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A Change Detection for

Land-Use and Land-Cover of Gaza City Using Geographic Information System (GIS)

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DEDICATION

To

My Beloved Parents

My Best Friends

My Brothers

My Wife

And

My Sons

ABSTRACT

Changes in Land Use and Land Cover (LULC) in Gaza City are very normal and dynamic as a result of human use of the land and his surrounding environment. By the coming of Palestinian Authority in 1994 and the continuous population growth in Gaza, the City has witnessed many evolutions in different fields which cause many changes on the land use.

The goal of this study is to detect and analyze the changes in LULC in Gaza City within the period from 1999 to 2007 by using GIS technology which has been chosen depending on available data and maps. The lands have been divided to four major categories; built up areas, green lands, wet lands, and dry lands. Actually GIS is the most useful, powerful and advanced tool in dealing with databases either in connecting database, processing, analyzing, or its ability to develop and update.

The study is able to describe the location of all changes in LULC and estimate the areas of those changes in all four categories of LULC. It is very obvious that within the period from 1999 to 2007, the built up areas have been reached the highest increase which is changed 8.06%. It reaches to 41.44% in 2007 in comparison with other land use categories. 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 was 24.16% in 1999. For the wet lands, the area of this category has been increased with a percent of 0.96% as 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 importance of this study is clear where it gives planners and decision makers all needed results and maps to reach full understanding of all nonstop changes in LULC and their trends either timely or spatially. It could be useful in periodic evaluation and redesign of strategic plans of LULC via using GIS and remote sensing in following changes in LULC by time. 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.

ملخص الدراسة

ان التغيرات الحادثة في استخدام الارض والغطاء الأرضي لمدينة غزة (LULC) هي ظواهر طبيعية وديناميكية باعتبارها نتيجة استخدام الإنسان للأرض و البيئة المحيطة به. ومع قدوم السلطة الفلسطينية عام 1994 و تزايد عدد السكان الكبير لمدينة غزة شهدت المدينة تطورات في جميع المجالات نتج عنها كثير من التغيرات على استخدامات الاراضي .

الهدف من هذه الدراسة كشف وتحليل هذه التغييرات التي حدثت لاستخدام الأراضي والغطاء الأرضي خلال الفترة بين 1999 و 2007 باستخدام تكنولوجيا نظم المعلومات الجغرافية والتي تم اختيارها على أساس البيانات والمخططات المتاحة للوصول إلى النتائج المطلوبة ،حيث تم تقسيم الاراضي المستخدمة والغطاء الأرضي الى اربع تصنيفات رئيسية تخدم هدف الدراسة وهي فئة اراضي البناء والتطوير (Built Up) والأراضي الخضراء (Green Land) والأراضي الرطبة (Wet Land) والأراضي الجافة (Dry Land). تكنولوجيا نظم المعلومات الجغرافية و التي تم استخدامها في الكشف عن التغيرات هي واحدة من أكثر الأدوات المفيدة والقوية والمتقدمة في مجال توفير قواعد بيانات وخرائط وربطها ببعضها البعض ومعالجتها وتحليلها بالإضافة الى امكانية تطويرها وتحديثها بشكل دائم.

توصلت الدراسة الى وصف اماكن التغيرات و تقدير مساحاتها الحادثة على الاراضي المستخدمة والغطاء الارضي للمدينة حسب تصنيفات الدراسة بالإضافة الى تقديم تفصيل لهذه التغيرات لكل حي من احياء المدينة. يظهر بوضح ان في الفترة الواقعة بين 1999 و2007 كان هناك زيادة في التوسع العمراني واستخدام مساحات جديدة لأغراض البناء والتطوير حيث احتل تصنيف اراضي البناء والتطوير اعلى نسبة في التغير مقارنة ببقية التصنيفات والذي قدر بـ 8.06 % ليشكل ما نسبته 41.44 % في عام 2007 من اجمالي مساحات المدينة. هذه الزيادة في مساحات البناء والتطوير كانت على حساب المساحات الخضراء والمساحات الجافة حيث شكلت المساحات الخضراء نسبة 38.80 % في عام 2007 بعد ان كانت تمثل نسبة 41.79 % في عام 1999 بينما تناقصت المساحات الجافة من 24.16 % في عام 1999 لتصل الى نسبة 18.80 % في عام 2007. اما بخصوص المساحات الرطبة فقد شهدت زيادة طفيفة ليمثل اجماليها نسبة 0.96 % في عام 2007. توقعت الدراسة حسب المعطيات المتوفرة من البحث ان النمو السريع لأراضي البناء والتطوير بسبب النمو السكاني الكبير للمدينة سيعمل على امتلاء كافة المساحات المخطط لها حسب المخطط الهيكلي للمدينة بحلول عام 2025.

تنبع أهمية هذه الدراسة من خلال وضع النتائج والخرائط بين يدي المخططين وأصحاب القرار من اجل فهم حجم تلك التغيرات واتجاهاتها مكانيا و زمانيا، وبالتالي المساعدة في تقييم واعادة رسم الاستراتيجيات والخطط المستقبلية السليمة لاستخدامات الاراضي في المدينة بالإضافة الى ضرورة وضع برنامج خاص لمراقبة واعادة تقييم التخطيط بشكل دوري وذلك باستخدام وسائل التكنلوجيا الحديثة مثل نظم ا لمعلومات الجغرافية والاستشعار عن بعد في متابعة استخدام الاراضي. كما أوصت الدراسة بإعطاء أهمية كبيرة للمشاركة المجتمعية و القطاعات المحلية والفعاليات الشعبية. و العمل على توعية المواطنين لأهمية استعمالات الأراضي ودورها في تطوير المدينة وضرورة الالتزام بهذه الاستعمالات من أجل الأجيال القادمة.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ΔNDVI	Image Differencing
ANN	Artificial Neural Networks
CVA	Change Vector Analysis
ECE	Economic Commission for Europe
EM	Expectation Maximization
FAO	Food and Agriculture Organization
GIS	Geographic Information System
GS	Gramm Schmidt
KT	Kauth Thomas transformation
LULC	Land Use and Land Cover
NDVI	Normalized Difference Vegetation Index
OO	Object Oriented
PCA	Principal Component Analysis
PCBS	Palestinian Central Bureau of Statistics
RMS	Root Mean Square error
SOI	Survey of India

CHAPTER (1): INTRODUCTION

1.1 Introduction

The human activities have an important impact in changing the landscape of the earth. Economic interests of human beings, which include all aspects of life such as agriculture, construction, roads, metals and others, have a major impact on the environment and natural styles and produce a new form of land, which can be seen, with the passage of time (Zubair, 2006).

(Meyer, 1995) said: "Land cover can be altered by forces other than anthropogenic. Natural events such as weather, flooding, fire, climate fluctuations, and ecosystem dynamics may also initiate modifications upon land cover. Globally, land cover today has been altered principally by direct human use as in agriculture and livestock raising, forests' harvesting and management, and urban/ suburban construction and development. There are also incidental impacts on land cover by other human activities such as forests and lakes damaged by acid rain from fossil fuel combustion and crops near cities damaged by troposphere ozone resulting from automobile exhaustion".

Providing specific information to the land use and land cover (LULC) is very important in the assessment and planning processes and therefore the possibility of optimal use in the field of basic human needs and environmental requirements of the earth. Scientific progress, especially in the field of remote sensing have an important impact in monitoring all changes that occur on the earth's surface features, infrastructures, managing natural resources, in addition to environmental changes. Developed tools of Remote Sensing (RS) and Geographic Information System (GIS) rapidly spread in recent years in order to monitor changes in LULC. Researches on change detection techniques move quickly and offer new methods that are promising regularly (Wilkie et al., 1996).

Therefore, this study will try to produce a map of the change detection occurred for LULC in Gaza City for the period between 1999 and 2007 by using Geographic Information System.

1.2 Statement of the Problem

Gaza City has witnessed extraordinary expansion growth and developmental activities such as buildings, road construction, and many other human activities since 1994 after the arrival of the Palestinian Authority just like many other cities in The Gaza Strip. This has, therefore, resulted in increasing land utilization and changing in the status of its land use and land cover over time without any detailed monitoring to evaluate this status. The data and information of these changes are very important for planners and necessary tools for planning to avoid all problems associated with continuous growth and expansion. Generally, this information could be important for the decision makers. Its users are both governmental and non-governmental agencies. Some of these probable users are municipalities, country planners, environmental specialists, statisticians, non-governmental agencies, landowners etc…

1.3 Justification of the Study

In recent years, the Gaza City has seen a large amount of land use and land cover changes, as a result of lack of planning and monitoring programs. This has lead to complex serious problems such as: lack of storm water infiltration, Increase the 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. So, the study has been made to document the growth of Gaza City in the past and the dynamics of Land use and Land cover at through following years. The changes detection in the area requires a more powerful and sophisticated system such as GIS which provides a better way to effectively map and monitor urban growth.

1.4 Aim and Objectives

The aim of this research is to detect changes occurred in Gaza City for land use and land cover during the interval between 1999 and 2007, especially in the built up class, green lands, wet lands, and dry lands using the technology of GIS. Based on the obtained images from Gaza Municipality, the oldest image was in 1999 and the latest image in 2007. This period is applicable when compared to the rapid changes that have occurred in the city. Since, the Gaza City was suffering from the siege because of the political situation since 2006 year.

The following specific objectives will pursue in order to achieve the aim above:

- Developing the classification scheme for land use and land cover.
- Determining the direction, nature, rate, location and magnitude of LULC changes.
- Expectation of the LULC according to the structural Plan.
- Getting recommendations for the planners to reduce probable negative impact of the land use changes for built-up, agricultural and environmental issue in the Gaza City.

1.5 The Research Methodology

The completely set stages of research toward the change detection process for land use and land cover are illustrated in (Figure 1.1). It consists of six stages. Stages one and two consist of search concept and data acquisition. Stages three and four include the practical parts; classifications and spatial modeling, for the study. Change detection steps are illustrated in stage five while obtaining results and performing analysis of these results are completed in stage six. In the recent times, GIS is one of most useful tools for powerful and advanced systems in providing general dynamitic evolution of large areas and changes of the land use and land cover. The use of GIS for land use and land cover's change detection depends on enough understanding of the study area and the satellite imaging system for change detection in order to complete the aim of the present study.

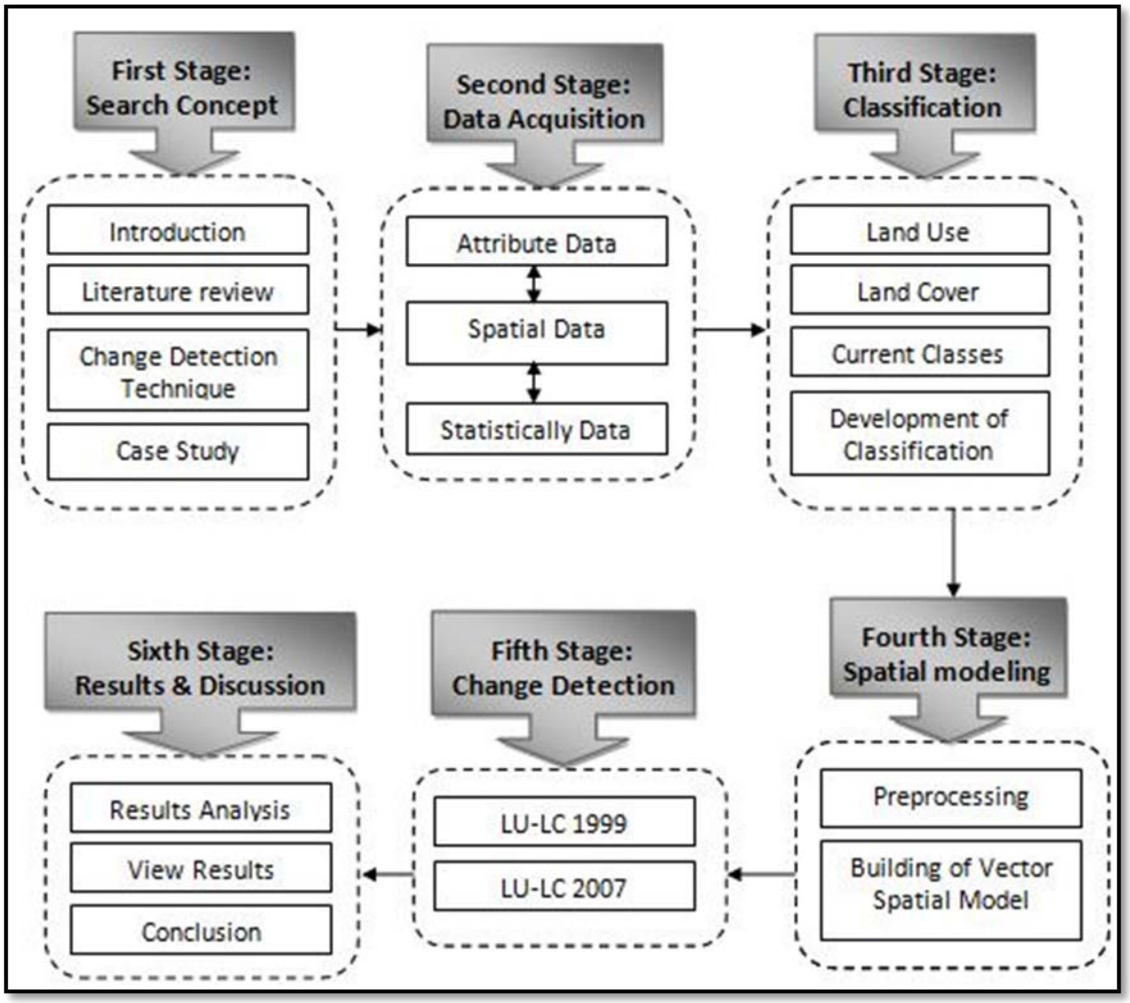

Fig. 1.1: Research Methodology

1.6 Organization of the Thesis

This thesis consists of six chapters. Chapter (1) presents the background to the study, statement of the problem, justification for the study, the aim and objective of the study area and the structure of the research methodology. Chapter (2) examines existing literature on LULC and change detection techniques. A summary of these techniques and application areas is provided in this chapter. Chapter (3) describes the study area, assembling data and development classification of the LULC to be suit purpose the research. Chapter (4) illustrates the methodology used to achieve the objectives of the study. The results and analyses as well as discussion of those results are present in Chapter (5). Chapter (6) concludes the study and highlights some limitations and recommendations.

CHAPTER (2): LAND USE – LAND COVER LITERATURE

2.1 Scope

Studies have displayed that there small area of land cover on the Earth that is still in their natural state. Due to human presence on the Earth and his use of land has had a deep effect upon the natural environment therefore resulting into a noticeable change in the LULC over time. This chapter reviews literature concerning the major issues of LULC and change detection in order to recognize the related information regard those issues.

2.2 Land Use and Land Cover

2.2.1 Definition of Land Use and Land Cover

Inglis-Smith (2006) defines land use as "the way in which humans use and modify the land". Usual land uses contain built up, agriculture, urban and infrastructure development. In difference to land use, Inglis-Smith (2006) defines land cover as "the physical state of the land surface. This includes streams, wetlands, bare surface rock, grasslands, forests and human modifications such as roads and buildings". On the other hand, from FAO (Food and Agriculture Organization) (2000) "Land use is defined as the arrangements, activities and input that people undertake on a certain land cover type''. Also from FAO (2000), "Land cover is the observed (bio) physical cover of the earth's surface".

From previous definitions, the land cover refers to physical conditions on the ground or natural cover of the land for example forests, grasslands, etc. while the land use refers to the human actions such as residential areas, industrial areas, and agricultural fields.

2.2.2 Land Use and Land Cover Change

The change of LULC is a result of complex relations between some biophysical and socio-economic situations that may occur at different temporal and spatial scales (Reid et al., 2000). LULC change detection is required for updating LULC maps and the management of natural resource.

Mainly, according to (Inglis-Smith, 2006; Briassoulis, 2000 and FAO, 2000), there are two types of changes in land cover by land use which are:

- Conversion: land conversion involves changes from one type of use to another type, for example from forest to grassland.
- Modification: it involves the change in the condition within a particular land cover type, for example from dense forest to open forest.

2.2.3 Previous Works on Land Use and Land Cover

Saleh Abo Amrah (2010) conducted a research to examine the application of GIS in the study of land use in Deir Al-Balah City of The Gaza Strip. The aim of his study is to determine the patterns of land use, analyze, evaluate, and construct the factors, which may organize this pattern, and then build a spatial analysis model simulates by using GIS in order to choose a green area in the City. In addition, the study aimed to show the function of technology in GIS to improve decision making in the City of Deir El-Balah. In general, the study recommends necessary implementation of GIS in studying land use, enacting laws and establishing conditions. It is important to keep agricultural land, and adopting local planning standards for the land uses. In addition, it is important to get the benefit of the experiences of other countries.

Data of the last study of Palestinian Central Bureau of Statistics regarding land use statistics in Palestinian Territory indicated that, the area of cultivated land represents 25.1% of the total area of the Palestinian Territory land, while it represents 24.8% in the West Bank and 30.1% in The Gaza Strip .The data indicated that there is a small change of the land use on the total cultivated area, permanent cultivated area, and rain-fed cultivated area during the years 2005-2008 compared to the base year (1998). At the same time there is some change in the temporary cultivated area, the greatest change creates during 2007 with a decrease of 5.9% compared with the year 1998 (PCBS, 2007).

Manar Sholi (2008) used satellite remote sensing to study the land cover in Nablus and some surrounding areas of Palestine. In addition, she analyzed the patterns to produce accurate maps by using GIS technique to know all variations in land use distribution in the study area. The most important results in this study are the evidence on the capability of remote sensing technique in producing accurate land use maps and the rule of this technique in environments of complicated topographic structures such as mountainous areas since they are difficult to be accessed. The study also showed the olive tree, as one of the main land cover patterns, occupies the highest percentage of the studied area while it plants in different environments. The study recommended the necessary use of remote sensing in studying land use change because this technique has the capability of giving updated data on continuous bases. In addition, this system considers less costly in studying large areas. Moreover, the study preferred using Spot data to study agricultural zones characterized by small to moderate field size.

Mohamed Alnojoom (2006) conducted analysis and evaluation of land use patterns in the Jericho of Palestine. The methodology of his study based on the descriptive analytical method in analyzing the structural plans depending on the experience of the researcher as an employer in the department of local government in Jericho. The results of the study indicated the negative/unconstructive variety in the City, such as the overlapping and invasion of land uses because the lack of knowledge of previous needs of structural plans. In addition, the study emphasized the necessity of preparing a new structural plan for the City, which regulates the existing land use and identifies the future in the next period. Additionally, the researcher highlighted the necessity of enhancing the touristy role and value of the City as well as emphasizing the protection of the historical and cultural areas and sites in the City. Moreover, develop the sector of public services and facilities that support and enhance the touristic role.

In Nablus City of Palestine, Read Halapi (2003) explored the use of (GIS) in land use maps to be helpful for data capture, data storage, data processing, data management and data analysis because the changes in products of land use in different periods. A large-scale aerial photograph taken in 1999 used to produce the land use maps. The photo contents are buildings, roads and land packages digitized. The field study conducted for all land use types in the City depending on the selected sample, while a complete survey for all agricultural lands, rangeland rods and cemeteries was adopted. The result observed the speed of residential use rate, which is about 53.53% out of the total use in the City while the trading use occupied the second place with a rate of 12.73%. The industrial use in the City came in the third place with a rate of 15.11%. In addition, the researcher recommends, the use of GIS technology as an effective tool in researching work and planning in public and private institutions and opening new roads in order to ease the traffic inside the City (Read Halapi, 2003).

Previous studies have shown increasing of the urban areas at the expense of green areas and recommended to use of modern technology to continue to use land and planning.

2.3 Change Detection

2.3.1 Definition of Change Detection

Change detection is the process of identifying differences in the state of an object or occurrence by observing it at different periods (Singh, 1989). Hsiung Huang and Ju Hsiao (2000), define 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.

2.3.2 Importance of Change Detection

Change detection is a key for the monitoring of the globe natural resources through the analysis of the 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 (Macleod & Congalton, 1998).

Change detection is helpful for an extensive range of applications that are; land use analysis, monitor agriculture, estimate of deforestation, and natural disaster e.g. environmental monitoring, and urban change (Bottomley, 1998; Inglis-Smith, 2006).

2.3.3 Change Detection Techniques

Because of the importance the monitoring change detection for land use and land cover, it is an active topic and provides varieties of new techniques constantly developed over the last years.

To choose a suitable technique for specific change detection, it is not easy. 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 (Francesca Giordano, 2008). For this reason, a review of change detection techniques used in previous researches is useful to understand how these techniques can be best use.

Lu et al. (2004), classified change detection techniques for land use and land cover into seven following categories namely: (1) Algebra, (2) Transformation, (3) Classification, (4) Advanced models, (5) Geographic Information Systems (GIS), (6) Visual analysis and (7) other techniques.

In this context, an explanation of the main characteristics, advantages and disadvantages for the six categories and techniques adapted from (Lu et al., 2004) will be clarified below.

2.3.3.1 Algebra

Algebra category techniques are most appropriate used for LULC change. It includes image differencing, image regression, image rationing, vegetation index differencing, change vector analysis (CVA) and background subtraction. These algorithms have a common characteristic, which is selecting thresholds to determine the changed areas. The advantages of these methods are relatively simple, straightforward, and easy to implement and interpret. In contrast, the disadvantages of this category are inability to provide complete matrices of change information and difficulty in selecting suitable thresholds to identify the changed areas.

2.3.3.2 Transformation

Transformation category techniques are most appropriate used for LULC. It includes principal component analysis (PCA), Kauth Thomas transformation (KT), Gramm–Schmidt (GS) and chi-square. One of the advantages of this category is reducing data redundancy between bands and emphasizing different information in derived components. Nevertheless, they cannot provide detailed change matrices and require selection of thresholds to identify changed areas. An additional disadvantage is the difficulty in interpreting and labeling the change information on the transformed images.

2.3.3.3 Classification

Classification category for LULC change detection includes post-classification comparison, spectral temporal combined analysis, expectation-maximization (EM) detection, unsupervised change detection, hybrid change detection and artificial neural networks (ANN). These methods depend on the classified images, quality and quantity of training sample data, which are essential to create good quality classification results. The ability of providing a matrix of change information and reducing external impact from atmospheric and environmental differences between the multi-temporal images is the major advantage of these categories. While, selecting high quality and sufficiently many training sample sets for image classification is often difficult, in particular for historical image data classification. In addition, the time-consuming and difficult task of producing highly accurate classifications often lead to unacceptable change detection results, especially when high-quality training sample data are not available.

