# Certification

## Palestine Polytechnic University

HEBRON.PALESTINE

## LAND USE CHANGE ANALYSIS USING LANDSAT TM DATA AND ARCHIVAL LAND USE MAP

BY

AFNAN QAWASMEH SAMAR NASERALDEEN

**In accordance with the recommendation of project supervisor and acceptance of all examining committee members , this research project has been submitted to Department of Civil and Architectural Engineering in the college of Engineering and Technology in partial fulfillment of requirements of the department for degree of Bachelor of Surveying and Geomantic Engineering.**

Signature of Project Supervisor Signature of Department Chairman

Name .............. Name .........

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APROJECT REPOST SUBMITTED IN PARTIAL FULFILLMENT OF
REQUIREMENTS FOR THE DEGREE OF
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SUPERVISED BY
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COLLGE ENGINEERING AND TECHNOLOGY
PALESTINE POLYTECHNIC UNIVESITY

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PALESTINE
2010

## Abstract

# LAND USE CHANGE ANALYSIS USING LANDSAT TM DATA AND ARCHIVAL LAND USE MAP

BY

AFNAN QAWASMEH SAMAR NASERALDEEN

SUPERVISED BY :
ENG.MAHER OWAIWI

Change detection is an important analytic function in pattern recognition and image processing. Its technique is determine the change between two or more time period of particular object of study. Information about change is necessary for updating land cover maps and the management of natural resources.

In this study, supervised classification ,unsupervised classification and combined classification methods were used to determine the change in land use and expansion in urban area, using Landsat images of 1985 and 1999 of West Bank .

Accorelation between PASSIA land use map and the resultant map shows an expansion of urban area of about 6 %.

## ملخص

# تحليل التغير في استخدام الأراضي باستخدام صور اقمار صناعية

إعداد

أفنان قواسمة　　　　سمر ناصر الدين

إشراف

الأستاذ ماهر العويوي

الكشف عن التغيرات تعتبر تقنية مهمة في تحليل وفهم الصورة، والمعلومات المتعلقة عن التغير ضرورية لتحديث خرائط الغطاء الأرضي وادارة الموارد الطبيعية.

في هذه الدراسة سيتم استخدام أساليب مختلفة لتصنيف المعلومات ودمج هذه الأساليب مع بعضها لدراسة التغير في استخدام الأراضي والتوسع في المناطق الحضرية بالاعتماد على صور أقمار صناعية لسنة ١٩٨٥و ١٩٩٩ لمنطقة الضفة الغربية وسيتم مقارنة النتائج مع خرائط طبوغرافية واظهار نسبة التوسع في المناطق العمرانية .

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# CHAPTER ONE

# INTRODUCTION

This chapter covers the general idea of the project, its problem definitions, objectives, methodology, and project time table. This Chapter includes the following items;

**1.1 Background**

**1.2 Problem Definition**

**1.3 Objectives**

**1.4 Methodology**

**1.5 Definition of Terms**

**1.6 Project Time Table**

## 1.1 Background

West Bank lies to the west of the Asian continent between longitudes 15-34 and 40-35 to the east, and between latitudes 30-29 and 15-33 to the north. As shown in Figure (1.1) it located in Middle East, west of Jordan with total area of about 5,800 km square divided into land: 5,640 sq km and water: 210 sq km, the population is more than 3,000,000 and Population growth rate is 3.13% .From the landscape noted that the region is landlock, highlands are main recharge area for the coastal aquifers.


Figure (1.1): Location Map of West Bank, Wikipedia, (2008)

## 1.2 Problem Definition

Recent advancement of Remote Sensing with wide ranging spectral and higher spatial resolution of satellite images and repetitive coverage, this research field of change detection has been growing strongly.

In recent years, there was an increase in construction at the expense of green areas in the West Bank and the water sources.

This study is an attempt to use the Landsat TM satellite image to classify the land of West Bank according to their usage and land cover, using ER Mapper RS software and land use map of 1996 with scale 1:50,000 (PASSIA,2009).

## 1-3 Objectives

### 1-3-1 General Objectives

The aim of this study is to produce a land use land cover map at different epochs, with the help of PASSIA Land Use Map, in order to detect the changes that have taken place particularly in the built-up area and subsequently predict likely changes that might take place in the same over a given period in West Bank.

