 2007
Built Up	81.98%	41.44%
Dry Land	0.00%	18.80%
Green Land	17.79%	38.80%
Wet Land	0.23%	0.96%

Table 5 presents percentage of area classes comparing between structural plan and the result change in 2007.

Expectation of the LULC according to the structural Plan is trying to highlight the problem of limited space areas and the continuous population growth where the built up class constitutes 81.98% which means the extra needs for an urgent planning and revising in order to recognize appropriate solutions for using the available areas to figure out future solutions. The idea of this expectation depends on finding a correlation equation between the built up area and the population in order to forecast the year of which the whole built up areas will be fully occupied according to the structural plan for Gaza City in 1997 by using prediction equation of the population growth rate P=Po (1+R)t [12].

The relation between the increasing uses of built up land and the population growth of the City is strong and effective relation and it was clearly observed in the use of the LULC, which was observed based on the results and data of the study.

Table 6 shows the relationship between the built up rate and the population assigned and predicted. Excel helps to develop the trend equation for this relation, (Y= 12371X-16404) where, (X) is the built up rate, and (Y) is the number of population growth expected practically. Applying the equation, it leads to know the predicted population growth rate and which year is expected in rise based on this census in the City using the equation to predict the population growth rate, year 2025 witnessing a complete using and possessing of areas in the City.

TABLE 6

Predicting the relationship between the built up rate and population

Year	% of Built Up	No. of Population
1997	30.98	367388
1999	33.38	395840
2007	41.44	496410
2025	81.98	997770

VI CONCLUSION

The study has designed many digital computerized and accurate maps, which are connected to databases for the most obvious results of the study indicates that the City witnessed a continuous growth and changing taking places in many terms; politically, governmentally, educationally, demographically and touristic. Those terms are considered as the most important change which consequently reflects on the LULC. The study comes to describe areas, places, rate and its change detection for classification study. The results observed increasing in built up purposes by alteration average 8.06% otherwise areas like dry land and Green land are declining by alteration average -5.36% in the dry land and -3.00% in the Green land. Noticeably, there was a slight increasing in the wet land areas by 0.30%. Regarding to the provided information research, the study expects a rapid growth for the built up class due to population growth, which will help on filling up all the chosen areas according

to the structural plan of the City by year 2025.

The study identifies a various transformations of the LULC during the study period referring to many reasons; political situations, social situations, economical and administration situations apparently because the absence of controlling systems and not fully put up with laws and construction regulations.

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