2.3.3.4 Advanced Models

The advanced models category techniques are most appropriate used for LULC. It includes the Li–Strahler reflectance model, spectral mixture models, and biophysical parameter estimation models. These methods depend on reflectance values of the image to physically based parameters or fractions through linear or non-linear models. The transformed parameters are more intuitive to interpret and better to extract vegetation information than spectral signatures. The main disadvantage of these methods is the time-consuming and difficult process of developing suitable models for change of image reflectance values to biophysical parameters.

2.3.3.5 GIS

The GIS category techniques are most appropriate in change detection of urban areas. Its techniques include the integrated GIS, remote sensing method, and the GIS approach. The best benefit of using GIS is the ability to combine different source data into change detection applications through providing convenient tools for the multi-source data processing and affectivity in treatment the change detection analysis using multi-source data. Nevertheless, one of disadvantages of GIS techniques is the different source data associated with different data accuracies and formats often affect the change detection results.

2.3.3.6 Visual Analysis

In this technique the texture, shape, size and patterns of the images are main elements helpful for classification of LULC change through visual interpretation. Nevertheless, these elements do not be used in the digital change detection analysis because of the difficulty in extraction of these elements. The visual analysis category includes visual interpretation of multi-temporal image composite and on-screen digitizing of changed areas. These methods depend on the analyst's experience and knowledge. The main disadvantage of this method is the time consumed for a large-area change detection application and it is difficult to update timely the change detection results.

2.3.3.7 Other Change Detection Techniques

Some methods that cannot be attributed to one of the six categories indicated above and that are not yet frequently been used in practice. (See Appendix A)

Land cover and land use changes are ongoing and dynamic phenomena as a result of human interactions with the environment. Studies on land use and land use change have begun only in the early nineties. Studies on land use hitherto have revealed strong relationship between land use change and population growth. The increasing impact of land use and cover changes on the environment has been an issue of concern in the developed and the developing countries with consequential effects on sustainable development and long term impact on the agricultural and other sectors of the economy. Timely and accurate change detection of Earth's surface features is extremely important for understanding relationships and interactions between human and natural phenomena in order to promote better decision making.

A large number of researchers, extracted land use and land cover change information from given satellite data using various techniques. Moreover, the choice of methods depends on the available GIS data, the allowed period, and the aim of the study. Difficulty in obtaining maps with high accuracy, providing maps with low resolution from multiple sources and the small size of the urban area was reasons to use the GIS technology for change detection of LULC.

Remote sensing data are primary sources extensively used for change detection in recent decades. Many change detection techniques have been developed.

Previous literature has shown that image differencing, principal component analysis and post-classification comparison are the most common methods used for change detection. In recent years, spectral mixture analysis, artificial neural networks and integration of geographical information system and remote sensing data have become important techniques for change detection applications.

2.2.4 Previous Works on Change Detection

In April (2011), the research scholar Y.Babykalpana in partnership with Dr. K.ThanushKodi presented the paper "Classification of Land Use Land Cover Change Detection Using Remotely Sensed Data " for Coimbatore City in India. They found that more agriculture lands are converted into residential areas. This conversion leads to reduce the vegetation growth. In addition, the industrial areas also increased so that pollution rate increases. While found reduction in the number of trees due to deforestation. As a result, the rainfall suggestion will be reduced.

R. Manonmani and G. Mary (2010) studied LULC changes using remote sensing and geographic information system (GIS) for the Villivakkam block (study area) in India. They aimed to detect land use changes between 1990 to 2005 using satellite images of Land Sat 1990, IRS LISS 2005 and digital topographic maps. The result of change detection has not showed that the built up area is greater than before (between 1990 and 2005) by 15.83%. In addition, the area with irrigated land farms have reduced to 2.48% and the scrubland decreased to 5.19%.

Empirical surveillance exposed a change in LULC classification in Kodaikanal taluk, Kodaikanal area identified as one of the biodiversity area in India. The changes in LULC for the City are taken over forty-year period (1969-2008). In this study, researchers applied remote sensing approach using Survey of India (SOI) Taluk map of town in 1969, Land Sat imageries of May 2003 and April 2008. Classification of LULC is performed based on the Survey of India map, Satellite imageries, and the use of GIS software to apply the thematic maps. The results show that the agricultural ground, built up region, harvested area and wasteland have practiced change. In 1969, the forest region increased to 70% of the City area but it decreased to 33% in 2008. In addition, it is observed that the built up lands have increased from 3% to 21% of the total area. The study explained that good land use planning is necessary for a sustainable development of Kodaikanal Taluk (Prakasam.C, 2010).

I.I. Abbas et al. (2010) assessed the Changes in LULC in Kafur local government area of Katsina state in Nigeria for more than thirteen years. This study explained the importance of remote sensing and GIS techniques in mapping and change detection. Researchers used map of 1995 for LULC and 2008 from Google earth images. The map and the image digitized to GIS situation for analysis by using the paired t-test analysis. The study was to identify any important change in the LULC from 1995 to 2008. The results of the analysis showed that the open space covered 34.00% from land area in 1995 which is considered the most type of LULC in the study area. The study also showed that the growth of the people and economic behavior strongly affected the existing land resources.

Tanmoy Das (2009) used object oriented (OO) method for map LULC and change detection analysis using post-classification technique. The study area was the Münster City in Germany. It covers about 100 km square. The results of the analysis indicated that the change detection of LULC in three different periods is quit consistent (0.6 to 0.7% per year) (from 1990 to 2000, from 2000 to 2005 and 1999 to 2005). Therefore, there is no change in area for the group of wetland during time. However, a small change in aerial degree noticed after cross-operation between results. In general, changes have noticed but in some cases, changes are too small.

In Accra, the capital City of Ghana the research is to detect the LULC change from 1990 to 2000. Land use change has been the reason for many social, economic and environmental problems in Accra over the past years ago. The main change is the transform of agriculture areas and forestland into urban areas mostly in an un-planned method making urban spread out characterize the urban change dynamics. The results illustrated extreme growth of urban areas and reduction of agriculture areas and forestland over the decade. The LULC classes' classifications are closed vegetation, open vegetation, dense herbaceous cover, grass, urban/bare areas and water bodies. The percentage change in the land cover classes was found to be 56.4%, 64.07%, 28.7%, 25.61%, 59.34% and 3.8% respectively (Ebenezer K.,2009).

Alfred A. (2009) assessed detection of land use and land cover change in Accra, Ghana, between 1985 and 2003. Post-classification comparison and combination of Normalized Difference Vegetation Index (NDVI) and image differencing (ΔNDVI) are used on Landsat TM images of 1985 and 2003 to determine and quantify the land cover changes that have occurred in Accra, the capital of Ghana. The result showed that about 34.8% of the forest area have been lost, where as 48.0% of the agriculture land have been lost. The reduction in the agriculture land was mostly due to increase in built up, while that of forest was due to increase in agricultural behavior.

With increasing in population growth rate in Sudan, there has been a raise for food production with agriculture. The research study work is interested in agricultural land use changes in the nation with the aim of discovering the agricultural land use changes that has occurred in the Sudan from 1986 to 2002 by using the remote sensing technique. The outcome of the research highlighted on the characteristic of remote sensing technology to be used in analyzing land use cover changes for agricultural land and sustainability monitoring (Olagunju E., 2008).

N. Wafa et al. (2008) conducted detection of land cover changes. In this study, they used two techniques for change detection classification to evaluate land cover changes in El Rawashda forest, Sudan from 2003 to 2006. Mainly the land cover classified into four classes; grassland, close forest, opens forest and bare land. Generally, the results showed a clear enlarge in the area on both close forest and open forest areas with reducing in grasslands within the study time. Extra one third of grassland (36%) was converted to close forest, and one-fourth (24%) to open forest areas.

ZUBAIR (2006) conducted a research to examine the use of GIS and Remote Sensing in mapping LULC in Ilorin city of Nigeria between 1972 and 2001 to detect the changes that has taken place in this status between these periods. Subsequently, suggestion a projecting observed LULC in the next fourteen years. For achieving this, Land Consumption Rate and Land Absorption Coefficient were introducing to help in the quantitative evaluation of the change.

Generally, the result observed a fast growth in built-up land between 1972 and 1986 while in the 1986 to 2001 explain a decrease in this group. It also suggested that change by 2015 might well resemble the trend in 1986-2001.

To look for evaluating urban temporal changes in a typical usual settlement in Ibadan capital of Nigeria, the used technique is remote sensing to evaluate LULC changes and a try made suggestion the observed LULC in 2023 by using marcov change model. The results showed that there are huge dynamic changes in Ibadan. In addition, the major class of changes is the vegetal cover, low density and sprawl increase. The paper concludes by suggesting ways to random urban growth that characterizes Ibadan (O. Fabiyi, 2006).

CHAPTER (3): STUDY AREA AND DEVELOPMENT OF CLASSIFICATION

3.1 Scope

This chapter describes the study area and development of classification for LULC in the Gaza City. This chapter contains information about the population and climate in the City. At the end of the chapter is establishing a special classification in this research to reflect the variance of the categories on the LULC so that it contains all categories.

3.2 Study Area

3.2.1 Introduction

The study area is Gaza City. Gaza City is a Palestinian City in the Gaza Strip. It is considered as the second capital of Palestine because of its strategic location and economic importance and the presence of most of the headquarters of the Palestinian National Authority (Wikipedia, 2011).

Gaza City has witnessed extraordinary expansion, growth and developmental activities such as buildings, roads' construction and many other human activities since 1994 after the arrival of the Palestinian Authority, just like many other cities in The Gaza Strip. This has, therefore, resulted in increasing land employ and changing in the status of its land use and land cover over time without any monitoring to evaluate this status. Therefore, Gaza City is facing rapid development, advanced and which had a significant impact on the spatial changes. In the past, the area of the City estimated at 46,481,734 square meters but now estimated at more than 55,806,796 square meters, any of approximately 9,325,062 square meters area added (Municipality of Gaza, 2011).

3.2.2 Geography and Location

The City of Gaza is part of the Gaza Strip, which has called its name to the ancient City. The Gaza Strip is located at the southeastern coast of the Mediterranean Sea (Figure 3.1), on the boundary of the Sinai Desert amid longitudes 34° 2" and 34° 25" east, and latitudes 31° 16" and 31° 45" north. The area of it is about 365 km^2 and its longest width is about 45 m. Gaza City busies 55,806,796 m^2 from whole area of The Gaza Strip (Municipality of Gaza, 2011).

Fig. 3.1: The geographic location of the study area (Municipality of Gaza, 2011)

Gaza City is located on a low-hill with an elevation about (45 meters) above sea level. Much of the urban expansion of the City is paralleled 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 (Municipality of Gaza, 2011).

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 3.2).

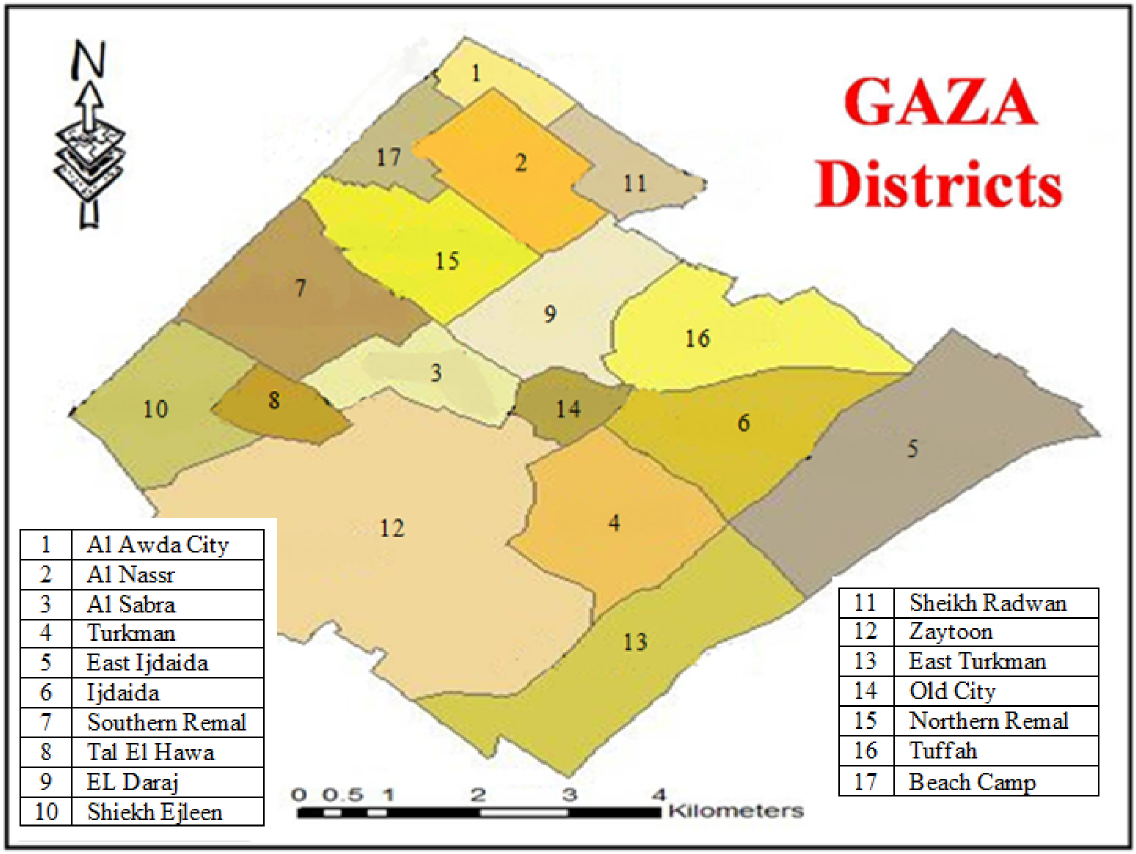

Fig. 3.2: Neighborhoods in Gaza City (Municipality of Gaza, 2011)

3.2.3 Population

Gaza Strip is considered as one of the most overpopulated areas all over the world (Wikitravel, 2012). The area of The Gaza Strip is estimated as 365 square kilometers with a population of 1,416,966 according to Palestinian Bureau Statistics Council in 2007 (PCBS, 2007). Population growth rate in The Gaza Strip is 3.8 %. In addition, the average population density is almost 3,881 person/km^2. Also referred to as, the population of Gaza is overwhelmingly composed of Muslims (Wikitravel, 2012). Moreover, Table 3.1 shows the revised estimates of the population projection up to year 2025 in The Gaza Strip as given by (PCBS, 2007).

Table 3.1: Population Growth in The Gaza Strip (2010 to 2025)

Year	Gaza
2010	1,868,000
2015	2,241,000
2020	2,618,000
2025	2,993,000

Nowadays, Gaza City is the biggest population center with about 496,410 inhabitants and average population density is almost 6913 person/km^2 (PCBS, 2007). Table 3.2 shows the last Gaza's population for each neighborhood in 2009 from Gaza Municipality.

Table 3.2: The Population in Gaza City in neighborhoods (2009)

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

3.2.4 Climate

Gaza City, as an element of the Gaza Strip, has the same typical Eastern Mediterranean climate with hot dry summers and mild winters. Temperature gradually changes during the year. The main findings of the time series indicate that the annual mean of air temperature ranges between 17.7 centigrade degrees and 23.6 centigrade degrees. Temperature gradually reaches its maximum in August (summer) and its minimum in January (winter); the average monthly maximum temperature ranges from about 17.7 C° in January to 32.0 °C in August while the average monthly minimum temperature for January is about 6.0 °C and 22.7 for August. Most of the rainfall occurs in the period from October to March, the rest of the year being completely dry (PCBS, Municipality of Gaza, 2011).

3.3 Assembling Data

The Landsat satellite images of Gaza City were acquired for two epochs, 1999 and 2007. 0n both 2007 and 1999 images, a notable feature can be observed which is the port of Gaza which was not yet constructed as of 1999. A structural plan for 1997 is available, which proposed as the land use and existing classified of land use for the City. In addition, a map divides neighborhoods of the City. These data acquired from the GIS Department and Planner Department of the Municipality of Gaza City. Some information has been got from previous scientific research and has been referred to in addition, the website of the PCBS and the website of the Municipality of Gaza.

3.4 Development of Classification

There are many land use 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) 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 (Saleh Abo Amrah, 2010).

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 3.3): 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.

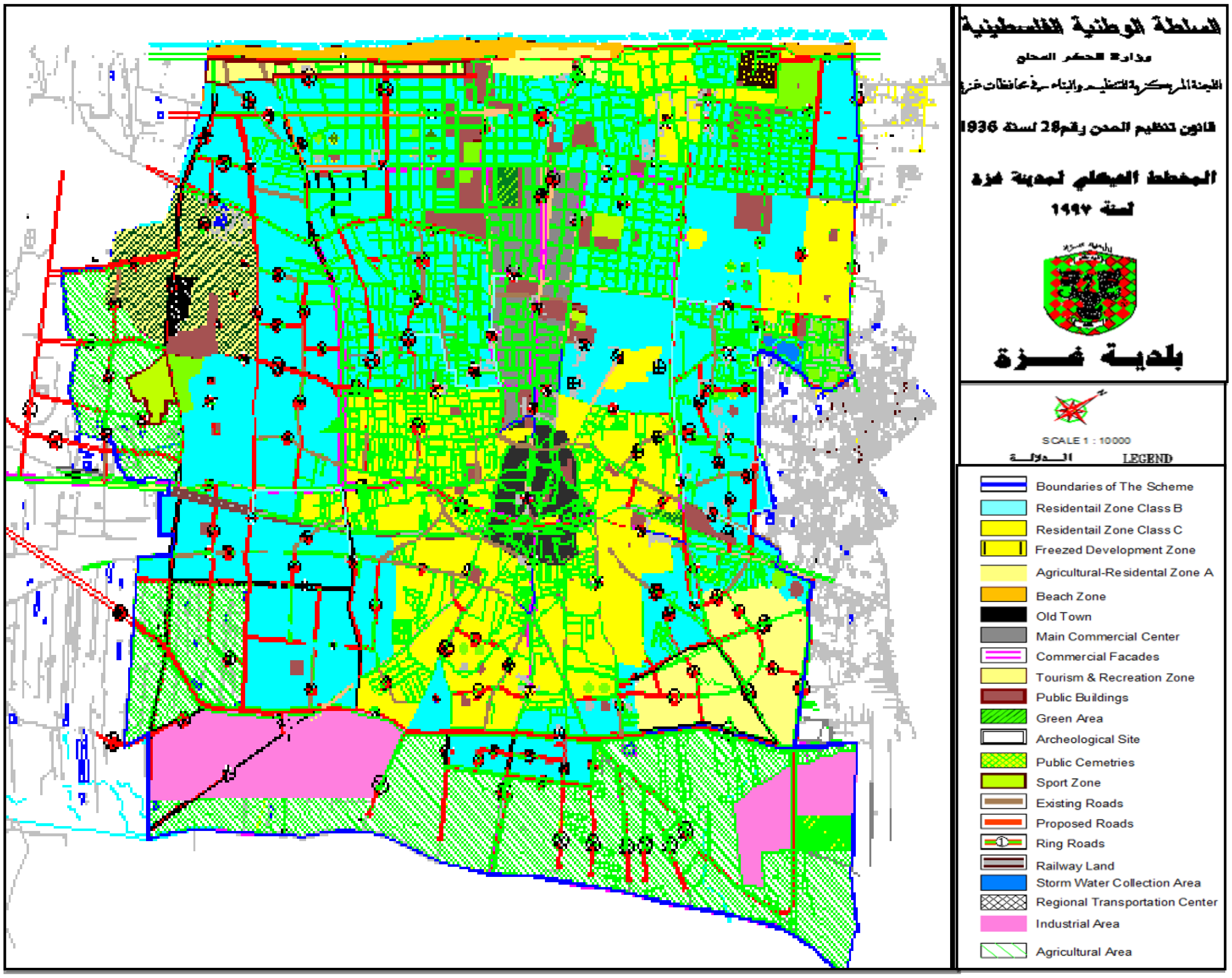

Fig. 3.3: Municipality of Gaza classification in 1997 (Municipality of Gaza, 2011)

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, the small size of the study area was used GIS technology 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, regional transportation center, sport zone, and industrial area.
- Green Land which consists of green area and agricultural area.
- Wet Land which consists of storm water collection area
- 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).

Note; the study area does not include shore area of Gaza City starting from Al-Rashid Street west to the eastern border of the City.

CHAPTER (4): METHODOLOGY

4.1 Scope

Many techniques are available in scientific literature for change detection of land cover and land use. Selection of suitable technique is, therefore, very important and needs to be implemented on the basis of the required results and the available schemes. 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.

4.2 Data Collection and Organization

4.2.1 Required Data

- Aerial Images: for spatial modeling and changes detection. It is necessary to have two different aerial images, one must be old and the second is modern. Aerial images of Gaza City taken in 1999 and 2007 were obtained from the Municipality of Gaza (show Figure 4.1). It is clear that the image's resolution of the year 1999 (120 cm) is lower than aerial image 2007 (50 cm).
- Structural schemes:
  1 - Map of districts of Gaza City which describes the boundaries and name of each district. It was obtained from the Municipality of Gaza.
  2 - Maps of urban planning for the City: in order to analyze the results after the changes detection process.
- Statistical data: In order to analyses and interpretation of the results
  1 - population growth.
  2 - Land use classification of the Gaza City.