### 1-3-2 Specific Objectives

1- Testing efficient satellite image enhancement methods for land cover classification [illegible] external input and low cost conditions.

2- Identifying the land cover/land use change according to USGS Land Use/ Land Cover standards and examining the change dynamics at different spatial and temporal scales, and with help of PASSIA Land Use.

3- Compared the satellite images for different years (1985 and 1999) and identify the differences in the areas of built up areas.

## 1.4 Methodology

The methods are multi-temporal images stacking, and change detection of the main components of the image and change detection after classification.

A general sketch of the methodology adopted has been described in figure (1.2) The present study is a framework of satellites images processing using a case study to classify West Bank land to examine the change in land use type by time.

Towards this approach, information extraction using satellites image processing using Remote Sensing (RS) data has been adopted.

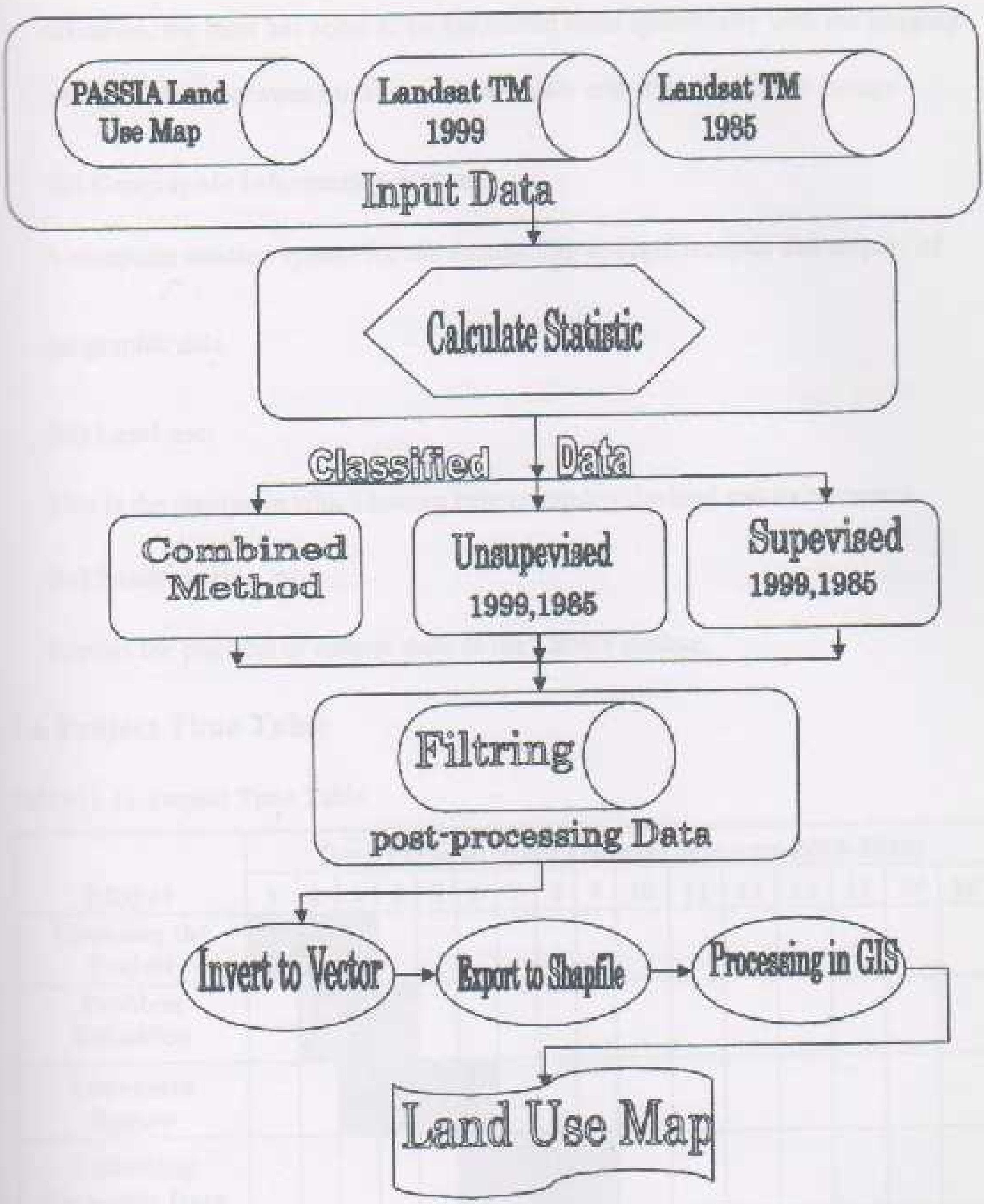


Figure (1.2): Workflow Diagram for Proposed Methodology

## 1.5 Definition of Terms

**(i) Remote sensing:**

Can be defined as any process whereby information is gathered about an object, area or phenomenon without being in contact with it. Given this rather general definition, the term has come to be associated more specifically with the gauging of interactions between earth surface materials and electromagnetic energy.

**(ii) Geographic Information system:**

A computer assisted system for the acquisition, storage, analysis and display of geographic data.

**(iii) Land use:**

This is the manner in which human beings employ the land and its resources.

**(iv) Land cover:**

Implies the physical or natural state of the Earth's surface.

## 1.6 Project Time Table

Table (1.1): Project Time Table

| Stages | Time Table In Week (Second Semester 2009-2010) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| Choosing the Project | | | | | | | | | | | | | | | | |
| Problem Definition | | | | | | | | | | | | | | | | |
| Literature Review | | | | | | | | | | | | | | | | |
| Collecting Necessary Data | | | | | | | | | | | | | | | | |
| Preparation of Different Data and Put it in Proper Syntax | | | | | | | | | | | | | | | | |
| Classification Images | | | | | | | | | | | | | | | | |
| Final Data in GIS | | | | | | | | | | | | | | | | |
| Writing Final Report | | | | | | | | | | | | | | | | |

# CHAPTER TWO

# LITERATURE REVIEW

This chapter describes several studies of using Remote Sensing technique for land use applications , and it give a brief description about the following studies,

## 2.1 The Comparative Study of Three Methods of Remote Sensing Image Change Detection

## 2.2 Change Detection Based on Remote Sensing Information Model and its Application on Coastal Line of Yellow River Delta

## 2.3 A Comparison of Change Detection Methods in an Urban Environment Using Landsat TM And ETM+ Satellite Imagery

## 2.4 Analysis and Simulation of Land-Use Change in the Central Arizona, USA

## 2.1 The Comparative Study of Three Methods of Remote Sensing Image Change Detection, Zhang Shaoqing, 2008.

Aim:

discusses three main methods of change detection: 1) Image subtraction method; 2) Image ratio method; 3) The method of change detection after classification.

Method:

Firstly, the elimination method of influence factors of change detection is discussed. Then the basic principle of the three main methods is introduced and the experiments of the methods are carried on ERDAS software. At last, the analysis comparison is carried on and the relative merits and the applicable scope of the three methods are pointed out.

Image subtraction method is a simple concept easy to understand and easy to use, a background value usually be repressed and a subtraction value often be enhanced in the result image. It is beneficial to information extraction, which value of the target and background is smaller, such as the beach zone, the ditch of estuaries. The main disadvantage is that it can not reflect which category is changed.

Image ratio method is applicable to be used in change detection of city. Its disadvantage is also that it can not reflect which category is changed. The information of change property is provided in this method. The disadvantage is that the accuracy depends on the classification accuracy; it can not be used for the detail change detection of city.

Conclusion:

Automatic data mining and automatic discover knowledge form GIS database, building intelligent systems of change detection and establishing a unified accuracy evaluation system are also explored. In this experiment, change detection is difficult to accuracy evaluated except using the visual method. It has subjective error. As a result, study of this part will be carried out.

## 2.2 Change Detection Based on Remote Sensing Information Model and its Application on Coastal Line of Yellow River Delta, XiaoMei Yang, RongQing Lan QiHe Yang, 2000.