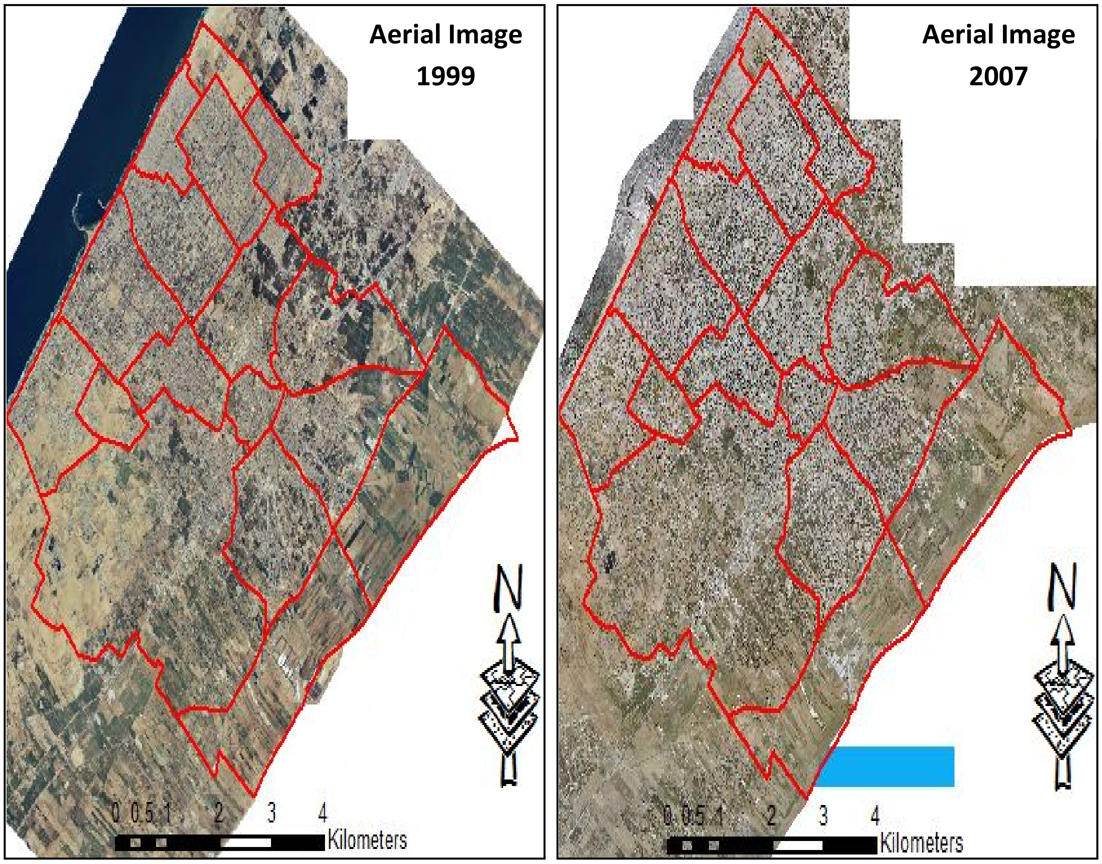

Fig. 4.1: Aerial Images (1999-2007) (Municipality of Gaza, 2011)

4.2.2 Data Preparation

Many steps have been done to prepare needed data. It starts by preparing the required layers for many processes in the project, making ready the database using Arc Catalog program (ArcGIS program), 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 program (ArcGIS), and preparing of all statistical data by Microsoft Excel software in order to simplify dealing with them through the project.

4.3 Materials Used

4.3.1 Software

Basically, five software were used for this project;

AutoCAD: used to identify data, export data to GIS program, view of urban planning for study area.

ArcGIS 9.3: used to display data and subsequent processing, enhancement of the image and processing of the data, and development of land use and land cover classes and subsequently for change detection analysis of the study area.

Microsoft Office: used mainly for the presenting the research, analyzing results and producing the bar graph.

4.3.2 Used Tools

- **Erase Tool**

In GIS, the erase function is an analytical process in which the output feature class is created by copying the portions of the input features that lie outside the boundaries of the erase features. In other words, the spatial data of the input layer that intersects the erase layer is excluded from the final output layer. A polygon feature can be used to erase other polygons, lines, or points. The erase function performs the opposite task the clip function performs.

The erase tool can help in saving a ton of editing time. Its main purpose is to perform an overlay analysis. The most common tool used for this is Clip, but output of this tool is just the overlap portion of your feature class. To be able to carry out the opposite of this, Erase Tool must be used. The Erase Tool will remove the overlapped portion from the feature class and leave a shape that resembles a doughnut.

In short, creates a feature class by overlaying the Input Features with the polygons of the Erase Features. Only those portions of the input features falling outside the erase features outside boundaries are copied to the output feature class. Through the study, erase tool was used with change detection process to LU &LC from 1999 – 2007. The LU & LC were classified by digitizing process, (Figure 4.2) explains example for use erase tool built up class between 1999 and 2007.

The results were as interpretation of quantities of any increases and decreases area of all classes for LU and LC in Gaza City (Wiki, 2011).

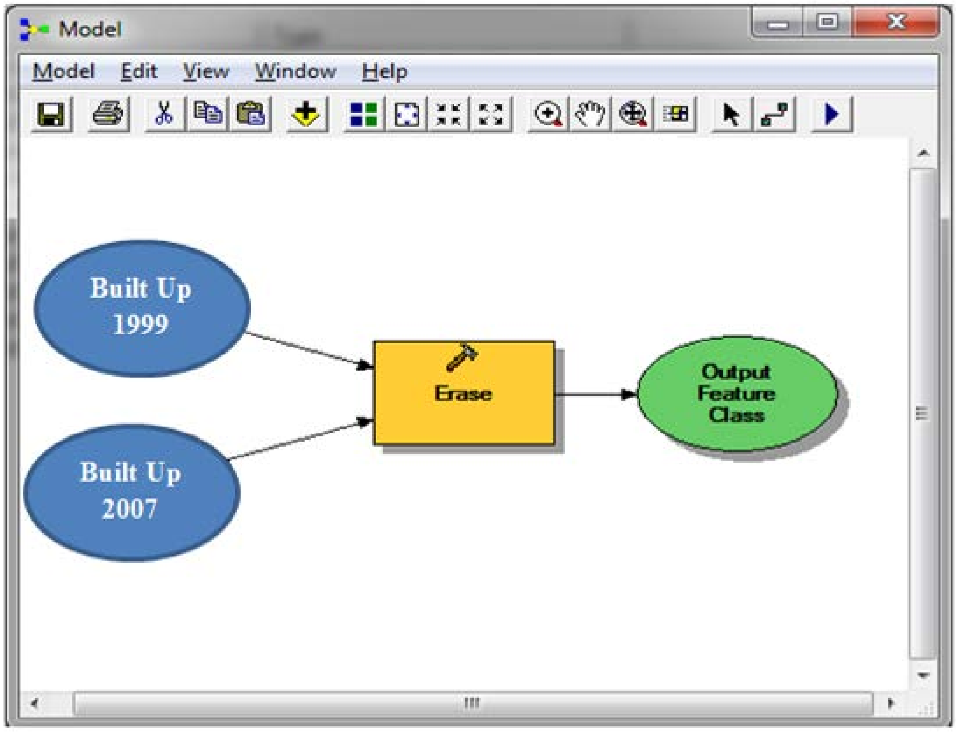

Fig. 4.2: Example for the use of erase tool (Built up 1999-2007)

- **Intersect Tool**

A GIS Intersect or Intersection is a process that takes two geometrical features and determines where they spatially intersect. These are the areas where the two features share the same space. The result contains only the features or partial features that overlap. In short, The Intersect tool calculates the geometric intersection of any number of feature classes and feature layers. The features or portion of features that are common to (intersect) all inputs will be written to the Output Feature Class.

It was exploited through this study to exploration directions of increase and decrease causes each Gaza areas, (Figure 4.3) explains example of using intersect tool with increasing of built up class and with decreasing of dry land, Green land and wet land. The processing results interpretation of directions of increase and decrease each all classes for LU and LC in Gaza City (Wiki, 2011).

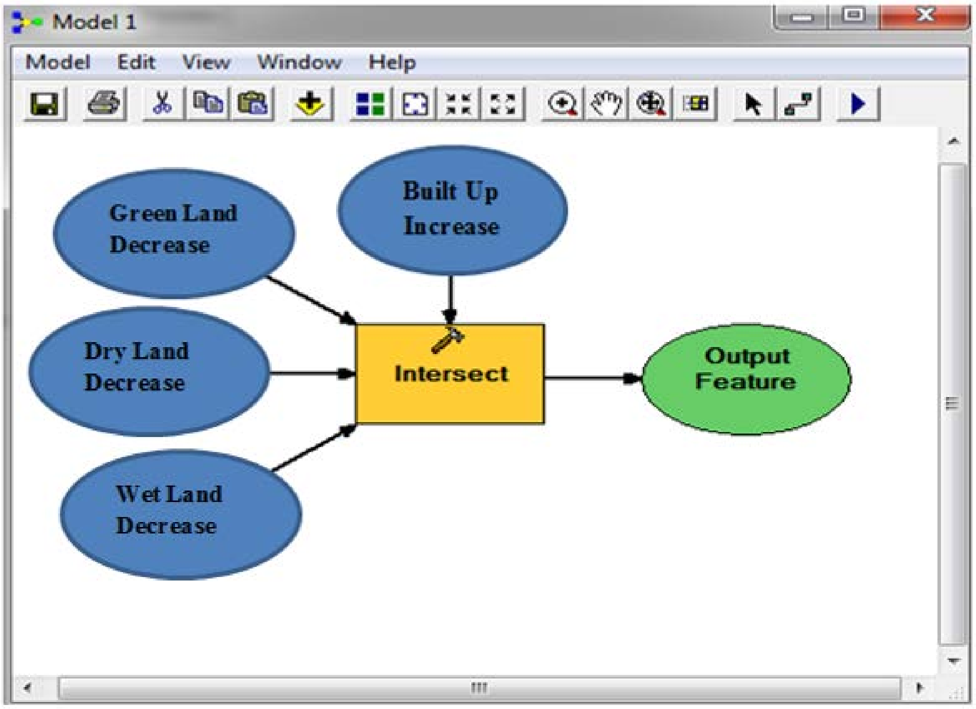

Fig. 4.3: Example for use of intersect tool (Built up class)

- **Excel Tool**

  Excel software is one of Microsoft Office applications, which is used through all project phases. It is used to prepare data, analyze results, and produce the bar graph, charts, and tables.

4.4 Limitations of the Study

For spatial limitation of practical part , there was taken of district's boundaries only, with an exclusion of beach side along Gaza City from western, northern and southern conservatism boundaries, and (Israel) from eastern side.

The temporal limitation based on available aerial images from Gaza Municipality. The better differences are clear in images of 1999-2007 period. There was a major limitation as a result of resolution difference. Image of 1999 was in bad resolution which has a spatial resolution of 1.20 meters, while the image of 2007 has a spatial resolution of 0.50 meters.

The study requires developing of main classification for LULC. The developed classes depend on basis classification of Gaza Municipality in 1997.

4.5 Pre-processing

4.5.1 Georeferencing Process

To georeference something means to define its existence in physical space. It is the process of establishing its location in terms of map projections or coordinate systems. The term is used both when establishing the relation between raster or vector images and coordinates but also when determining the spatial location of other geographical features.

In short, system that links information to position on earth's surface, those requirements are:

- Unique, linking information to exactly one location
- Shared, so different users understand the meaning of a georeference
- Persistent through time, so today's georeferences are still meaningful tomorrow

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 local projection system is Palestine Grid1923. 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. So, it was taken 20 coordinates points to rectify the two images. Note that, the accuracy of aerial image of the year 1999 is lower than the accuracy of 2007 aerial image. This is one of the main reasons for an error value and a limited accumulated during subsequent processes.

During the georeferentiation process, a Root Mean Square error (RMS) was calculated (0.005). In other words, the RMS error is the difference between the desired output coordinates for a 1999 and 2007 images and the actual output coordinates for the same points, when the point are transformed with geometric transformation (Wiki, 2011).

4.5.2 Digitizing Process

Digitizing is the process of converting analog information into a digital representation. In regards to spatial information, one application of this is the process of creating a vector digital database by creating point, line and polygon objects. Scanning a map can also be considered as digitizing (turning colors shades on the map into digital values), but for this class when we refer to digitizing this for the most part refers to create vector datasets.

Some basic issues related to digitizing:

1) Digitizing point features simply is the process of creating a single point feature with an x, y coordinate.
2) Digitizing lines involves creating a line feature that consists of a node (start and end) and a series of vertices which indicate a change of direction along that line. Straight features require fewer vertices; curved/complex features require more vertices.
3) Digitizing Polygons involves creating a set of connected lines. Editing tools simplify the process of closing polygon features.
4) It is often the case that you want to attach or snap new features to existing features in a dataset or existing features in another dataset. This assists in reducing overlaps and intersections of features and creating topology. This can be done by setting the snap environment. From the Editor Toolbar, choose Snapping to turn snapping on/off for different features. From Editor Toolbar, choose Options to set snapping distance.

   Since, snapping is an important control in the environment. It will assure that features snap to each other, and that dangles, overshoots, gaps, or slivers are avoided. And, it defines an automatic editing operation in which points or features within a specified distance (tolerance) of other points or features are moved to match or coincide exactly with each other's coordinates.
5) Digitizing involves creating features from a specific scale. Small scale maps (i.e. maps of large spatial areas - given a fixed map size) generalize features, large scale maps (i.e. maps of small spatial areas - given a fixed map size) represent features more accurately with less generalization. A key is that the digitized dataset you create is only as good as your source data.

For process applications during the project, it was based mainly on the existing classification of the LU & LC of Gaza City. The process is to build vector spatial model that describes the type of spatial data for the LU & LC 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 LU & LC items in Gaza City for years 1999 and 2007 separately in order to apply change detection process using these data (Wiki, 2011).

4.5.3 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 (Wiki, 2011).

4.5.4 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 (Wiki, 2011).

4.6 Development of a Classification Scheme

Based on the classification of Gaza Municipality of main classification for LU&LC 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 LU&LC by attribute data with spatial data for each area. (Figure 4.4) shows the classification method:

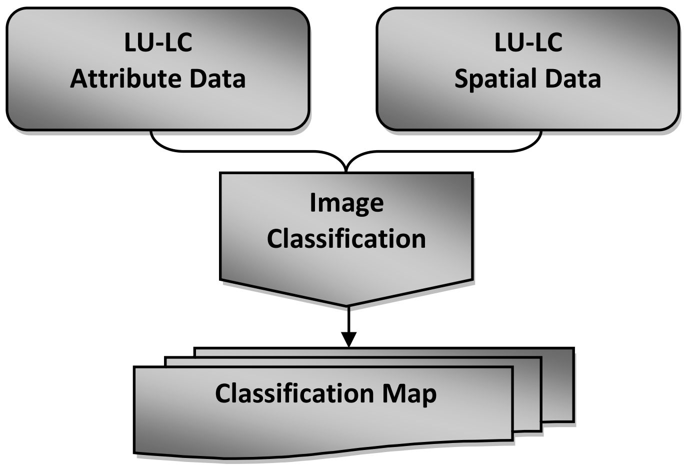

Fig. 4.4: Classification Method

4.7 The Used Methodology

4.7.1 Spatial Modeling

A methodology or set of analytical procedures used to derive information about spatial relationships between geographic phenomena. A vector spatial model was built to present integration process to fulfill this study as show in the (Figure 4.5).

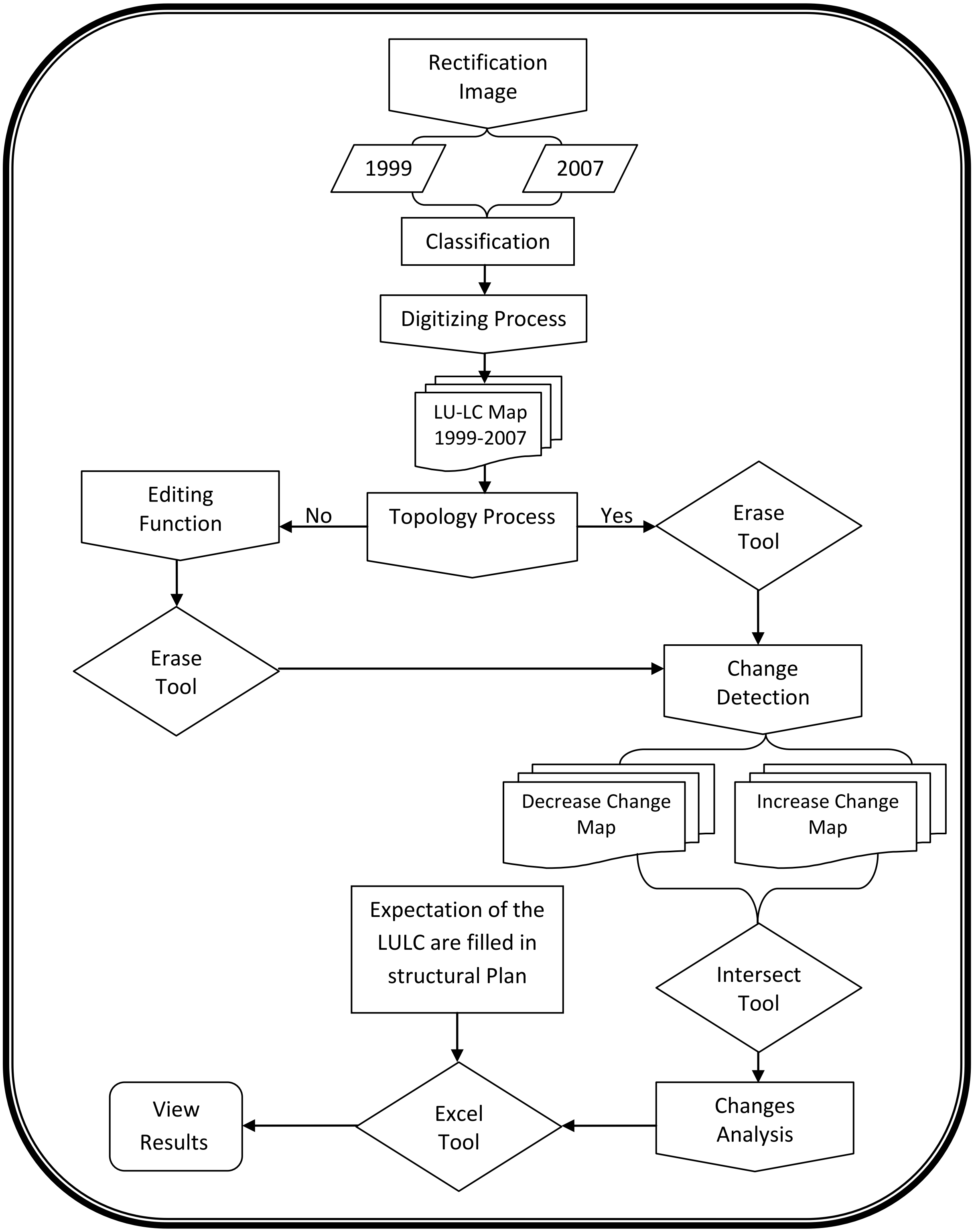

Fig. 4.5: Chart of Methodology

CHAPTER (5): RESULT, ANALYSIS AND DISCUSSION

5.1 Scope

This chapter describes the results and discussion of change detection for LULC in the Gaza City. This chapter focuses on describing the progress work by using ARCGIS in addition to the discussion of the change detection for LULC that occurred in the neighborhoods. Also, displays spaces planned to study classifications according to the structural plan for the city. At the end of the chapter is trying to highlight the year it expected full spaces allowed construction linking the number of the city's population is expected.

5.2 Progress Work Using ARCGIS

As shown in Chapter Four, the measures which have been executed using ARCGIS software, have passed into three main stages as follows:

Firstly, it is the georeferencing processes. Georeferencing applied to the two Aerial maps; 1999 and 2007. Twenty points are selected to connect both of them. 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. All this has been done before digitizing process for LULC for the two maps. Since, the Root Mean Square error (RMS) was calculated (0.005). (Figure 5.1) explain the location of selected points and their coordinates are illustrated in Table 5.1.

Table 5.1: Coordinates of the selected points of the study area (Gaza City)

No.	X	Y	No.	X	Y
1	94,586.52	101,502.36	11	97,398.61	104,809.84
2	95,446.18	99,316.80	12	96,859.50	104,270.74
3	97,704.59	97,990.89	13	96,130.98	103,250.81
4	99,059.64	97,466.36	14	96,320.40	101,648.07
5	101,026.64	99,229.38	15	97,223.76	100,220.17
6	103,620.17	101,473.22	16	98,972.21	99,171.10
7	101,813.44	102,522.29	17	99,627.88	100,395.01
8	100,458.39	103,221.67	18	99,074.21	101,706.35
9	100,021.28	104,431.01	19	99,015.92	102,959.40
10	98,986.78	104,664.14	20	100,531.25	101,021.54

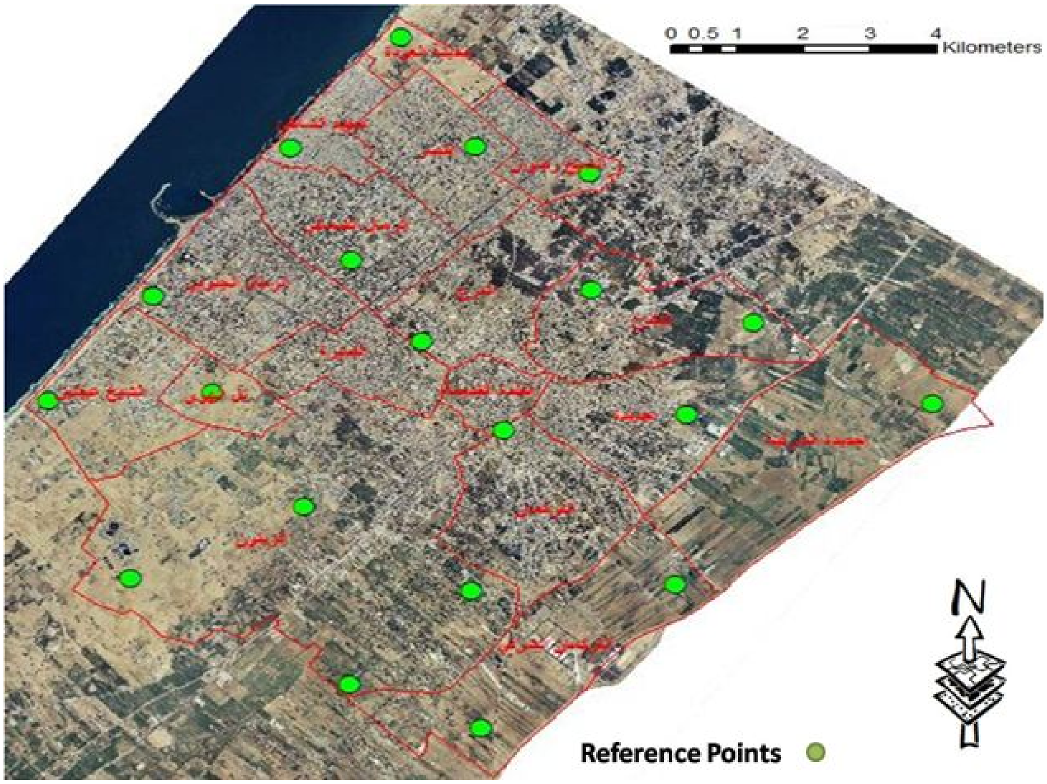

Fig. 5.1: Location for the selected points for the study area (Municipality of Gaza, 2011)

Secondly, before starting the digitizing stage, the coordinates of neighbor board are located in the two Aerial maps. Digitizing processes are considered as the basic process to build vector spatial model which will be used to apply the study results in land use and land cover.