Information about change is necessary for updating land cover maps and the management of natural resources. Many researches have been undertaken to develop methods of obtaining change information. Based on the summarization of the methods on change information extracted from remotely sensed data, the paper promotes the method of change detection based remote sensing information model. This method is applied to detect the coastal line change of Yellow River Delta (YRD). It lays the foundation for research on the change relation of natural and human activity impact each other, and finally aids to study the regional geographic feature through more than 30 years remote sensing images in YRD.

## 2.3 A Comparison of Change Detection Methods in an Urban Environment Using Landsat TM And ETM+ Satellite Imagery, Paul Digirolamo, 2006.

Land cover change detection in urban areas provides valuable data on loss of forest and agricultural land to residential and commercial development. Using Landsat 5 Thematic Mapper (1991) and Landsat 7 ETM+ (2000) imagery of Gwinnett County, GA, change images were obtained using image differencing of Normalized Difference Vegetation Index (NDVI), principal components analysis (PCA), and Tasseled Cap-transformed images. Ground truthing and accuracy assessment determined that land cover change detection using the NDVI and Tasseled Cap image transformation methods performed best in the study area, while PCA performed the worst of the three methods assessed. Analyses on vegetative and vegetation changes from 1991-2000 revealed that these methods perform well for detecting changes in vegetation and/or vegetative characteristics but do not always correspond with changes in land use. Gwinnett County lost an estimated 13,500 hectares of vegetation cover during the study period to urban sprawl, with the majority of the loss coming from forested areas.

## 2.4 Analysis and simulation of land-use change in the central Arizona USA, Landscape Ecology, 2004

To understand how urbanization has transformed the desert landscape in the central Arizona – Phoenix region of the United States, we conducted a series of spatial analyses of the land-use pattern from 1912–1995. The results of the spatial analysis show that the extent of urban area has increased exponentially for the past 83 years, and this urban expansion is correlated with the increase in population size for the same period of time. The accelerating urbanization process has increased the degree of fragmentation and structural complexity of the desert landscape. To simulate land-use change we developed a Markov-cellular automata model. Model parameters and neighborhood rules were obtained both empirically and with a modified genetic algorithm. Land-use maps for 1975 and 1995 were used to implement the model at two distinct spatial scales with a time step of one year. Model performance was evaluated using Monte-Carlo confidence interval estimation for selected landscape pattern indices. The coarse-scale model simulated the statistical patterns of the landscape at a higher accuracy than the fine-scale model. The empirically derived parameter set poorly simulated land-use change as compared to the optimized parameter set. In summary, our results showed that landscape pattern metrics (patch density, edge density, fractal dimension, contagion) together were able to effectively capture the trend in land-use associated with urbanization for this region. The Markov-cellular automata parameterized by a modified genetic algorithm reasonably replicated the change in land-use pattern

# CHAPTER THREE

# REMOTE SENSING (RS) AND CHANGE DETECTION

3.1 Introduction

3.2 Remote Sensing Systems

3.3 Change Detection

3.4 Land Use\Land Cover Classification Systems

3.5 Image Classification

3.6 Landsat 7

3.7 ER Mapper

3.8 Arc GIS

## 3.1 Introduction

**What is Remote Sensing?**

Remote sensing can be defined as the study of something without making actual contact with the object of study. More precisely, it can be defined as:

"The acquisition and measurement of data/information on some property(ies) of a phenomenon, object, or material by a recording device not in physical, intimate contact with the feature(s) under surveillance

The process of remote sensing involves an interaction between incident radiation and the targets of interest. The figure bellow shows the imaging systems where the following seven elements are involved. Note, however that remote sensing also involves the sensing of emitted energy and the use of non-imaging sensors.
See figure (3.1)

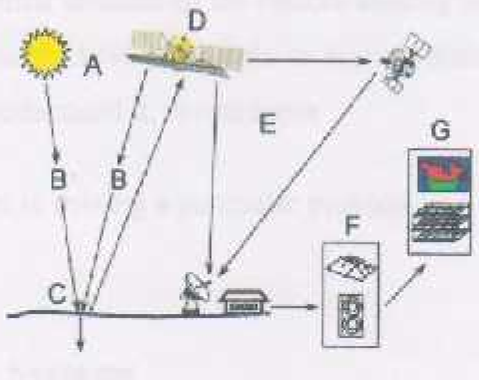


Figure (3.1): Electromagnetic Remote Sensing of the Earth , Lichaa El-Khoury,(2002)

1. Energy Source or Illumination (A) - the first requirement for remote sensing is to have an energy source which illuminates or provides electromagnetic energy to the target of interest.