The process 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. (Figure 5.2) explains an example of digitizing process for one of the neighborhoods of the City which is "Al Awda".

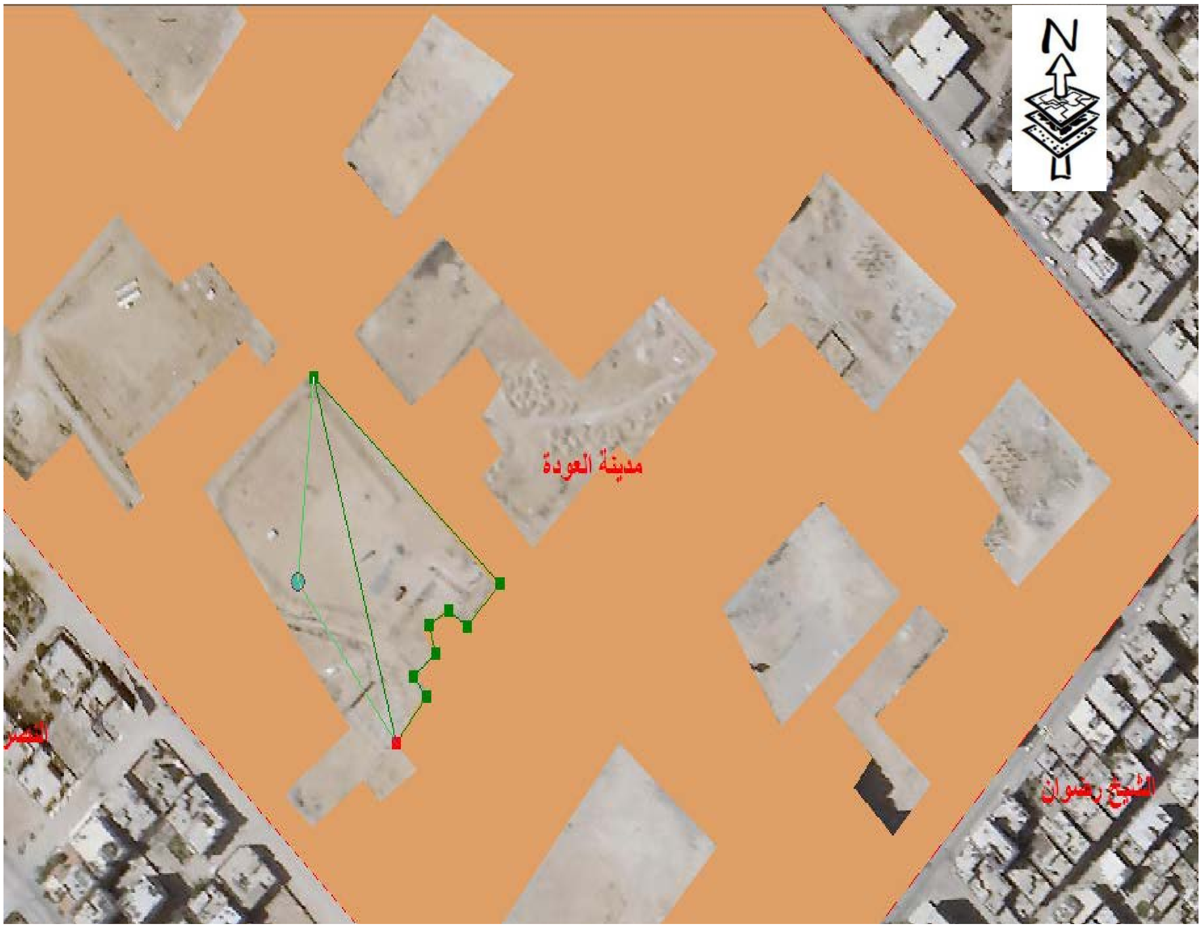

Fig. 5.2: Example of Digitizing Process “Al Awda neighborhood”

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.

Thirdly, change detection process is the next stage. It is helpful to get the accuracy for the results of this study. ARCGIS software provides an Erase Tools which is useful in showing change of places and areas in general. (Figure 5.3) shows the use of Erase Tool and its application in special vector model for 1999 and 2007 images.

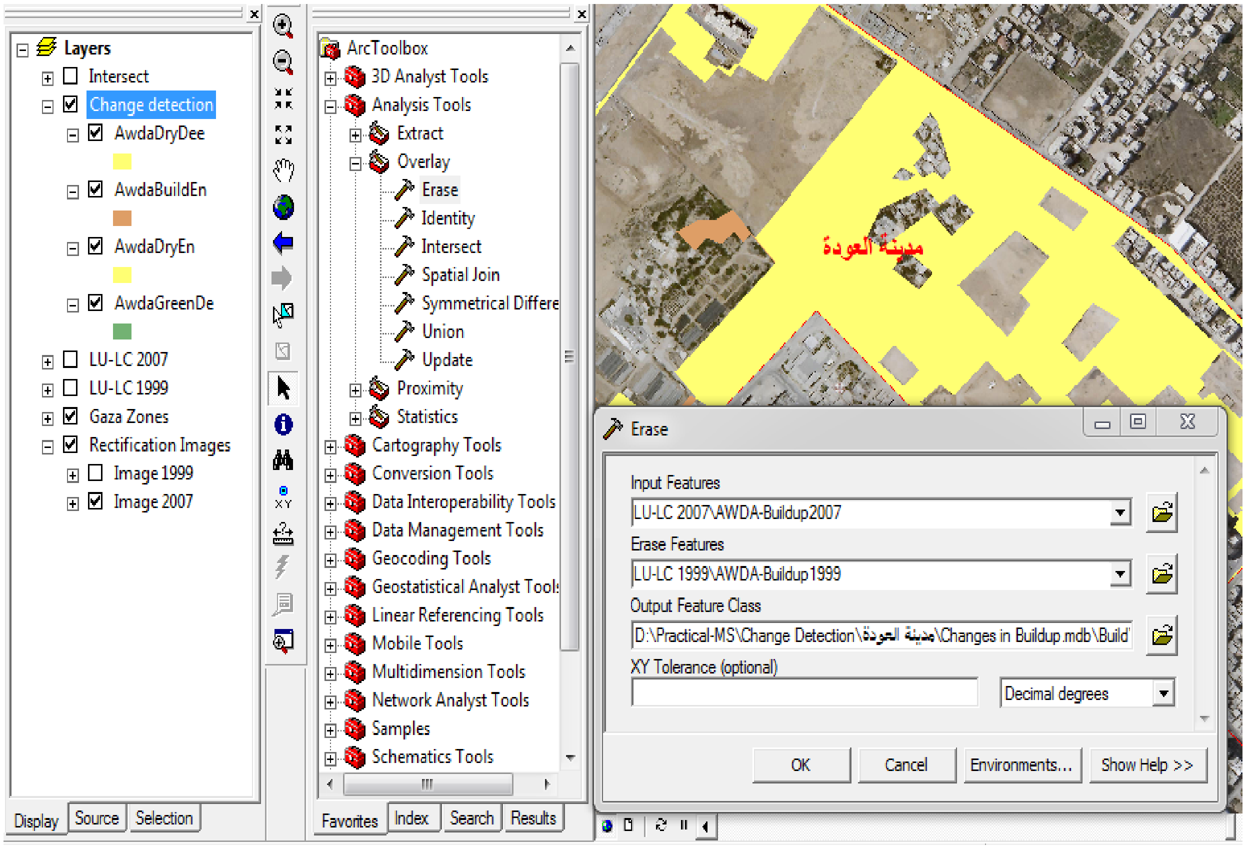

Fig. 5.3: Using Erase Tool

To know the directions of any increasing or decreasing which could be occurred in classification study, the intersect tools had been used. (Figure 5.4) shows the practice stage for intersect tools using ARC GIS software.

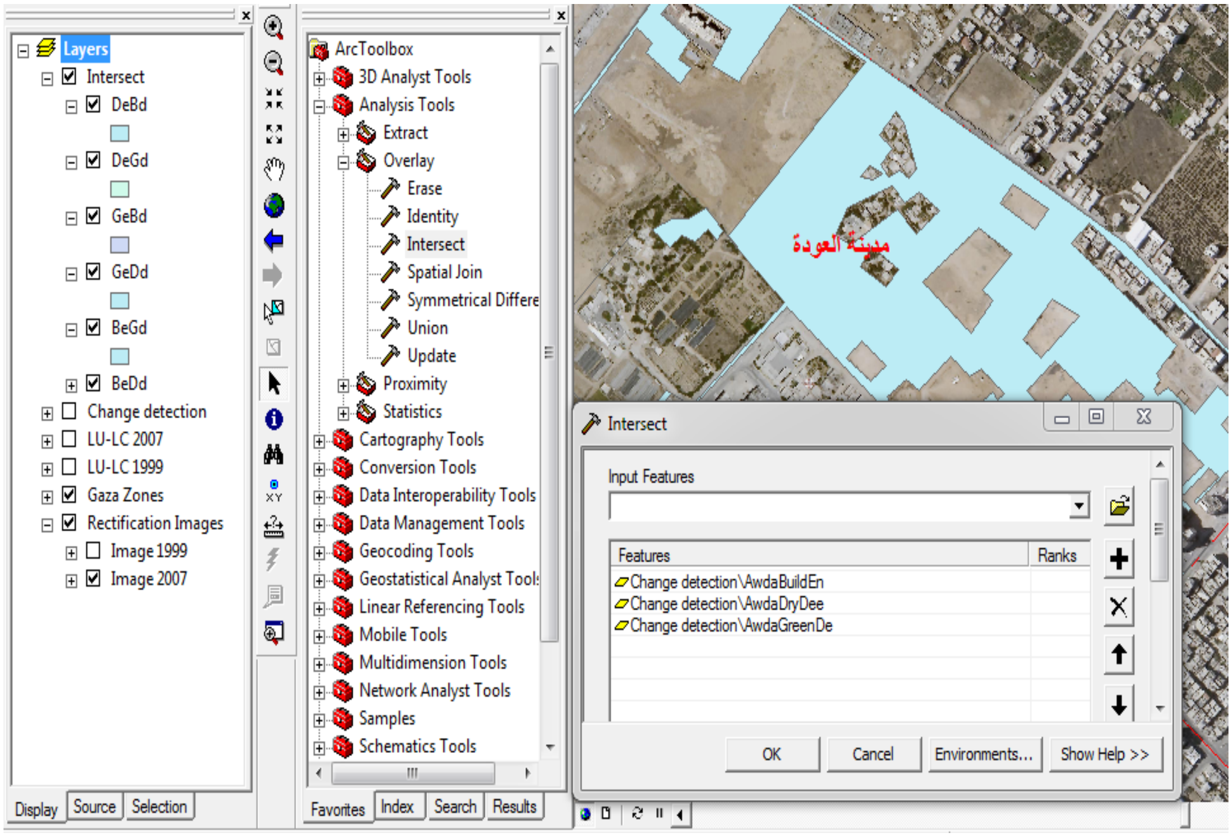

Fig. 5.4: Using Intersect Tool

5.3 LULC Distribution Statues

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 5.2 presents the areas and study classification percentage in 1999 and 2007.

Table 5.2: Summary of area for LULC Types (1999 – 2007) period

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%

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, see (Figure 5.5).

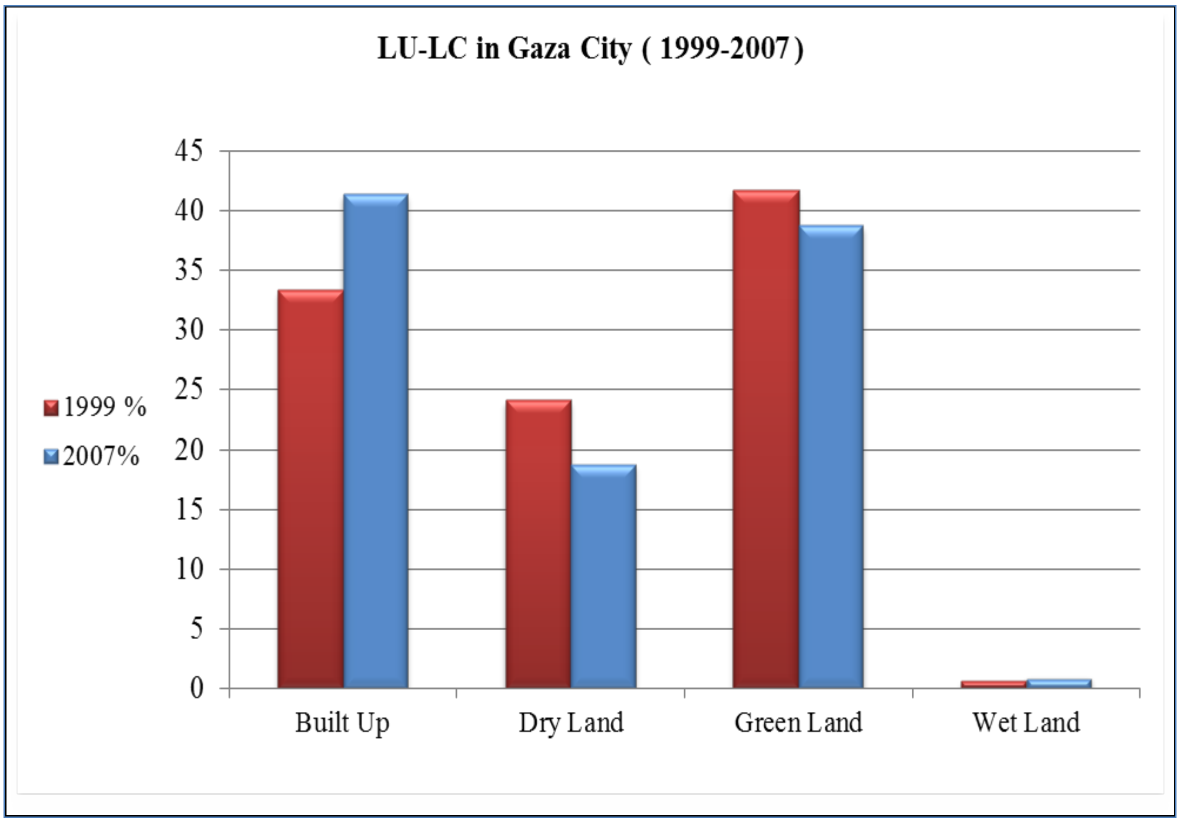

Fig. 5.5: Land Use and Land Cover Distribution (1999-2007) (Percentage)

5.4 LULC Change Detection on Gaza City

The percentage of changes between different LULC classes for the period 1999 to 2007 can be derived from Table 5.3. 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.

Table 5.3: 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%

In addition, Table 5.3 presents a summary of the area change for LULC types by dunom while (Figure 5.6) shows the percentage change of net area increase or decrease for the different LULC categories for the same period.

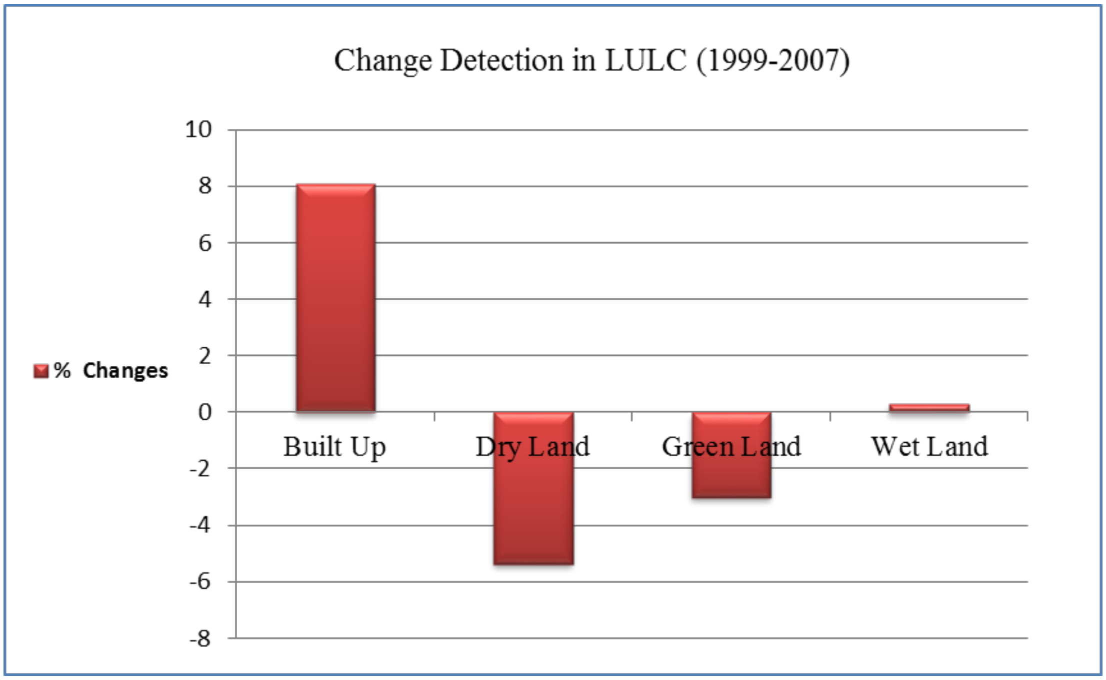

Fig. 5.6: Percentage of Change Detection in LULC Classes

5.5 Direction of Changes

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 which occurs either as a willing or Elis willing. Intersect tool has been used to get these results as shown in (Figure 5.7) and (Figure 5.8). They explain the location of all increases and decreases for built up, green land, dry land and wet land.

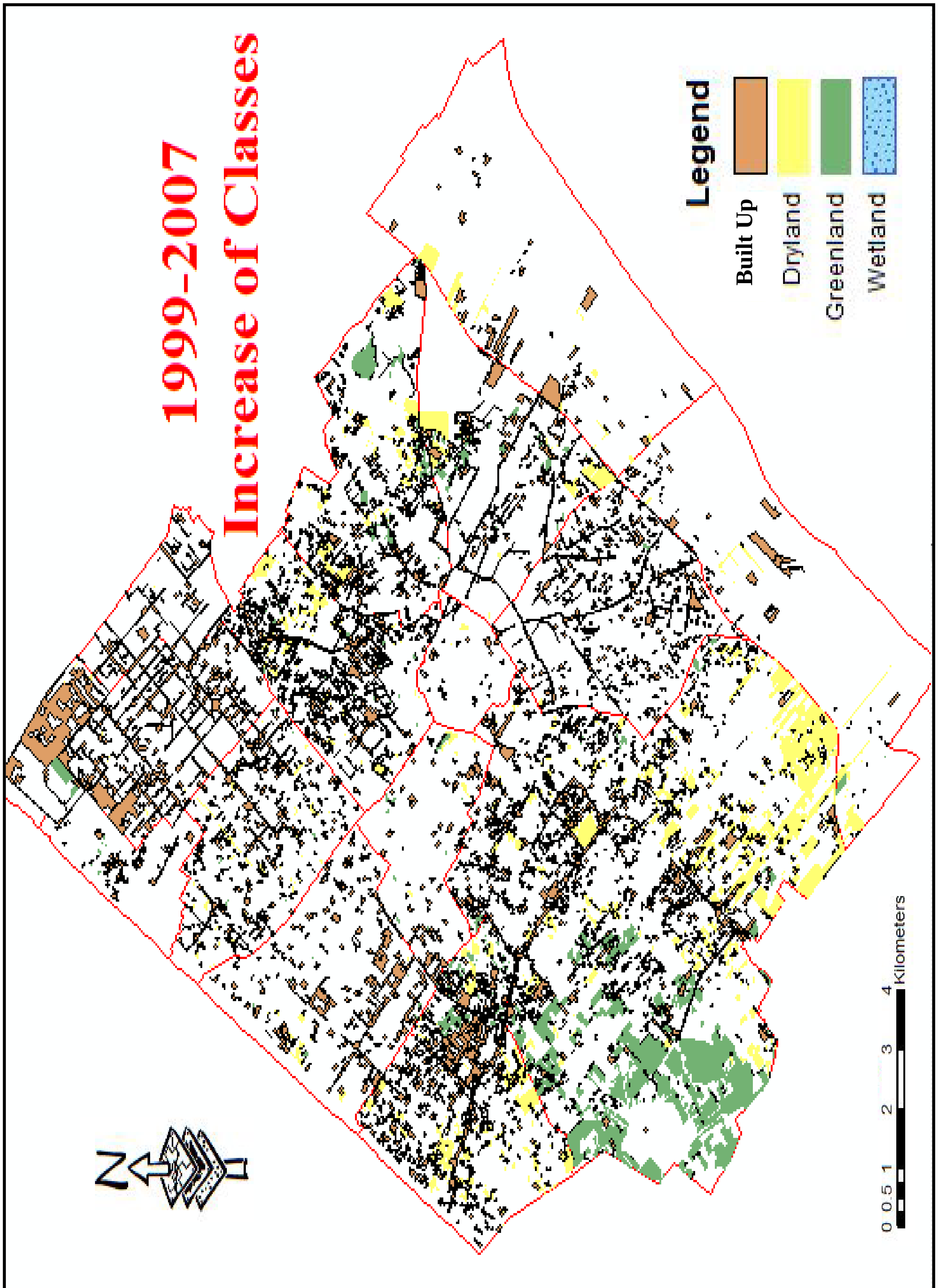

Fig. 5.7: LULC increase of classes (1999-2007)

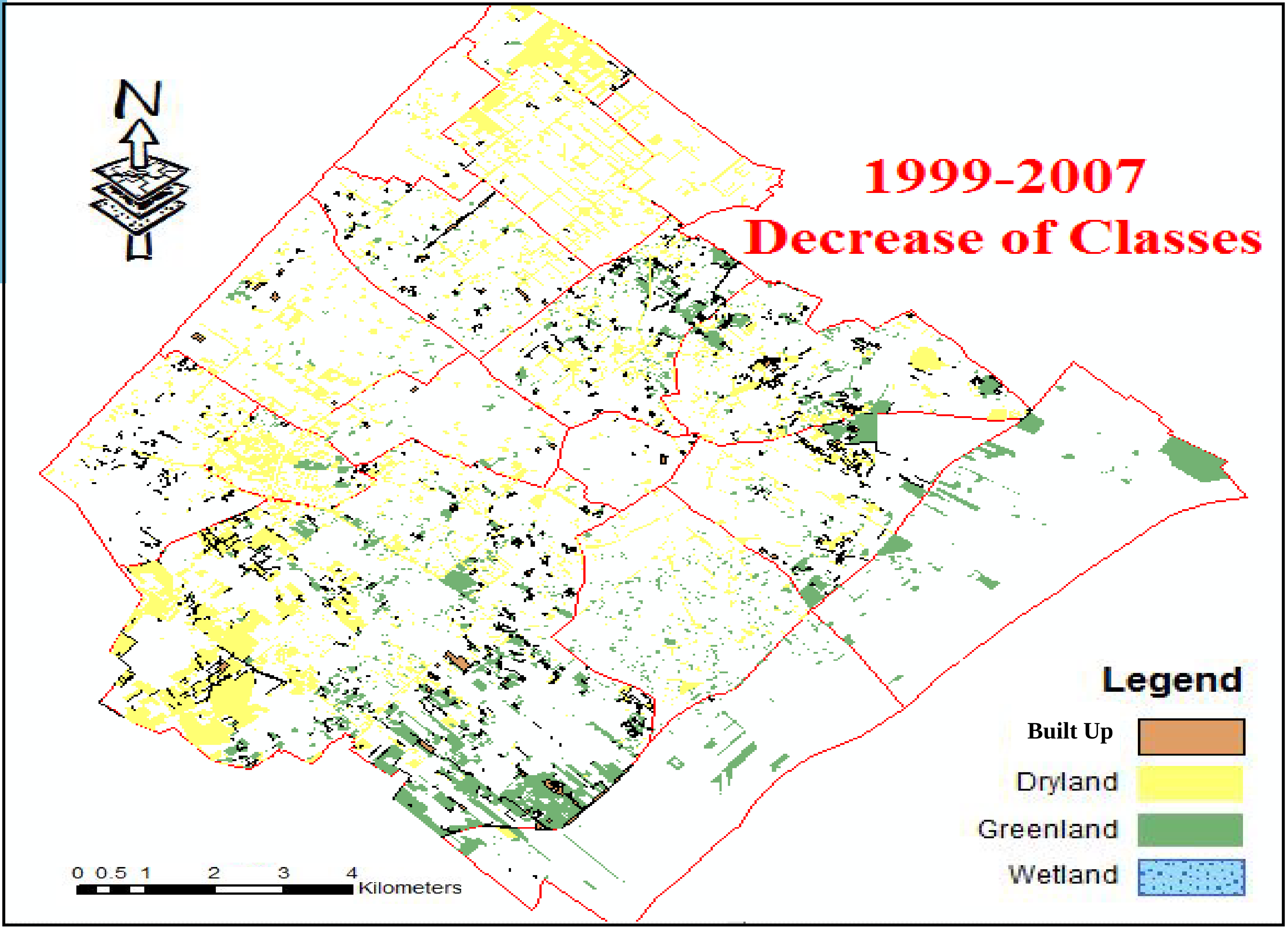

Fig. 5.8: LULC decrease of classes (1999-2007)

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. Also in the south of the City, the dry land decreased because it transfers to green land. In addition, the built up class increased in "Tal El hawa" neighborhood to face the extension of Netsareem settlement during that time. The politic 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 attacks on this region and the damages of its trees. Table 5.4 explains the general direction of change throw transfer and cross of the classification classes increasing or decreasing. For example, the general type of change in built up class was increased throw converted 73.40% from dry land and 26.60% from green land.