2. Radiation and the Atmosphere (B) - as the energy travels from its source to the target, it will come in contact with and interact with the atmosphere it passes through. This interaction may take place a second time as the energy travels from the target to the sensor.

3. Interaction with the Target (C) - once the energy makes its way to the target through the atmosphere, it interacts with the target depending on the properties of both the target and the radiation.

4. Recording of Energy by the Sensor (D) - after the energy has been scattered by, or emitted from the target, we require a sensor (remote - not in contact with the target) to collect and record the electromagnetic radiation.

5. Transmission, Reception, and Processing (E) - the energy recorded by the sensor has to be transmitted, often in electronic form, to a receiving and processing station where the data are processed into an image (hardcopy and/or digital).

6. Interpretation and Analysis (F) - the processed image is interpreted, visually and/or digitally or electronically, to extract information about the target which was illuminated.

7. Application (G) - the final element of the remote sensing process is achieved when we apply the information we have been able to extract from the imagery about the target in order to better understand it, reveal some

new information, or assist in solving a particular problem

### 3.2 Remote Sensing Systems

So far, we know that remote sensing imply a sensor fixed to a platform (usually satellite or aircraft), which detect and record radiation reflected or emitted from the earth's surface.

The sensor mechanisms are very variable, and each has a distinct set of characteristics, but the main points are:

a)The sensor can be an active system (where the satellite or the aircraft provides the source of illumination, this technique is used when no suitable natural source of radiation exists), or be a passive system (the source of the object illumination is independent of the sensor and it is a natural source).

A variety of different parts of the electromagnetic spectrum can be used including:

- Visible wavelengths and reflected infrared (imaging spectrometer): Remote sensing in the visible and near infrared (VNIR) wavelengths usually falls into the passive category. Here the sun is the source of the irradiance on the object being observed. The sensor collects the solar radiation which is reflected by the object. Active remote sensing occurs at these wavelengths only in the rare case where an aircraft carries a laser as the source of illumination.

  Blue, green, and red are the primary colors or wavelengths of the visible spectrum. They are defined as such because no single primary color can be created from the other two, but all other colors can be formed by combining blue, green, and red in various proportions.

- Thermal sensors: Remote sensing in the thermal-infrared wavelengths usually falls into the passive category, but in this case, the source of the radiation is the object itself. There is no irradiance and the sensor detects radiation which has been emitted by the object.

- Microwaves (radar): These are used in the active remote sensing systems. The satellite or aircraft carries an antenna which emits a microwave signal. This signal is reflected by the ground and the return signal is detected again by the antenna.

The Figure (3.2) below shows the sections of the electromagnetic spectrum most commonly used in remote sensing

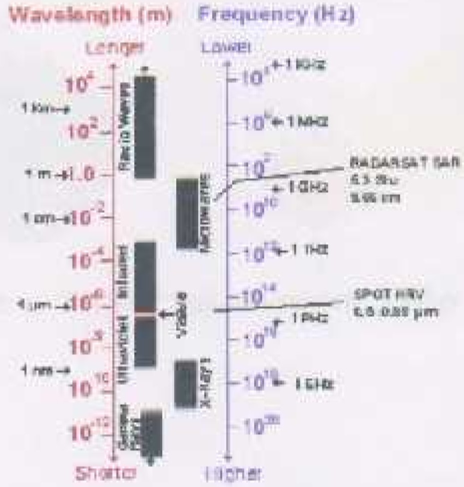


Figure (3.2): The Electromagnetic Spectrum, Canada Center for Remote Sensing, (2002).