Table 5.4: General Direction of Change of Classes (Percentage of increases/decreases)

Classes	Type of Change	Total Area (Dunom)	Direction of Change (%)			
			Built Up	Dry Land	Green Land	wet land
Built Up	Increase	3963.7120	-----------	73.4%	26.6%	0.0%
Dry Land	Decrease	-4500.9129	64.2%	-----------	35.8%	0.0%
Green Land	Decrease	-3056.5213	50.9%	49.1%	-----------	0.0%
Wet Land	Increase	137.6669	0.0%	0.0%	100.0%	-----------

5.6 Change Detection of Neighborhoods in Gaza City

The changes in the LULC neighborhoods in Gaza City can be observed through Table 5.5 which displays the proportion of representing area as structural plan, population from Municipality in 2009 and the change detection happened in (built up, green land, dry land, wet land).

Table 5.5: Percentage Change in Classification Study 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 5.5, 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 (Figure 5.9). Another rising on the area is estimated as 1.4% as a residential tower to accommodate 1.4% of the population. Also Tal El Hawa residential 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%.

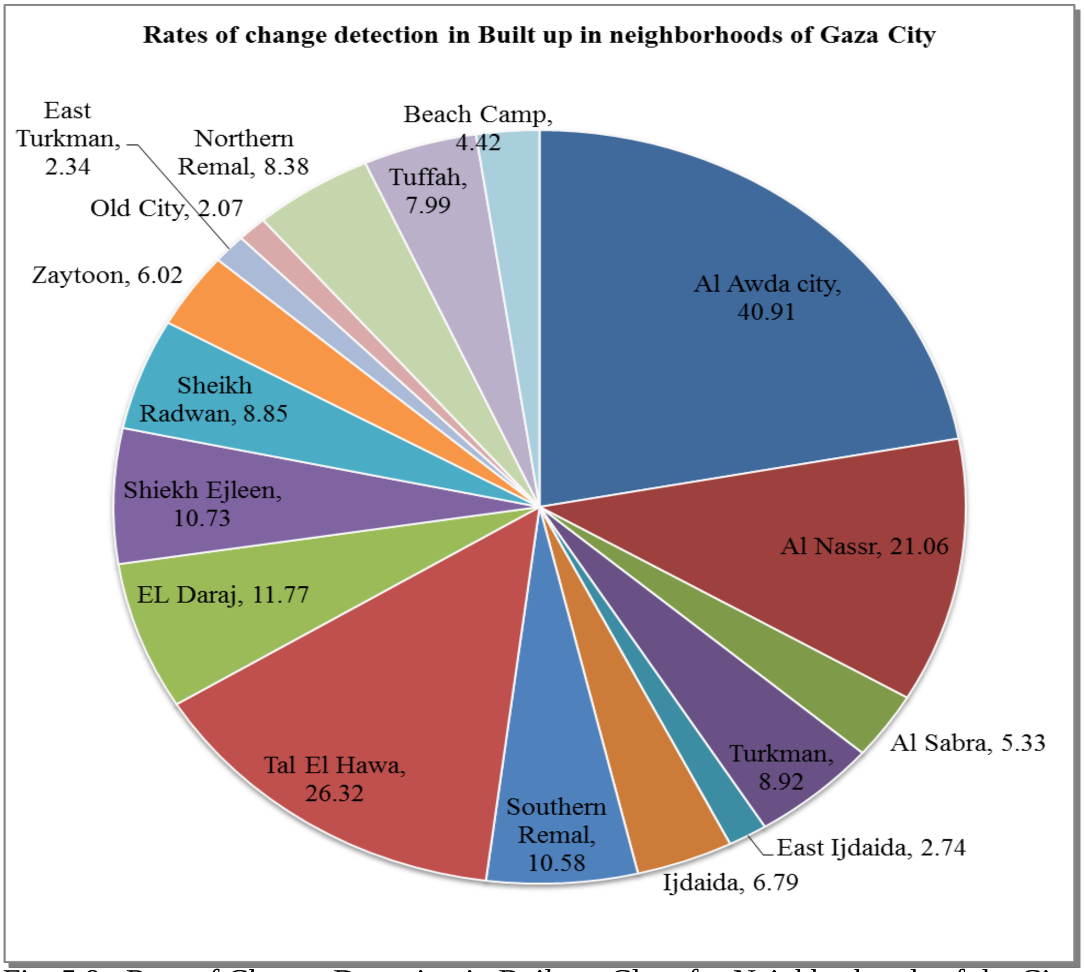

Fig. 5.9: Rate of Change Detection in Built up Class for Neighborhoods of the City

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.

Al Nasser neighborhood is twice Al Sheick Ajleen in change detection of built up which constitute 21.06% although the area occupies 4.46%. Shiekh Ejleen neighborhood places on 4.62% of the total City area and increasing change detection of built up is 10.73%. . Due to the social inheritance laws causing the disintegration of agricultural land into small fragment pieces and to be converted into built up class and the dominated political situation, all of this causes the conversion of the areas to be dry land within 3.94%.

The relationship between the political situation and population growth is clear in the neighborhoods of Gaza City. For example, The East Ijdaida neighborhood does not exceed the proportion of the population of 0.17% and change detection in built up class estimates as 2.74% only although its large area occupied of the City which is estimated as 10.78%.

Furthermore, AL Zaytoon neighborhood is generally considered the largest in terms of area as estimated 24.72% of the total City area (Figure 5.10), while its population constitutes 11.23% and increasing rate in built up is 6.02%. Otherwise Beach Camp is the most overcrowded neighborhood in population as estimated 15.31% (Figure 5.11) comparing to its area land. This problem attributed to the compulsory immigration of the refugees from 1948 lands to The Gaza Strip forming a new residential overcrowded spot and deep impact on the use of LULC in this neighborhood.

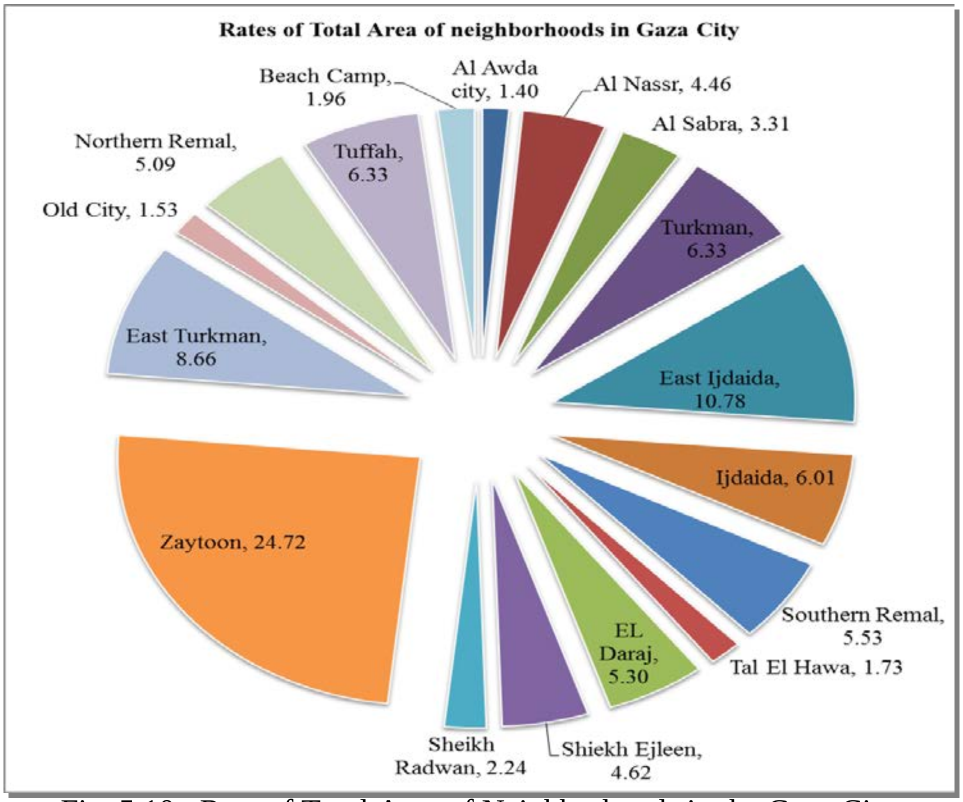

Fig. 5.10: Rate of Total Area of Neighborhoods in the Gaza City

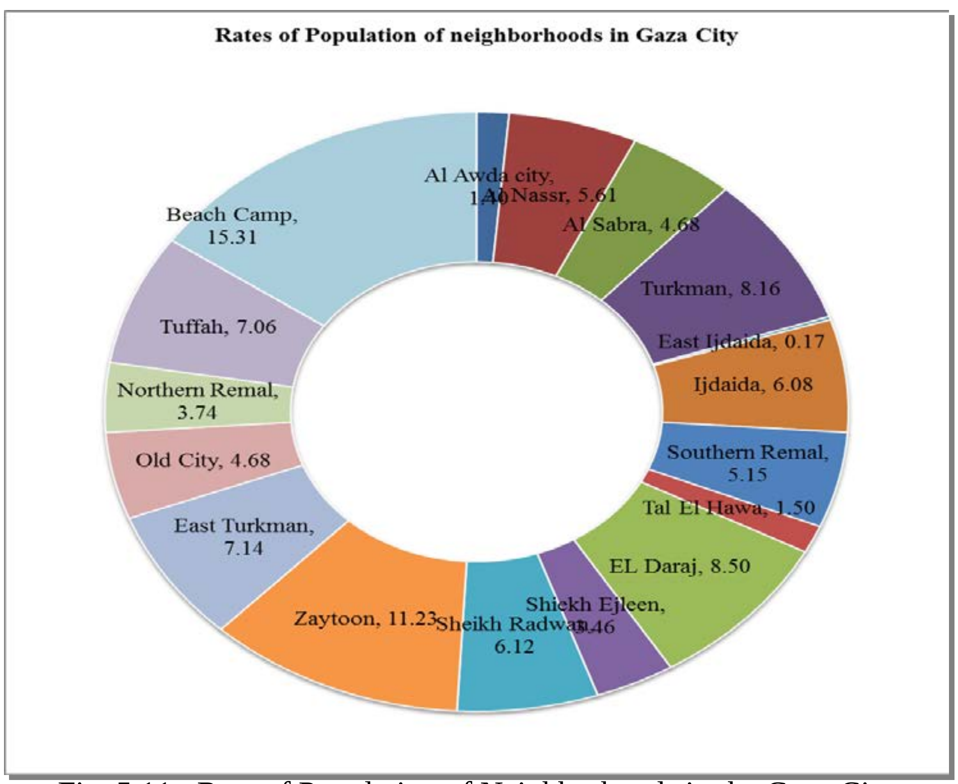

Fig. 5.11: Rate of Population of Neighborhoods in the Gaza City

Involved Beach Camp in terms of over population, the Old City neighborhood almost has not any empty areas or open spaces because of its commercial importance which makes it the center formation of Gaza City. In 2007, the built up class which constitutes 89.29% in Old City neighborhood, while constitutes 95.13% in the Beach camp neighborhood, see Table 5.6.

Table 5.6 shows summary of the percentage areas for every neighborhood from year 1999 to 2007 in addition to the changing rate for every class of the study.

Table 5.6: Rate Area for Every Neighborhood from 1999 to 2007

SN	**Neighborhood**	**Classification**	**1999**	**2007**
			% of Area	**% of Area**
1	Al Awda City	Built Up	17.13%	58.04%
		Dry Land	76.90%	33.29%
		Green Land	5.97%	8.67%
		Wet Land	0.00%	0.00%
		Total Area	100%	100%
2	Al Nassr	Built Up	69.09%	90.15%
		Dry Land	30.91%	9.85%
		Green Land	0.00%	0.00%
		Wet Land	0.00%	0.00%
		Total Area	100%	100%
3	Al Sabra	Built Up	77.76%	83.08%
		Dry Land	11.43%	6.94%
		Green Land	10.81%	9.98%
		Wet Land	0.00%	0.00%
		Total Area	100%	100%
4	Turkman	Built Up	45.13%	54.05%
		Dry Land	12.75%	8.17%
		Green Land	42.12%	37.78%
		Wet Land	0.00%	0.00%
		Total Area	100%	100%
5	East Ijdaida	Built Up	4.89%	7.64%
		Dry Land	1.71%	3.15%
		Green Land	93.40%	86.43%
		Wet Land	0.00%	2.79%
		Total Area	100%	100%

Table 5.6: Continued

SN	Neighborhood	Classification	1999	2007
			% of Area	% of Area
6	Ijdaida	Built Up	44.41%	51.20%
		Dry Land	16.15%	14.81%
		Green Land	39.44%	33.99%
		Wet Land	0.00%	0.00%
		Total Area	100%	100%
7	Southern Remal	Built Up	60.37%	70.95%
		Dry Land	32.84%	23.57%
		Green Land	6.79%	5.48%
		Wet Land	0.00%	0.00%
		Total Area	100%	100%
8	Tal El Hawa	Built Up	10.16%	36.48%
		Dry Land	79.24%	50.69%
		Green Land	10.60%	12.83%
		Wet Land	0.00%	0.00%
		Total Area	100%	100%
9	EL Daraj	Built Up	49.11%	60.88%
		Dry Land	21.14%	16.68%
		Green Land	29.75%	22.44%
		Wet Land	0.00%	0.00%
		Total Area	100%	100%
10	Shiekh Ejleen	Built Up	15.87%	26.60%
		Dry Land	32.96%	36.90%
		Green Land	51.18%	36.50%
		Wet Land	0.00%	0.00%
		Total Area	100%	100%
11	Sheikh Radwan	Built Up	76.71%	85.57%
		Dry Land	14.29%	5.43%
		Green Land	0.00%	0.00%
		Wet Land	9.00%	9.00%
		Total Area	100%	100%
12	Zaytoon	Built Up	15.00%	21.03%
		Dry Land	39.52%	33.34%
		Green Land	43.61%	43.77%
		Wet Land	1.86%	1.86%
		Total Area	100%	100%

Table 5.6: Continued

S N	Neighborhood	Classification	1999	2007
			% of Area	% of Area
13	East Turkman	Built Up	8.88%	11.22%
		Dry Land	4.60%	5.92%
		Green Land	86.52%	82.86%
		Wet Land	0.00%	0.00%
		Total Area	100%	100%
14	Old City	Built Up	87.22%	89.29%
		Dry Land	5.76%	3.95%
		Green Land	7.02%	6.76%
		Wet Land	0.00%	0.00%
		Total Area	100%	100%
15	Northern Remal	Built Up	65.78%	74.16%
		Dry Land	22.35%	16.36%
		Green Land	11.87%	9.48%
		Wet Land	0.00%	0.00%
		Total Area	100%	100%
16	Tuffah	Built Up	30.42%	38.40%
		Dry Land	26.31%	20.89%
		Green Land	43.27%	40.70%
		Wet Land	0.00%	0.00%
		Total Area	100%	100%
17	Beach Camp	Built Up	90.71%	95.13%
		Dry Land	7.74%	2.71%
		Green Land	1.55%	2.16%
		Wet Land	0.00%	0.00%
		Total Area	100%	100%

5.7 Structural Plan of Gaza City in 1997

The Structural plan of Gaza City in 1997 gets a classification of LULC to 23 classes which are grouped and re-divided in proportion to the objective of this research. The following Table 5.7 shows the total area by the new classification; note that the beach zone is not a comprehensive area in this study.

Table 5.7: Total area by research classification according to the structural plan 1997

No.	Basic Classes	Developed Classes	Area (Dunom)	% Area
1	Boundaries of The Scheme	Built Up	37582.89727	81.98%
2	Residential Zone Class B			
3	Residential Zone Class C			
4	Agricultural-Residential Zone A			
5	Old Town			
6	Main Commercial Center			
7	Commercial Facades			
8	Tourism & Recreation Zone			
9	Public Buildings			
10	Archeological Site			
11	Public Cemeteries			
12	Sport Zone			
13	Existing Roads			
14	Proposed Roads			
15	Ring Roads			
16	Railway Land			
17	Regional Transportation Center			
18	Industrial Area			
19	Freezed Development Zone			
20	Green Area	Green Land	8155.49125	17.79%
21	Agricultural Area			
22	Storm Water Collection Area	Wet Land	103.207	0.23%
23	Beach Zone	Dry Land	Non	0.00%
Total			45841.59552	100%

(Figure 5.12) displays the location of the classification study as in the structural plan. The vast majority of the agricultural areas are located on the eastern and southern of the City due to fear is to start construction projects on these areas because nearest of border of The Gaza Strip with Israel. In addition, the existence of Netsareem settlement in the south of the City during the study period, determines the formation of that land as agricultural areas and frozen regions.

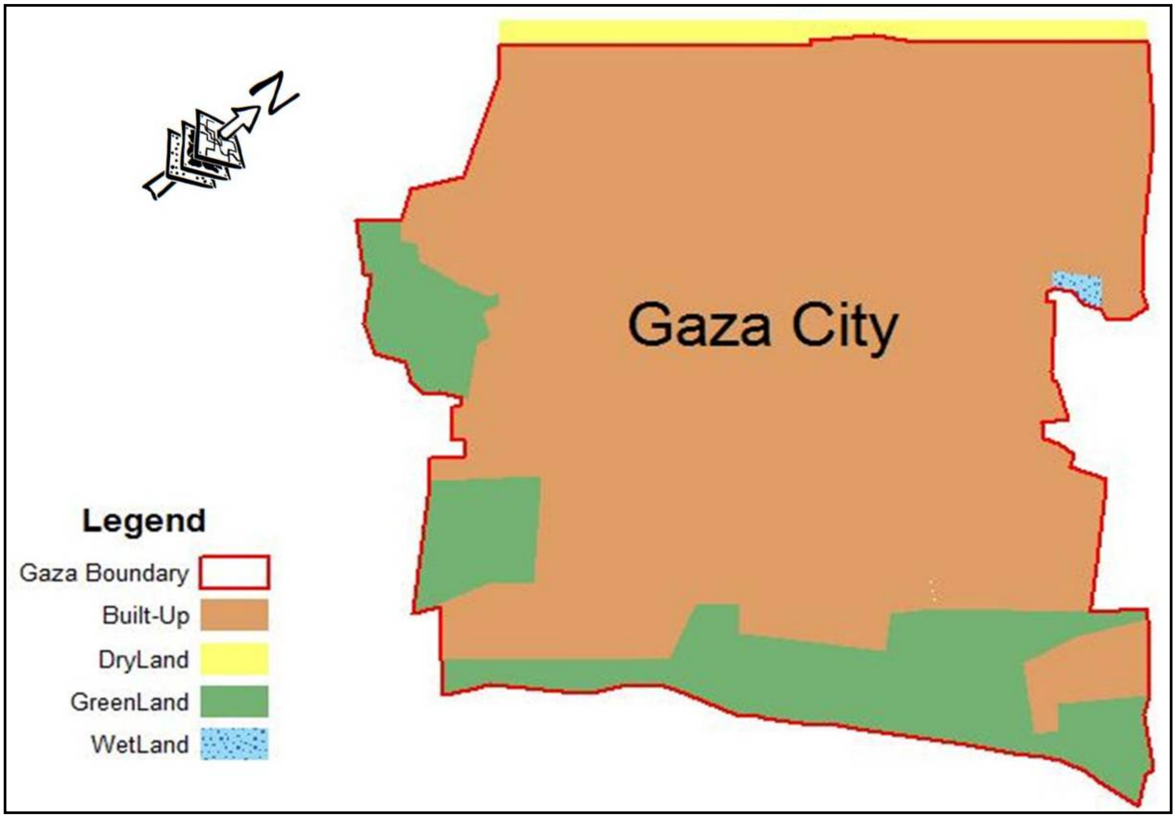

Fig. 5.12: Location of the Classification Study as in the Structural Plan

Structure Plan 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. (Figure 5.13) explains the percentage of built up, green land, dry land and wet land in the structure plan. In addition, Table 5.8 presents percentage of area classes comparing between structural plan and the result change in 2007.

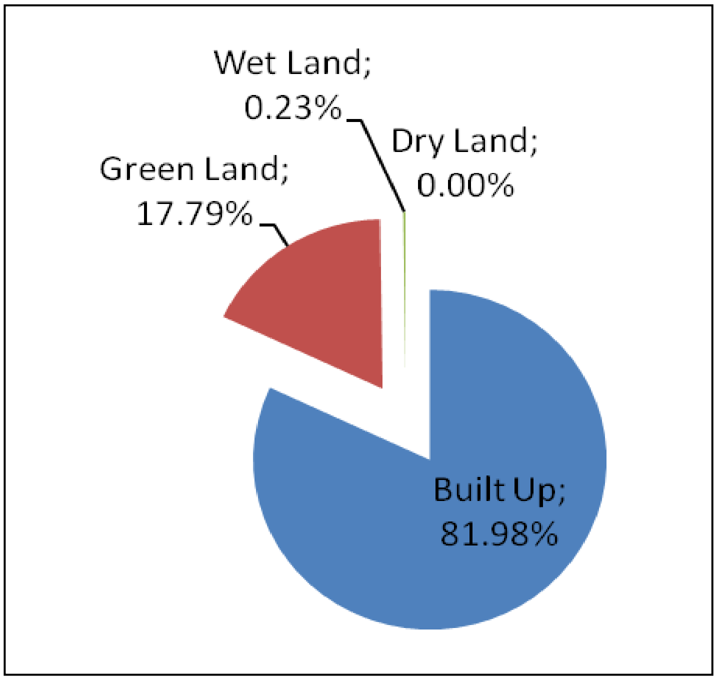

Fig. 5.13: Percent of LULC Classification Study in Structure Plan

Table 5.8: Percent of area classes for structural plan and the result change in 2007

Classes	**Area of Structural Plan**	**Area of Result Change in 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%

5.8 Expectation of the LULC according to the structural Plan

This part of study 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 [$P=P_o\ (1+R)^t$] (Morris et al., 2002).

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.

Knowledge of population, population growth and rate of built up for studying years are important in the production equation. Table 5.9 shows figures, predicted and obtained by using Excel software. Those figures show the relationship between the built up rate and the population is expecting of a direct correlation. Excel also 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 (Figure 5.14). Applying the equation, it leads to know the predicted population growth rate and which year is expected in rise in 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 5.9: Predicted 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

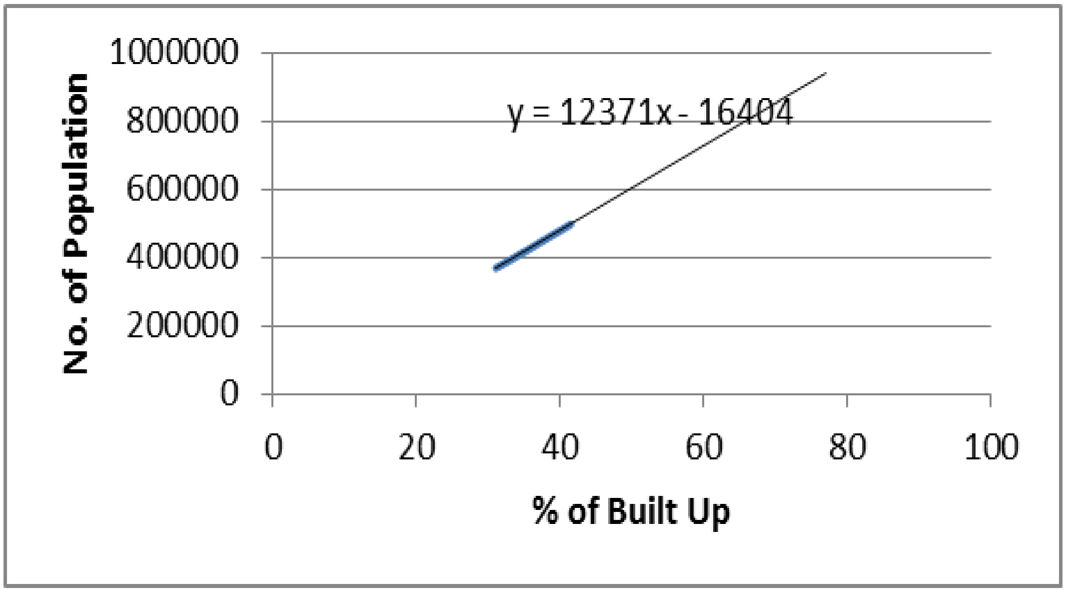

Fig. 5.14: Trend Equation between the Built up Rate and Population

CHAPTER (6): CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The purpose of this study basically focused on specifying the changes detection on land use and land cover of Gaza City between year 1999 and 2007. Moreover it is displaying values and average of the areas based on the City structure plan for year 1997. In addition, the study attempts to identify the year where the specified areas for built up usage are full according to the City population growth. Depending on the data and outputs of the study, it draws the following results:

- 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.
- The study has designed many digital computerized and accurate maps, which are connected to databases for every City neighborhoods, as it cannot be done unless using geographical information system. Furtherance it can be possibly modified and adjusted up to date. They contribute largely and effectively in identifying the change detection of LULC, they can be employed in taking the best decision in planning and dividing the land to be in harmony with the possible population growth.

- The GIS 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. The GIS is recognized with its ability to view two stages of the study categories on maps. However, this technique is characterized with accuracy, speed, trialing and analyzing many data, it requires huge effort in adding data and information.
- The study shows that the large population growth is the most important factor that causes increasing in the use of LULC specially for built up class.
- The study notices that using of land is interlocked and divided disparately throughout the City that makes it hard to determine a specific line mostly for all regions. Nevertheless, worth saying that, the Old City neighborhood naturally depends on trade, the east and south parts of the City is agricultural whereas camp beach is residential.
- It is noticeable that there are no green regions or enough green areas in neighborhoods through the entire City for the advantage of the population.
- The study infers that the operative laws and regulations inside the City have partial contributed to determine some types of LULC by the City structure plan.
- The study demonstrates that the political status and the Israel flagrant violations have great effect on the LULC and the regrouping and division of the agricultural areas and the types of crops to be grown in the east and south of the City.
- Obviously, the green areas of the City have been shrunken as a result of the ongoing growth of the population and the legacy laws that led to disintegration of many lands.

6.2 Recommendation

Based on the study and its results, it is advisable to draw the general points to benefit from this study and is recommended the following:

- Take benefits from the current content of the study for the forthcoming studies especially decision makers looking forward to support developing and uplifting the City.
- Design a new structure plan for the City utilizing the previous laws, political, economic, environmental, social, educational, religious and historical theories for the City allowing resolving the past problems and containing disparity of land nature and basically for construction developments.
- The necessary to identify a local strategic for LULC considering practical and scientifically dimensions so as to lack advantage from other countries experiences. In addition to activate the institutions, government departments and private sectors also participate in taking decisions.
- Grant a great consideration for associated local sectors and public activities participation and working on rise citizens' awareness for the importance of LULC and the vital role of developing the City also the necessity to adhere to these commitments for the upcoming generations.
- The urgent needs to device special programme for observation and periodical evaluation of LULC. Moreover using modern technology as geographical information system and remote sensation to monitor land use and land cover.
- It is recommended to use GIS in studying the alteration of LULC referring to its ability to deal with constant data up to date. Furthermore observing the transformation of LULC basically helps in taking the suitable decision for emergent problems. Otherwise, it is the possible way to conduct studies with less time and expense especially in large spaces.
- The study of LULC and its characteristic is basically a process that needs a massive amount of information and data attempting to overcome the deficiency to be appropriate with needed decisions. It is advisable to use GIS to input, store, and analyze information and to geographically connect to its locations.

- It is considerably important to activate restriction and conditions to maintain agricultural land and prevent all standing violation besides direct constructions towards. Also it is important to direct our attentions toward green areas as to achieve food security in addition to be income resources to the country.

- It is considered very important to prevent any existence of industrial regions nearby residential areas regarding to the fatal and dangerous affection environmentally and healthy.
- Developing research centers for LULC planning and providing lands for that purposes.
- The study is reflecting accurate and good results though mistakes are evitable factor because of human falls or other reasons.
- The Municipality committed to establish laws and regulations of land using. In addition, choosing public services regions and follow scientific basic in the study and planning.

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APPENDIXS

APPENDIX (A): Summary of change detection techniques categories

Table A.1: Summary of change detection techniques categories (Lu et al., 2004).

Techniques	Characteristics	Advantages	Disadvantages
Category (1): Algebra			
1.1. Image differencing	Subtracts the first date image from a second-date image, pixel by pixel.	Simple and straightforward, easy to interpret the results.	Cannot provide a detailed change matrix, requires selection of thresholds.
1.2. Image regression	Establishes relationships between bitemporal images, then estimates pixel values of the second-date image by use of a regression function, subtracts the regressed image from the first-date image.	Reduces impacts of the atmospheric, sensor and environmental differences between two-date images.	Requires to develop accurate regression functions for the selected bands before implementing change detection.
1.3. Image ratioing	Calculates the ratio of registered images of two dates, band by band.	Reduces impacts of Sun angle, shadow and topography.	Non-normal distribution of the result is often criticized.
1.4. Vegetation index differencing	Produces vegetation index separately, then subtracts the second-date vegetation index from the first-date vegetation index.	Emphasizes differences in the spectral response of different features and reduces impacts of topographic effects and illumination.	Enhances random noise or coherence noise.
1.5. Change vector analysis (CVA)	Generates two outputs: (1) the spectral change vector describes the direction and magnitude of change from the first to the second date; and (2) the total change magnitude per pixel is computed by determining the Euclidean distance between end points through n-dimensional change space.	Ability to process any number of spectral bands desired and to produce detailed change detection information.	Difficult to identify land cover change trajectories.
1.6. Background subtraction	Non-change areas have slowly varying background grey levels. A low-pass filtered variant of the original image is used to approximate the variations to the background image. A new image is produced through subtracting the background image from the original image.	Easy to implement.	Low accuracy

Table A.1: Continued

Techniques	Characteristics	Advantages	Disadvantages
	Category (2): Transformation		
2.1. Principal component analysis (PCA)	Assumes that multi-temporal data are highly correlated and change information can highlighted in the new components. Two ways to apply PCA for change detection are: (1) put two or more dates of images into a single file, then perform PCA and analyze the minor component images for change information; and (2) perform PCA separately, then subtract the second-date PC image from the corresponding PC image of the first date.	Reduces data redundancy between bands and emphasizes different information in the derived components.	PCA is scene dependent, thus, the change detection results between different dates are often difficult to interpret and label. It cannot provide a complete matrix of change class information and requires determining thresholds to identify the changed areas.
2.2. Tasselled cap (KT)	The principle of this method is similar to PCA. The only difference from PCA is that PCA depends on the image scene, and KT transformation is independent of the scene. The change detection is implemented based on the three components: brightness, greenness and wetness	Reduces data redundancy between bands and emphasizes different information in the derived KT components. KT is scene independent.	Difficult to interpret and label change information, cannot provide a complete change matrix; requires determining thresholds to identify the changed areas. Accurate atmospheric calibration for each date of image is required.
2.3. Gramm–Schmidt (GS)	The GS method orthogonally spectral vectors taken directly from bi-temporal images, as does the original KT method, produces three stable components corresponding to multi-temporal analogues of KT brightness, greenness and wetness, and a change component.	The association of transformed Components with scene characteristics allow the extraction of information that would not be accessible using other change detection techniques.	It is difficult to extract more than one single component related to a given type of change. The GS process relies on selection of spectral vectors from multi-date image typical of the type of change being examined

Table A.1: Continued

Techniques	Characteristics	Advantages	Disadvantages
2.4. Chi-square	Y~(X2M)T S21 6(X2M) Y: digital value of change image, X: vector of the difference of the six digital values between the two dates, M: vector of the mean residuals of each band, T: transverse of the matrix, S21: inverse covariance matrix of the six bands.	Multiple bands are simultaneously considered to produce a single change image.	The assumption that a value of Y~0 represents a pixel of no change is not true when a large portion of the image is changed. Also the change related to specific spectral direction is not readily identified.
Category (3): Classification			
3.1. Postclassification comparison	Separately classifies multi-temporal images into thematic maps, then implements comparison of the classified images, pixel by pixel.	Minimizes impacts of atmospheric, sensor and environmental differences between multi-temporal images; provides a complete matrix of change information.	Requires a great amount of time and expertise to create classification products. The final accuracy depends on the quality of the classified image of each date.
3.2. Spectral–temporal combined analysis	Puts multi-temporal data into a single file, then classifies the combined dataset and identifies and labels the changes.	Simple and timesaving in classification.	Difficult to identify and label the change classes; cannot provide a complete matrix of change information.
3.3. EM detection	The EM detection is a classification-based method using an expectation–maximization (EM) algorithm to estimate the a priori joint class probabilities at two times. These probabilities are estimated directly from the images under analysis.	This method was reported to provide higher change detection accuracy than other change detection methods.	Requires estimating the a priori joint class probability.
3.4. Unsupervised change detection	Selects spectrally similar groups of pixels and clusters date 1 image into primary clusters, then labels spectrally similar groups in date 2 image into primary clusters in date 2 image, and finally detects and identifies changes and outputs results.	This method makes use of the Unsupervised nature and automation of the change analysis process.	Difficulty in identifying and labeling change trajectories.

Table A.1: Continued

Techniques	Characteristics	Advantages	Disadvantages
3.5. Hybrid change detection	Uses an overlay enhancement from a selected image to isolate changed pixels, then uses supervised classification. A binary change mask is constructed from the classification results. This change mask sieves out the changed themes from the LULC maps produced for each date.	This method excludes unchanged pixels from classification to reduce classification errors.	Requires selection of thresholds to Implement classification; somewhat complicated to identify change trajectories.
3.6. Artificial neural networks (ANN)	The input used to train the neural network is the spectral data of the period of change. A back propagation algorithm is often used to train the multi-layer perception neural network model.	ANN is a nonparametric supervised method and has the ability to estimate the properties of data based on the training samples.	The nature of hidden layers is poorly known; a long training time is required. ANN is often sensitive to the amount of training data used. ANN functions are not common in image processing software.
Category (4): Advanced models			
4.1. Li–Strahler reflectance model	The Li–Strahler canopy model is used to estimate each conifer stand crown cover for two dates of imageries separately. Comparison of the stand crown covers for two dates is conducted to produce the change detection results	This method combines the techniques of digital image processing of remotely sensed data with traditional sampling and field observation methods. It provides statistical results and maps showing the geometric distribution of changed patterns.	This method requires a large number of field measurement data. It is complex and not available in commercial image processing software. It is only suitable for vegetation change detection.

Table A.1: Continued

Techniques	Characteristics	Advantages	Disadvantages
4.2. Spectral mixture model	Uses spectral mixture analysis to derive fraction images. End members are selected from training areas on the image or from spectra of materials occurring in the study area or from a relevant spectral library. Changes are detected by comparing the 'before' and 'after' fraction images of each end member. The quantitative changes can be measured by classifying images based on the end member fractions.	The fractions have biophysical meanings, representing the areal proportion of each end member within the pixel. The results are stable, accurate and repeatable.	This method is regarded as an advanced image processing analysis and is somewhat complex.
4.3. Biophysical parameter method	Develops a biophysical parameter estimation model through integration of field measurements and remotely sensed data and estimates the parameter for the study area. The vegetation types are classified based on the biophysical parameter. The model is also transferred to other image data with different dates to estimate the selected parameters after reflectance calibration or normalization. Change detection is implemented through comparing the biophysical parameters.	This method can accurately detect vegetation change based on vegetation physical structures.	Requires great effort to develop the model and implement accurate image calibration to eliminate the difference in reflectance caused by different atmospheric and environmental conditions. Requires a large number of field measurement data. The method is only suitable for vegetation change detection.
Category (5): GIS			
5.1.Integrated GIS and Remote sensing method	Incorporates image data and GIS data, such as the overlay of GIS layers directly on image data; moves results of image processing into GIS system for further analysis.	Allows access of ancillary data to aid interpretation and analysis and has the ability to directly update land-use information in GIS.	Different data quality from various sources often degrades the results of LULC change detection.

Table A.1: Continued

Techniques	Characteristics	Advantages	Disadvantages
5.2. GIS approach	Integrates past and current maps of land use with topographic and geological data. The image overlaying and binary masking techniques are useful in revealing quantitatively the change dynamics in each category.	This method allows incorporation of aerial photographic data of current and past land-use data with other map data.	Different GIS data with different Geometric accuracy and classification system degrades the quality of results.
Category (6): Visual analysis			
6.1. Visual interpretation	One band (or VI) from date1 image as red, the same band (or VI) from date2 image as green, and the same band (or VI) from date3 image as blue if available. Visually interprets the colour composite to identify the changed areas. An alternative is to implement on-screen digitizing of changed areas using visual interpretation based on overlaid images of different dates.	Human experience and knowledge are useful during visual interpretation. Two or three dates of images can be analyzed at one time. The analyst can incorporate texture, shape, size and patterns into visual interpretation to make a decision on the LULC change.	Cannot provide detailed change information. The results depend on the analyst's skill in image interpretation. Time-consuming and difficulty in updating the results.

ANNEX

ANNEX (A): The Geographic Information

A.1 Introduction to the Geographic Information System (GIS)

A Geographic Information System (GIS) can be defined as a system for entering, storing, manipulating, analyzing, and displaying geographic or spatial data. These data are represented by points, lines, and polygons (Figure A.1) along with their associated attributes (i.e., characteristics of the features which the points, lines, and polygons represent). For example, the points may represent hazardous waste site locations and their associated attributes may be the specific chemical dumped at the site, the owner, and the date the site was last used. Lines may represent roads, streams, pipelines, or other linear features while polygons may represent vegetation types or land use.

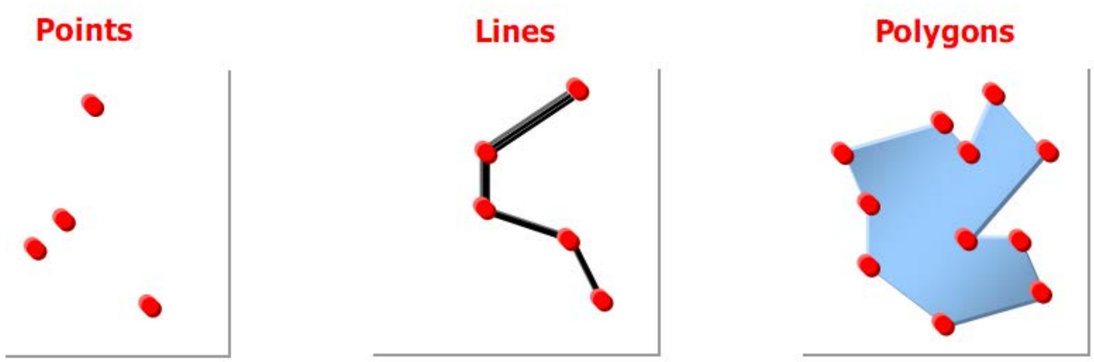


Figure A.1: The 3 elements of geographic data

A.2 GIS importance at its three levels

In science and engineering, there are a number of roles that can be served by GIS technologies. As with any class of technologies, there are a variety of ways to employ the tools. The goal, of course, is to be innovative with the application of tools. Therein lies the challenge and the reward for successful work, GIS data is effective in three levels, 1, 2 and 3 :

A.2.1 Level (1)

At the lowest level of effort, the GIS data can be used to supply inventory information. The presence or absence of given land cover or water classes, or change in these variables on a spatial basis, can be valuable in planning and management. The variety or quantity of certain land cover or water types can be summarized by a certain watershed to produce statistics of interest. The capability to store, quantify, and present data on a spatial basis is an inherent characteristic of GIS technologies.

A.2.2 Level (2)

At the highest level of technology, a GIS can provide a spatial database of information to support modeling of phenomena. The GIS supplies the spatial data in a form that can be input to deterministic or statistical models. The spatial power of the GIS database is used in full by the model, and more detailed and spatially averaged results are produced. This represents a high level of integration and achievement that is now seen in the industry. It has taken a while for such applications to develop, however. This is due to the absence of spatially integrated models for water resource phenomena. Many models use spatial data but average or summarize these data by watershed and/or sub watershed, and thereby lose much of the detail of spatial variability that often influences phenomena. This is the same level of detail necessary to provide high quality model simulations. In general, the strength of GIS is that it is possible to process the data sets using any type of numerical analysis procedure. In particular, certain procedures are valuable for data visualization and analysis, including image processing techniques, virtual reality, and simulation modeling. The digital approach to storing and processing spatial or image data is a fantastic boon to these analyses of data, and the capabilities have yet to be fully realized.

A.2.3 Level (3)

Of particular interest is also the application of a GIS in the automation of infrastructure modeling and information management using modern computer techniques and graphics technology to build what is called _intelligent infrastructures‘. However, this along with the other rewarding applications of a GIS in environmental and water resources engineering cannot be fully conceived by the reader before a terse overview of the basic components and features of any GIS.

A.3 Delivering Custom GIS Applications

Faced with an overabundance of raw information, organizations are awakening to the value of geographic analysis and spatial visualization because of their proven ability to improve operational efficiency and decision making within an organization. May be called business intelligence, analytic applications, or decision support, knowledge workers benefit from software applications that provide them with the information they need to quickly and accurately assess a situation and act accordingly. There are many potential users of geographic information system (GIS)-enhanced applications who are not GIS professionals and are unequipped to take advantage of the comprehensive tools available on the market without a steep learning curve.

A.3.1 Open Source applications

When programmers can read, redistribute, and modify the source code for a piece of software, the software evolves. People improve it, people adapt it, people fix bugs. And this can happen at a speed that, if one is used to the slow pace of conventional software development, seems astonishing.

A.3.2 Custom open source GIS applications

Custom open source GIS applications could act as Decision Support System (DSS) and to some extent as a Spatial Decision Support System (SDSS) which is a computer–based system designed to assist decision system. Typically, such a system will include spatial data relevant to the decision.