Each part of the spectrum has different characteristics and gives rather different information about earth's surface. In addition, different surface covers (vegetation, water, soil, etc) absorb and reflect differently in different parts of the spectrum. Different wavebands in the electromagnetic spectrum therefore tend to be useful for different purposes.

c) The sensor may be sensitive to a single portion of the electromagnetic spectrum (e.g. the visible part of the spectrum, like panchromatic film which is sensitive to the same wavebands as our eyes). Alternatively, it may be able to detect several parts of the spectrum simultaneously. This latter process is called multispectral sensing.

d) Sensor equipment takes many shapes and forms, such as cameras, scanners, radar,…

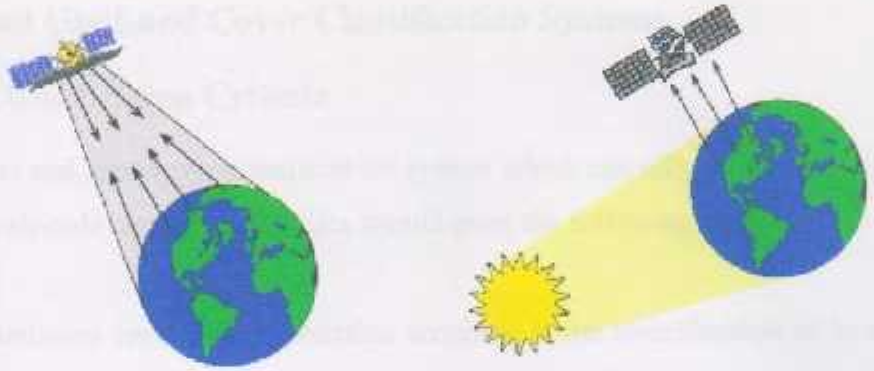

Figure (3.3): Active Versus Passive Sensors , Maher Owaiwi, (2010).

## 3.3 Change Detection

Change detection in imagery is quite useful generally but it has particular value in the remote sensing context. The aim of change detection is to find pixels in pairs of co-registered images that correspond to real changes on the ground.

Land cover change detection using remote sensing satellite imagery is a powerful tool for monitoring urbanization and the resulting loss of forest and agricultural land. Planners, lawmakers, community leaders, and others rely on accurate data in decision making and planning for future growth and development. Environmental quality is threatened in many urban areas around the globe by the rapid spread of low-density, automobile-oriented development known as urban sprawl. Public and political opinion is evolving as awareness of the environmental, economic, and social impacts of sprawl become clearer. Satellite imagery offers a unique multi temporal, multi-spectral, and synoptic perspective on urbanization at regional scales providing valuable data for monitoring and assessment of change.

## 3.4 Land Use\Land Cover Classification Systems

### 3.4.1 Classification Criteria

A land use and land cover classification system which can effectively employ orbital and high-altitude remote sensor data should meet the following criteria

1. The minimum level of interpretation accuracy in the identification of land use and land cover categories from remote sensor data should be at least 85 percent.
2. The accuracy of interpretation for the several categories should be about equal.
3. Repeatable or repetitive results should be obtainable from one interpreter to another and from one time of sensing to another.
4. The classification system should be applicable over extensive areas.
5. The categorization should permit vegetation and other types of land cover to be used as surrogates for activity
6. The classification system should be suitable for use with remote sensor data obtained at different times of the year.
7. Effective use of subcategories that can be obtained from ground surveys or from the use of larger scale or enhanced remote sensor data should be possible.
8. Aggregation of categories must be possible.
9. Comparison with future land use data should be possible.
10. Multiple uses of land should be recognized when possible.

### 3.4.2 USGS Land Cover

The USGS has been at the core of land cover and land use research and applications since the late 1960's. Under the geography banner within the survey, it is arguably the largest operational land cover agency in the world today. Land cover has historically been part of USGS's research heritage, and has been significantly influential in the science of mapping land cover and land use.

Current mapping techniques of land cover would not be possible today without milestones such as James Anderson's 1976 publication entitled A Land Cover

Classification System for Use with Remote Sensor Data. Anderson et al., produced three hierarchical levels of classifying land cover and land use with level three being the most detailed, representing over 100 landuse types. Development of such techniques has facilitated the mapping, modeling and measurement of many land cover applications, which in turn has stimulated collaborative partnerships with other outside agencies.