A.3.3 Solutions for Efficient GIS Development

The ideal solution to a prolonged GIS development effort is the availability of a component-based development framework that will allow solution providers or an organization's internal developers to rapidly build industry specific GIS applications. A GIS development framework provides the necessary comprehensive spatial functionality for applications and allows the software developer to focus on building application specific logic. ESRI® ArcGIS® Engine is such a GIS framework, created in response to ESRI software users' requests that the rich technology of ArcGIS be productized to enable embedding of spatial functionality in new or existing applications. This will be of particular interest to programmers and project managers who want to embed mapping and GIS functionality in new or existing custom applications and deploy those applications, perhaps in a cross platform environment, in a cost-effective manner.

A.4 Delivering Custom GIS Applications with ArcGIS Engine from ESRI

A.4.1 ArcGIS Engine

ArcGIS Engine is a complete library of embeddable GIS components and tools packaged together for developers to build new or extend existing custom desktop applications. Using ArcGIS Engine, developers can embed GIS functions into existing applications, such as custom industry specific products, and commercial productivity applications, such as Microsoft Word and Excel, as well as build focused custom applications for delivering GIS to many users in their organizations.

A.4.2 Use of ArcGIS Engine

Many users require focused, industry specific access to GIS from within familiar software applications. They need much less than the general GIS products, yet they may require access to sophisticated GIS logic in their applications.

A.5 GIS Analysis Techniques

Once all the necessary existing and new data have been collected then it can all be registered to a common base map. As mentioned, the collection and registering of all these data from various sources can be an expensive, time consuming, and frustrating process. Once completed, however, the analysis can begin. Basic GIS analysis techniques include overlay analysis, modeling, buffering, and network analysis.

A.5.1 Overlay Analysis

The concept of overlaying data layers to obtain certain information is not a new concept to GIS, (figure A.2). Many of us have used tracing paper and colored pencils to produce transparent maps that could lie over the top of each other in order to derive some information; that could be considered a primitive 'GIS'. The ability to analyze spatial data separates GIS from mere spatial databases.

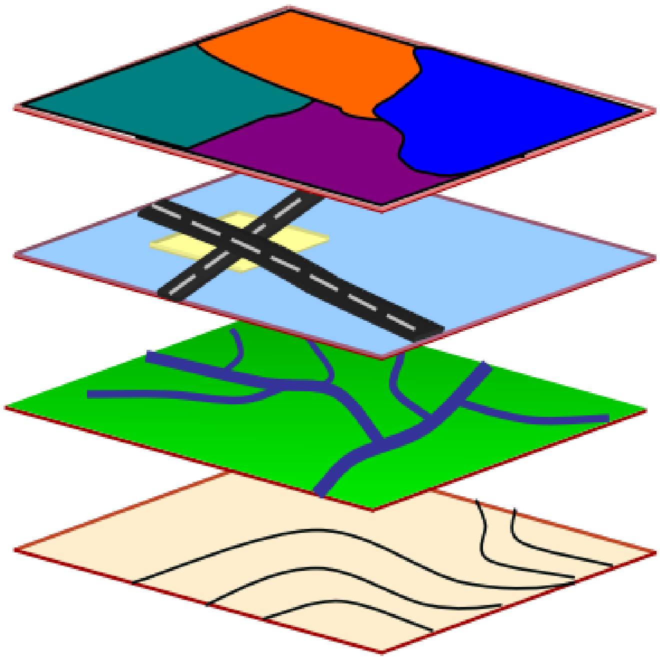


Figure A.2: An example of overlaying various layers in a GIS

The ability to extract specific information from a data layer and combine it with other information from that same or some other data layer depends on the use of Boolean algebra. This procedure involves the use of the operators AND, OR, and NOT to manipulate spatial data by testing to see if a given condition or statement is true or false. It is then possible to combine data layers to form a new layer, which is similar in concept with the Raster Calculator in ArcMap from ESRI.

A.5.2 Vector Spatial Analysis

- **Map Overlay**
  - Union, Intersect, Identity, Erase, Symmetrical Difference, Update Extract
  - Point in Polygon, Line in Polygon, Polygon on Polygon
  - Clip, Select, Split, Table Select

- **Proximity**
  - Buffer, Multiple Ring Buffer, Near, Point Distance
- **Statistics**
  - Frequency, Summary Statistics

A.5.3 Vector overlay tools

Feature overlay tools are located in the Analysis toolbox, Overlay toolset. Conceptually, the tools are similar-they differ by the feature types they allow you to overlay, by whether you can overlay multiple layers at one time, and by which input and overlay features are maintained in the output layer.

The Overlay toolset contains tools to overlay multiple feature classes to combine, erase, modify, or update spatial features in a new feature class. New information is created when overlaying one set of features with another. There are six types of overlay operations; all involve joining two existing sets of features into a single set of features to identify spatial relationships between the input features.

- Intersect
- Union
- Identity
- Erase
- Symmetrical Difference
- Update

A.5.3.1 Intersect

The Intersect tool calculates the geometric intersection of any number of feature classes and feature layers. The features or portion of features that are common to (intersect) all inputs will be written to the Output Feature Class.

Intersect does the following:

- Determines the spatial reference for processing. This will also be the Output Feature Classes' spatial reference. For details on how this is done, see Spatial Reference. All the input features are projected into this spatial reference for processing.
- Cracks and clusters the features. Cracking inserts vertices at the intersection of feature edges; clustering snaps together vertices that are within the xy tolerance.
- Discovers geometric relationships (intersections) between features from all the feature classes or layers.
- Writes these intersections as features (point, line, or polygon) to the output.

To explicitly control the output spatial reference (coordinate system and domains), set the appropriate environments, the Output Z Aware, and Output M Aware.

The inputs can be any combination of geometry types (point, multipoint, line, polygon). The output geometry type can only be of the same geometry or a geometry of lower dimension as the input feature class with the lowest dimension geometry (point = 0 dimension, line = 1 dimension, poly = 2 dimension). Specifying different OUTPUT TYPE will produce different types of intersection of the input feature classes. These are not a different representation of the same intersections; they are intersections that can only be represented by that geometry type (point, line, or polygon).

Intersect can run with a single input. In this case, instead of discovering intersections between the features from the different feature classes or layers, it will discover the intersections between features within the single input. This can be useful to discover polygon overlap and line intersections (as points or lines).

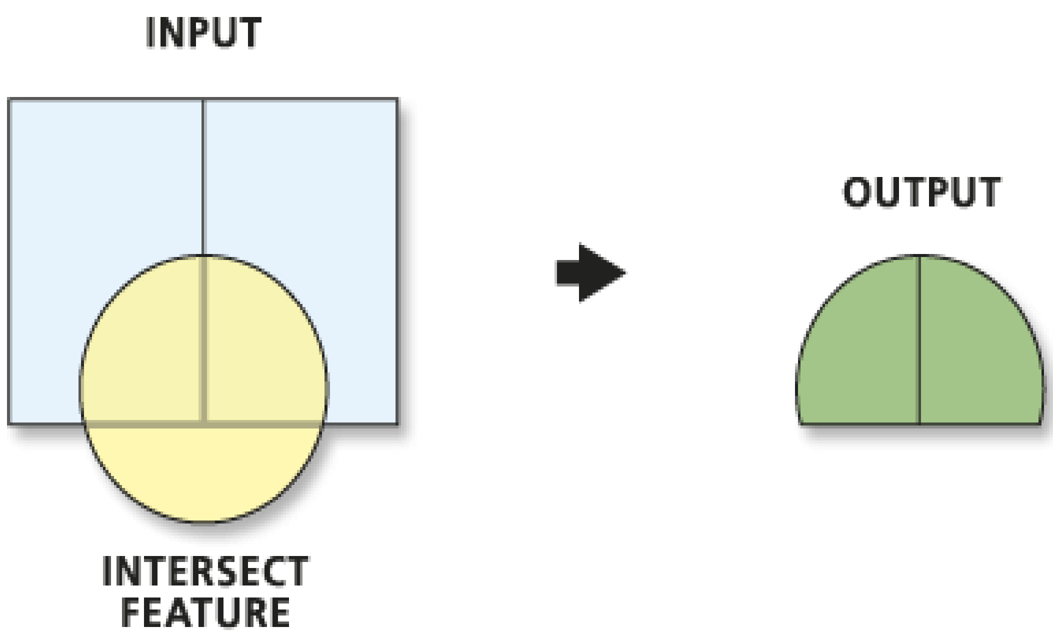


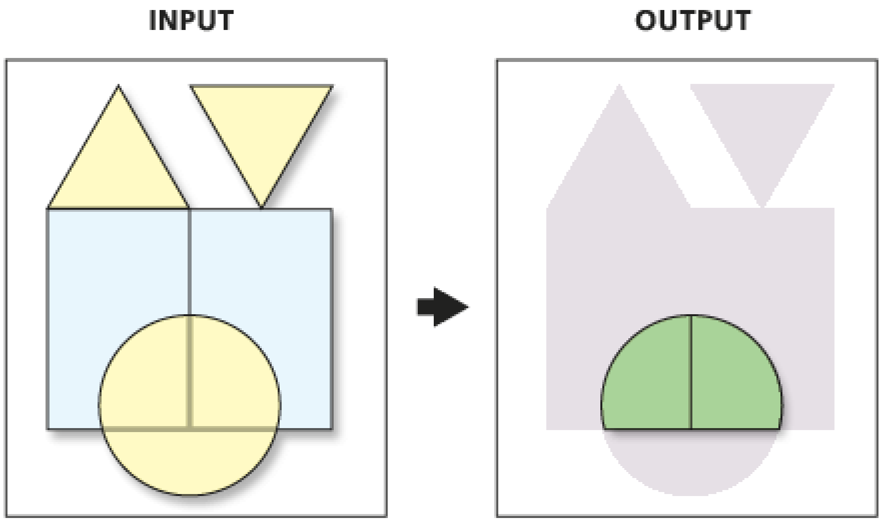
Figure A.3: An example of Intersect in a GIS

- Polygons can intersect in three ways:

- Overlap; This area of overlap can be produced by leaving the Output Type to its default value (LOWEST).
- Common boundary/touch at a line; This type of intersection can be produced by specifying LINE as the Output Type.
- Touch at a point; This type of intersection can be produced by specifying POINT as the Output Type.

- **Polygon inputs and polygon output**

The graphic below illustrates the result of intersecting two polygon feature classes with the Output Type parameter set to either POLY or the default (LOWEST). The output polygon features are where a polygon from one of the input feature class or layer intersects a polygon from the other input feature class or layer.



- Figure A.4: An example of Polygon inputs and polygon output in a GIS

- **Polygon inputs and line output.**

The graphic below illustrates the result of intersecting two polygon feature classes with the Output Type parameter set to LINE. The output line features are where a polygon from one of the input feature classes share a common boundary (intersect at a line) with a polygon from the other input feature class.

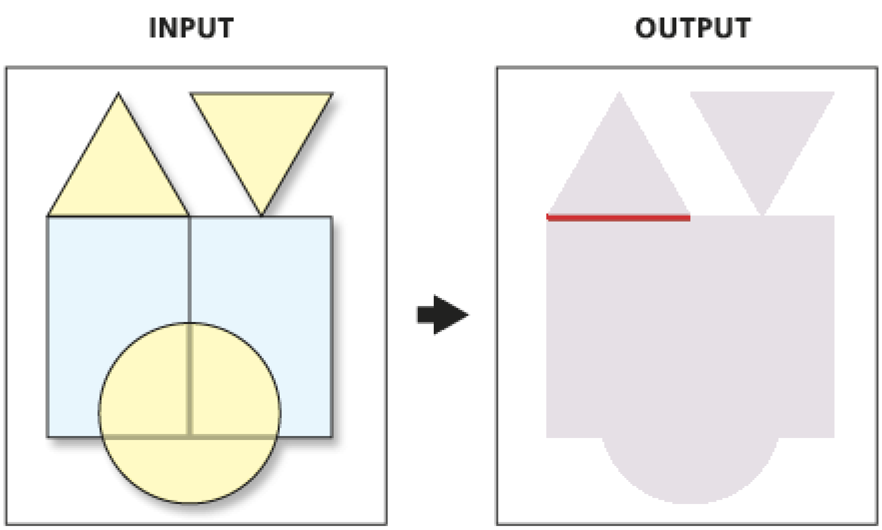


Figure A.5: An example of Polygon inputs and line output in a GIS

- **Polygon inputs and point output**

The graphic below illustrates the result of intersecting two polygon feature classes with the Output Type parameter set to POINT. The output point features are where a polygon from one of the input feature classes has a vertex intersecting the boundary (intersect at a point) of a polygon from the other input feature class.

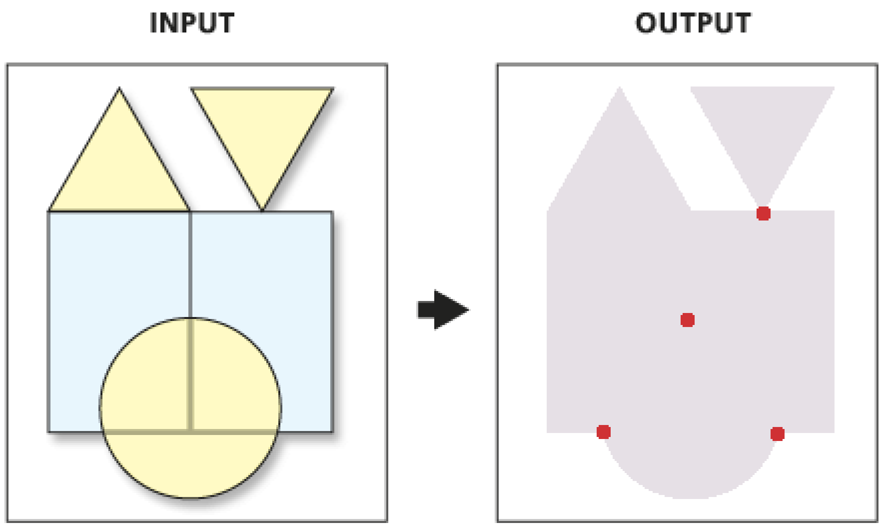


Figure A.6: An example of Polygon inputs and point output in a GIS

- **Line feature class inputs**

When all the inputs are line feature classes, the intersect tool can be used to determine where the features from the input feature classes overlap and intersect at points and lines.

Line inputs and line output. The graphic below illustrates the result of intersecting two line feature classes with the Output Type parameter set to either LOWEST or LINE. The output line features are where a line from one of the input feature classes overlaps a feature from the other input feature class.

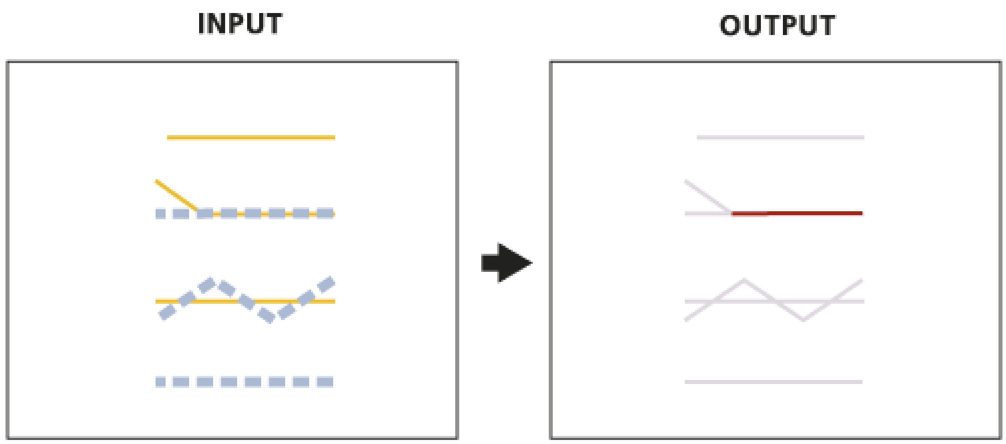


Figure A.7: An example of Line feature class inputs in a GIS

- **Line inputs and point output**

The graphic below illustrates the result of intersecting two line feature classes with the Output Type parameter set to POINT. The output point features are where a line from one of the input feature classes crosses a feature from the other input feature class.

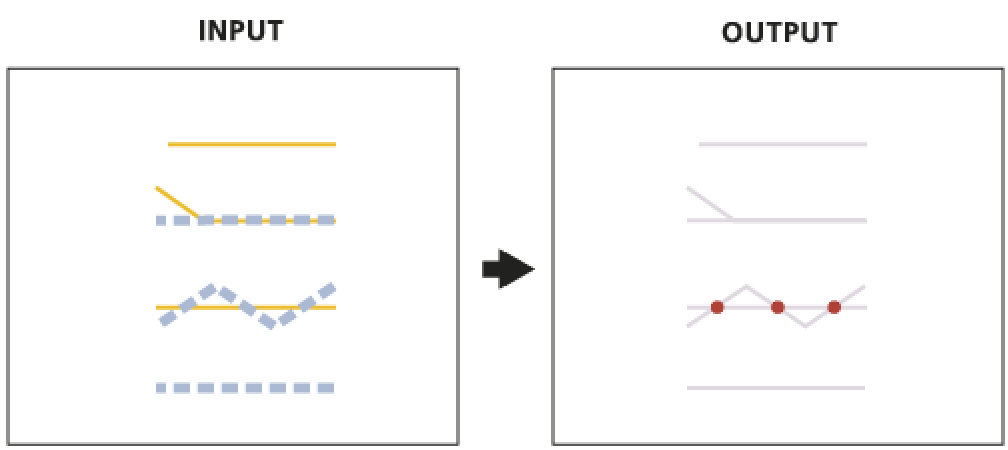


Figure A.8: An example of Line inputs and point output in a GIS

- **Point feature class inputs**

When all the inputs are point feature classes, the intersect tool can be used to determine which points are common to all input feature classes.

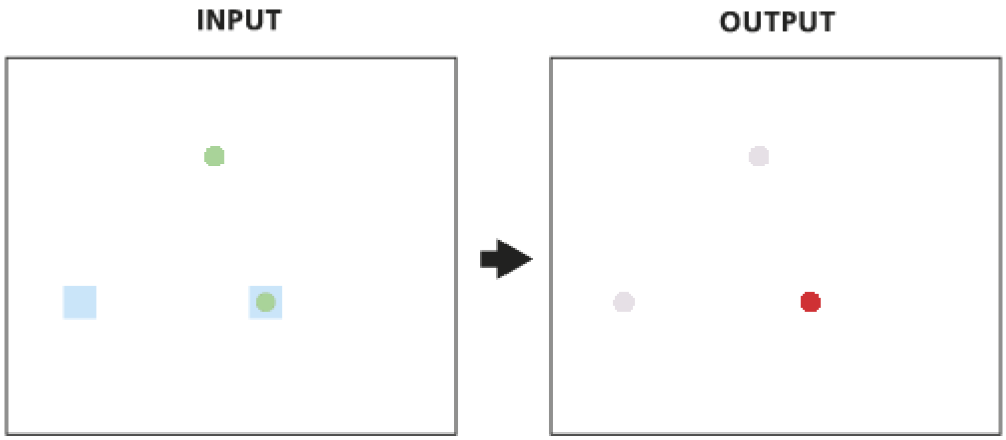


Figure A.9: An example of Point feature class inputs in a GIS

- **Mixed geometry feature class inputs**

Intersect can be used with feature classes of different geometries. The default (and highest allowable) Output Type is the same as the feature class with the lowest dimension geometry.

- **Polygon and line input for line output**

The graphic below illustrates the result of intersecting a line and polygon feature classes with the Output Type parameter set to LINE. The output line features are where a line from one of the input feature classes overlaps a polygon from the other input feature class.

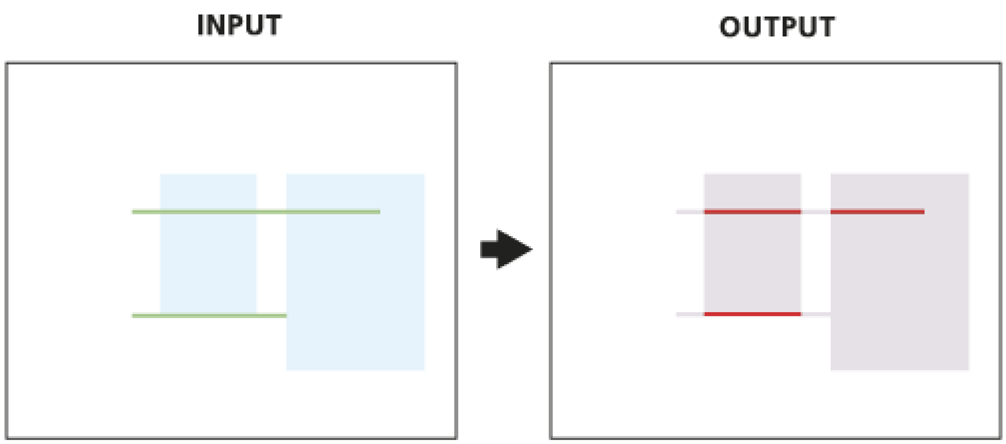


Figure A.10: An example of Polygon and line input for line output in a GIS

- **Polygon and line input for point output**

The graphic below illustrates the result of intersecting a line and polygon feature classes with the Output Type parameter set to POINT. The output point features are where lines touch at a point on the polygon boundary.

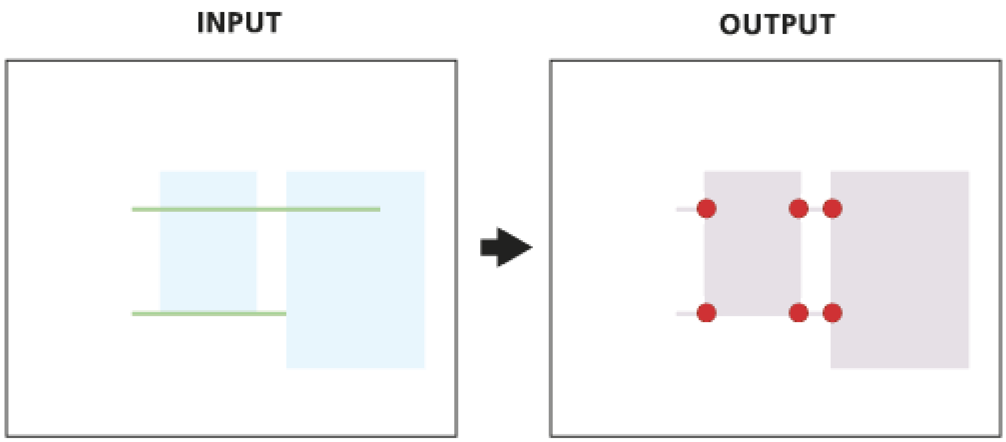


Figure A.11: An example of Polygon and line input for point output in a GIS

- **Polygon, line, and point input for point output**

The graphic below illustrates the result of intersecting point, line, and polygon feature classes. The output can only be a point feature class. Each point in the output will intersect at least one feature in each of the input feature classes.

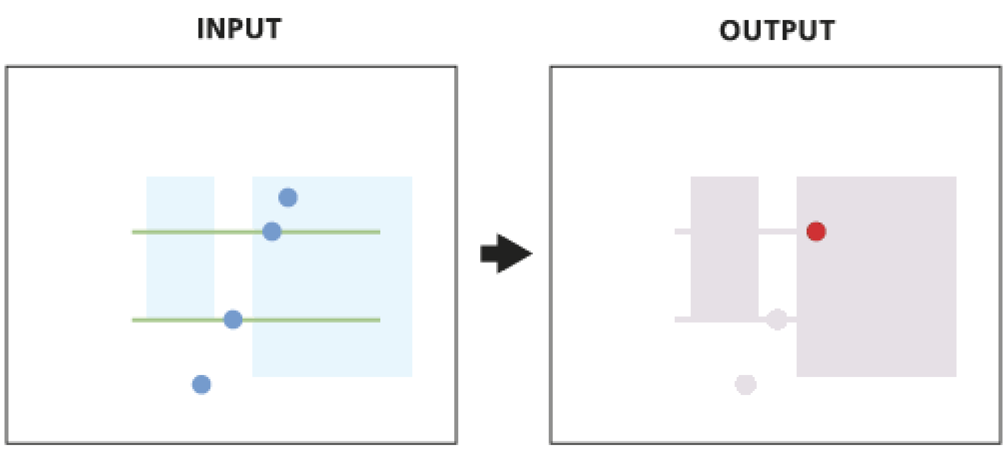


Figure A.12: An example of Polygon, line, and point input for point output in a GIS

A.5.3.2 Union

Union calculates the geometric intersection of any number of feature classes and feature layers .

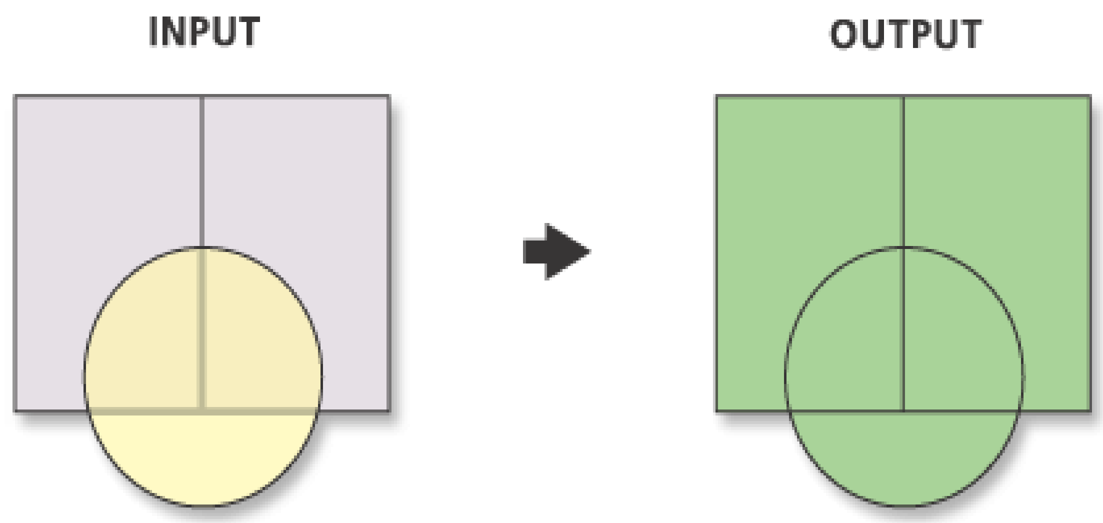


Figure A.13: An example of Union in a GIS

All inputs must be of a common geometry type and the output will be of that same geometry type. This means that a number of polygon feature classes and feature layers can be unioned together. The output features will have the attributes of all the input features that they overlap.

Union does the following:

- Determines the spatial reference for processing. This will also be the output spatial reference. For details on how this is done, see Spatial Reference. All the input feature classes are projected (on the fly) into this spatial reference.
- Cracks and clusters the features. Cracking inserts vertices at the intersection of feature edges; clustering snaps together vertices that are within the xy tolerance.
- Discovers geometric relationships (overlap) between features from all feature classes.
- Writes the new features to the output.

To explicitly control the output spatial reference (coordinate system and domains), set the appropriate environments, the Output Z Aware, and Output M Aware as desired. Note that the spatial reference used during processing is the same as the output spatial reference; therefore, all Input Features must be within the X, Y, Z, and M domains.

Union can run with a single input feature class or layer. In this case, instead of discovering overlap between the polygon features from the different feature classes or layers, it will discover the overlap between features within the single input. The areas where features overlap will be separated into new features with all the attribute information of the input feature. The area of overlap will always generate two identical overlapping features, one for each of the features that participates in that overlap.

Below is an example of Union with features within a feature class that overlap. In this case, the area of overlap will be duplicated to maintain all the attributes and areas. To recreate the overlapping features, use the Dissolve tool on the feature class produced by Union, and dissolve by all fields except FID.

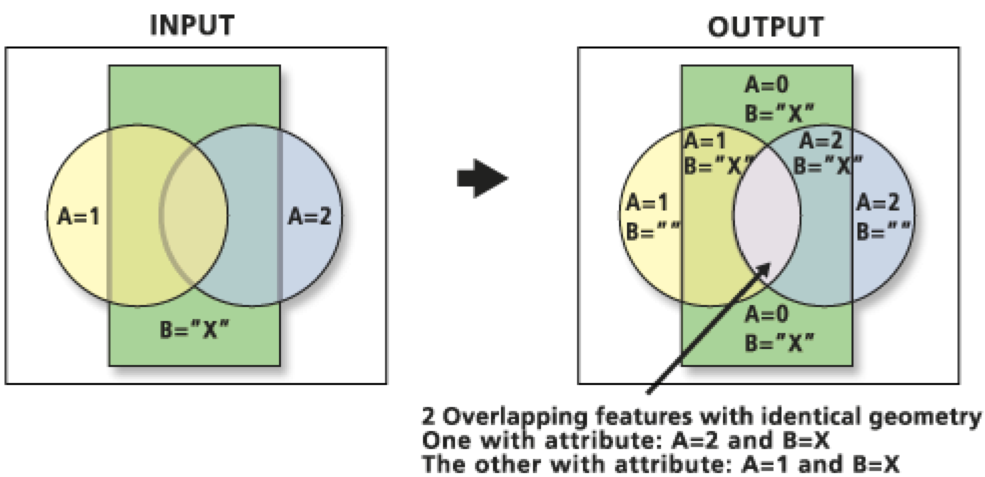


Figure A.14: An example of Union overlaps in a GIS

Below is an example of the result of executing Union with the Gaps Allowed parameter unchecked. A polygon feature is created that would otherwise be left empty. The "gap" features can be identified by doing an attribute query of all the input feature's FID fields = -1.

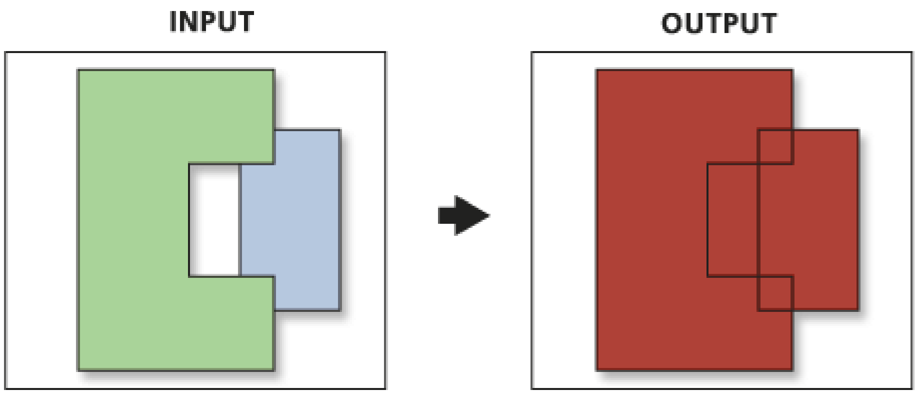


Figure A.15: An example of Union result in a GIS

A.5.3.3 Identity

Identity calculates the geometric intersection of the input and identity feature classes and feature layers.

Identity does the following:

- Determines the spatial reference for processing. This will also be the output spatial reference. For details on how this is done, see Spatial Reference. All the input feature classes are projected (on the fly) into this spatial reference.
- Cracks and clusters the features. Cracking inserts vertices at the intersection of feature edges; clustering snaps together vertices that are within the xy tolerance.
- Discovers geometric relationships (overlap) between the input features and the identity features.
- Input Features or portions of Input Features that do not overlap Identity Features are written to the output. Input features or portions of Input Features that overlap Identity Features get the attribute information from the Identity Feature and are written to the output.
- To explicitly control the output spatial reference (coordinate system and domains), set the appropriate environments, the Output Z Aware, and Output M Aware as desired. Note that the spatial reference used during processing is the same as the output spatial reference;

therefore, all Input Features and Identity Features must be within the X, Y, Z, and M domains.

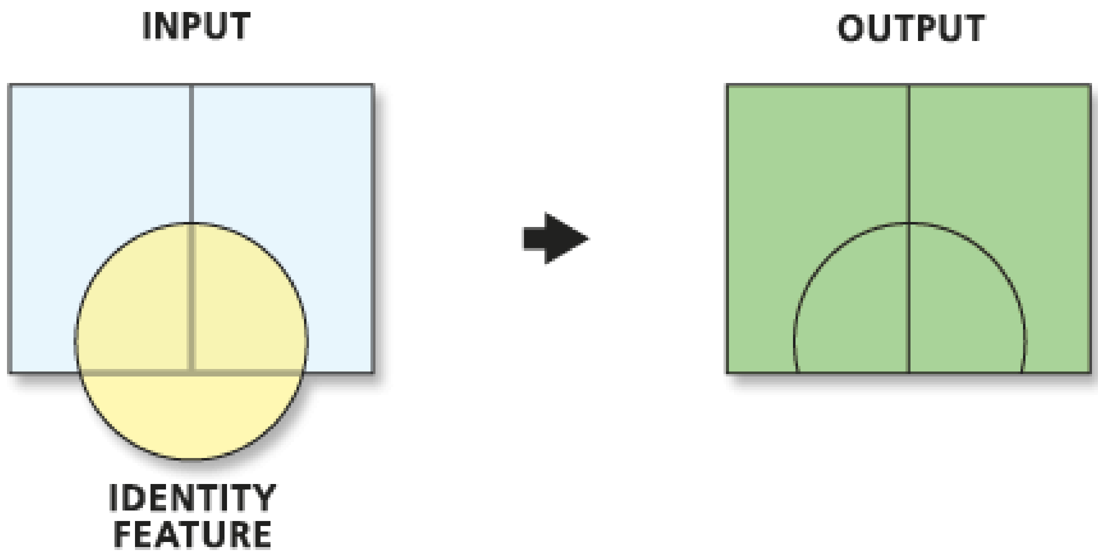


Figure A.16: An example of Identity in a GIS

A.5.3.4 Erase

Erase creates a new feature class by overlaying two sets of features. The Erase Features polygons define the erasing area. Input Features or portions of input features that overlap the Erase Features are not written to the output feature class.

Input Features can be points, lines, or polygons, but Erase Features must be polygons. Output Features will be of the same geometry type as Input Features.

Erase does the following:

- Determines the spatial reference for processing. This will also be the output spatial reference. For details on how this is done, see Spatial Reference. All the input feature classes are projected (on the fly) into this spatial reference.

- Cracks and clusters the input and erase features. Cracking inserts vertices at the intersection of feature edges; clustering snaps together vertices that are within the xy tolerance.

- Discovers geometric relationships (overlap) between the input features and the erase features.

Input features or portions of input features that do not overlap erase features are written to the output feature class.

To explicitly control the output spatial reference (coordinate system and domains), set the appropriate environments, the Output Z Aware, and Output M Aware as desired. Note that the spatial reference used during processing is the same as the output spatial reference; therefore, all Input Features and Identity Features must be within the X, Y, Z, and M domains.

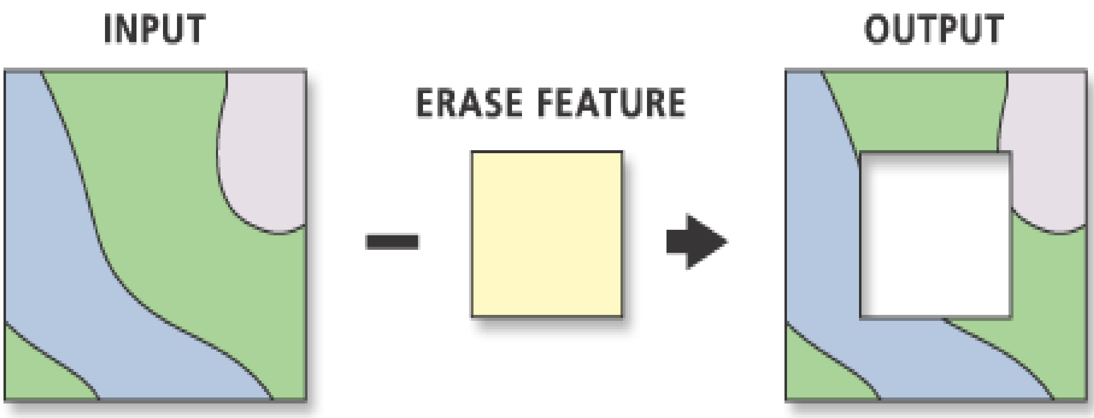


Figure A.17: An example of Erase in a GIS

A.5.3.5 Symmetrical Difference

Symmetrical Difference calculates the geometric intersection of two input feature classes or feature layers and writes out features that are are not overlapped in the other input. This is to say that features or portions of features in the Input Features which are NOT overlapped by features in the Update Features will be written to the Output Feature Class. Same logic applies to the Update Features in relation to the Input Features: features or portions of features in the Update Features which are NOT overlapped by features in the Input Features will be written to the Output Feature Class. The input and update feature layers or feature classes must both be polygons.

Symmetrical Difference does the following:

- Determines the spatial reference for processing. This will also be the output spatial reference. For details on how this is done, see Spatial Reference. All the input feature classes are projected (on the fly) into this spatial reference.
- Cracks and clusters the features. Cracking inserts vertices at the intersection of feature edges; clustering snaps together vertices that are within the xy tolerance.
- Discovers geometric relationships (overlap) between Input and Update Features.
- Writes the Input Features that are not overlapped by Update Features as well as Update Features which are not overlapped by Input Features to the Output Feature Class.
- To explicitly control the output spatial reference (Coordinate System and domains), set the appropriate environments, the Output Z Aware, and Output M Aware as desired. Note that the spatial reference used during processing is the same as the output spatial reference; therefore, all Input Features and Update Features must be within the X, Y, Z, and M domains.

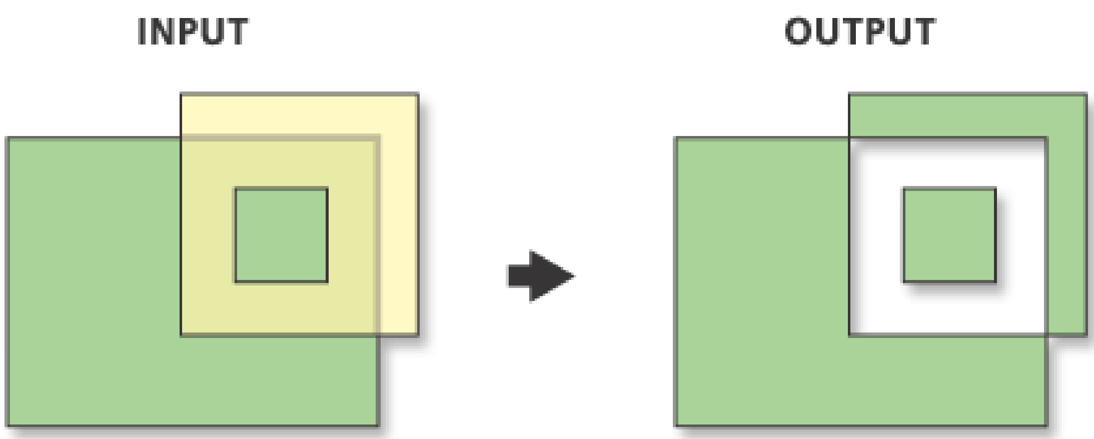


Figure A.18: An example of Symmetrical Difference in a GIS

A.5.3.6 Update

The Update Features are used to erase then replace the features in the input feature class or feature layer.

Update does the following:

- Determines the spatial reference for processing. This will also be the output spatial reference. For details on how this is done, see Spatial Reference. All the input feature classes are projected (on the fly) into this spatial reference.

- Cracks and clusters the features. Cracking inserts vertices at the intersection of feature edges; clustering snaps together vertices that are within the xy tolerance.
- Discovers geometric relationships (overlap) between input and update features.
- Writes the Input Features or portions of input features that do not overlap Update Features to the Output Feature Class. The Input Features or portions of Input Features that overlap update features will be erased, and the update features will be written to the Output Feature Class.
- To explicitly control the output spatial reference (coordinate system and domains), set the appropriate environments, the Output Z Aware, and Output M Aware as desired. Note that the spatial reference used during processing is the same as the output spatial reference; therefore, all Input Features and Update Features must be within the X, Y, Z, and M domains.

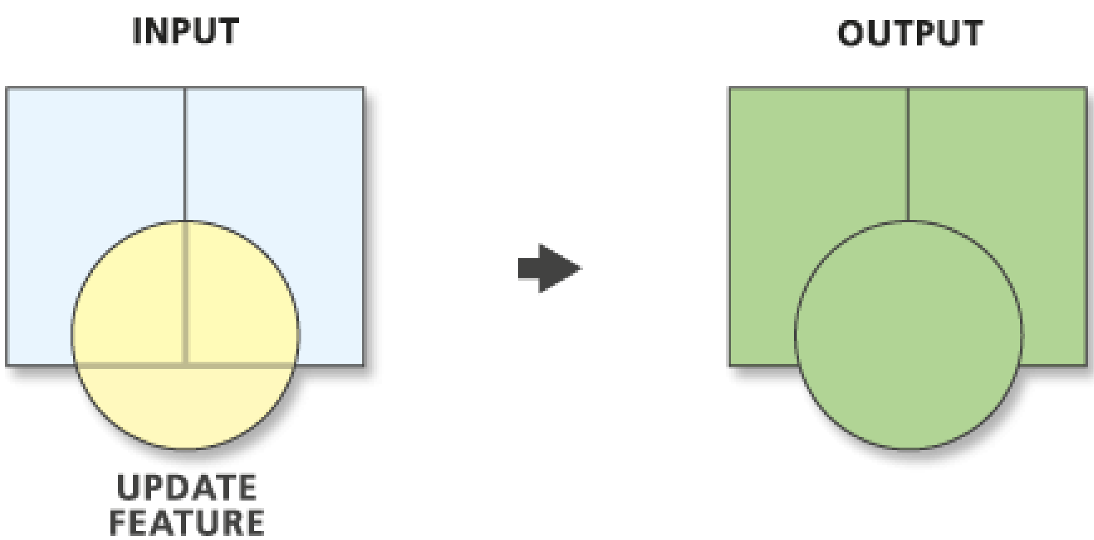


Figure A.19: An example of Update in a GIS

A.6 Processes

A.6.1 Georeferencing Process

To georeference something means to define its existence in physical space. That is, establishing its location in terms of map projections or coordinate systems. The term is used both when establishing the relation between raster or vector images and coordinates but also when determining the spatial location of other geographical features. Examples would include establishing the correct position of an aerial photograph within a map or finding the geographical coordinates of a place name or street address. This procedure is thus imperative to data modeling in the field of geographic information systems (GIS) and other cartographic methods. When data from different sources need to be combined and then used in a GIS application, it becomes essential to have a common referencing system. This is brought about by using various georeferencing techniques. Most georeferencing tasks are undertaken either because the user wants to produce a new map or because they want to link two or more different datasets togther by virtue of the fact that they relate to the same geographic locations.

A.6.2 Digitizing Process

Digitizing is the process of converting analog information into a digital representation. In regards to spatial information one application of this is the process of creating a vector digital database by creating point, line and polygon objects. Scanning a map can also be considered digitizing (turning colors shades on the map into digital values), but for this class when we refer to digitizing this for the most part refers to creating vector datasets.

A.6.2.1 Snapping

Snapping is an important control in the environment. It will assure that features snap to each other, and that dangles, overshoots, gaps, or slivers are avoided.and defined An automatic editing operation in which points or features within a specified distance (tolerance) of other points or features are moved to match or coincide exactly with each others' coordinates.

A.6.2.2 snapping environment

Settings in the ArcMap Snapping Environment window and Editing Options dialog box that define the conditions in which snapping will occur. These settings include snapping tolerance, snapping properties, and snapping priority.

A.6.2.3 snapping properties

In ArcMap editing, a combination of a shape to snap to and a method for determining what part of the shape will be snapped to. Snapping properties can be set to have a feature snap to a vertex, edge, or endpoint of features in a specific layer. For example, a layer snapping property might allow snapping to the vertices of buildings. A more generic, sketch-specific snapping property might allow snapping to the vertices of a sketch being created.

A.6.2.4 snapping tolerance

A specified distance within which points or features within are moved to match or coincide exactly with each others' coordinates.

A.6.3 Topology Process

Topology model is a mathematical approach that allows us to structure data based on the principles of feature adjacency and feature connectivity. It is in fact the mathematical method used to define spatial relationships. Without a topologic data structure in a vector based GIS most data manipulation and analysis functions would not be practical or feasible.

According to References books, topology is the "property that describes adjacency and connectivity of features. A topological data structure encodes topology with the geocoded features". Another definition is "The numerical description of the relationships between geographic features, as encoded by adjacency, linkage, inclusion, or proximity. Thus a point can be inside a region, a line can connect to others, and a region can have neighbors. The numbers describing topology can be stored as attributes in the GIS and used for validation and other stages of description and analysis".

A.6.3.1 Advantages

Topology has for the first time allowed the user to do some error detection. The major problems associated with sliver polygons and unsnapped nodes are fixed because each line is stored only once and that the only duplication is the endpoints. The user is now allowed to "clean" the map. The best advantage of having a "topologically consistant map is that when two or more maps must be overlain.

A.6.3.2 Disadvantages

The basic disdvantages to using this system is that when using arcs or polygons, some reconstruction of the map is a necessity and it is a sophisticated database to go through, with very complex software.