The scope of USGS land cover activities ranges spatially and temporally, from local to global scales and includes historical, current and future timeframes. A selection of current land cover applications ongoing within USGS includes, biodiversity conservation, water quality and assessment, phenology of ecosystems, and assessing the rates, causes and consequences of contemporary United States land cover change. Land cover research and applications is now a significant growth area in the world of science and we can expect to see further opportunities in the coming years.

Table (3.1): U.S.G.S. Level 1 Land Use Color Code

| | |
|---|---|
| 1. Urban or Built-up Land | Red (Munsell 5R 6/12) |
| 2. Agricultural Land | Light Brown (Munsell 5YR 7/4) |
| 3. Rangeland Light | Orange (Munsell 10YR 9/4) |
| 4. Forest Land | Green (Munsell 10B 7/7) |
| 5. Water | Dark Blue (Munsell 10B 7/7) |
| 6. Wetland | Light Blue (Munsell 7.5B 8.5/3) |
| 7. Barren Land | Green-Gray (*Munsell 10G 8.5/1.5*) |
| 8 Barren Land | Gray (Munsell N 8/0) |
| 9. Perennial | Snow or Ice White (Munsell N 10/0) |

Table( 3.2): Land Use and Land Cover Classification System for Use With Remote Sensor Data

| Level I | Level II |
|---|---|
| 1. Urban or Built-up Land | 11 Residential |
| | 12 Commercial and Services |
| | 13 Industrial |
| | 14 Transportation, Communications, and Utilities |
| | 15 Industrial and Commercial Complexes |
| | 16 Mixed Urban or Built-up Land |
| | 16 Mixed Urban or Built-up Land |
| 2. Agricultural Land | 21 Cropland and Pasture |
| | 22 Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticultural Areas |
| | 23 Confined Feeding Operations |
| | 24 Other Agricultural Land Areas |
| 3. Rangeland | 31 Herbaceous Rangeland |
| | 32 Shrub and Brush Rangeland |
| | 33 Mixed Rangeland |
| 4. Forest Land | 41 Deciduous Forest Land |
| | 42 Evergreen Forest Land |
| | 43 Mixed Forest Land |
| 5. Water | 51 Streams and Canals |
| | 52 Lakes |
| | 53 Reservoirs |
| | 54 Bays and Estuaries |
| 6. Wetland | 61 Forested Wetland |
| | 62 Nonforested Wetland |
| 7. Barren Land | 71 Dry Salt Flats |

| | | |
|---|---|---|
| | 72 Beaches | |
| | 73 Bare Exposed Rock | |
| | 74 Strip Mines Quarries, and Gravel Pits | |
| | 75 Transitional Areas | |
| | 76 Mixed Barren Land | |
| 8 Tundra | 81 Shrub and Brush Tundra | |
| | 82 Herbaceous Tundra | |
| | 83 Bare Ground Tundra | |
| | 84 Wet Tundra | |
| | 85 Mixed Tundra | |
| 9 Perennial Snow or Ice | 91 Perennial Snowfields | |
| | 92 Glaciers | |

## 3.5 Image Classification

The intent of the classification process is to categorize all pixels in a digital image into one of several land cover classes, or "themes". This categorized data may then be used to produce thematic maps of the land cover present in an image. Normally, multispectral data are used to perform the classification and, indeed, the spectral pattern present within the data for each pixel is used as the numerical basis for categorization.The objective of image classification is to identify and portray, as a unique gray level (or color), the features occurring in an image in terms of the object or type of land cover these features actually represent on the ground.

Image classification is perhaps the most important part of digital image analysis. It is very nice to have a "pretty picture" or an image, showing a magnitude of colors illustrating various features of the underlying terrain, but it is quite useless unless to know what the colors mean.Two main classification methods are Supervised Classification and Unsupervised Classification.

### 3.5.1 Supervised Classification

With supervised classification, we identify examples of the Information classes (i.e., land cover type) of interest in the image. These are called "training sites". The image processing software system is then used to develop a statistical characterization of the reflectance for each information class. This stage is often called "signature analysis" and may involve developing a characterization as simple as the mean or the rage of reflectance on each bands, or as complex as detailed analyses of the mean, variances and covariance over all bands. Once a statistical characterization has been achieved for each information class, the image is then classified by examining the reflectance for each pixel and making a decision about which of the signatures it resembles most. See figure (3.4).

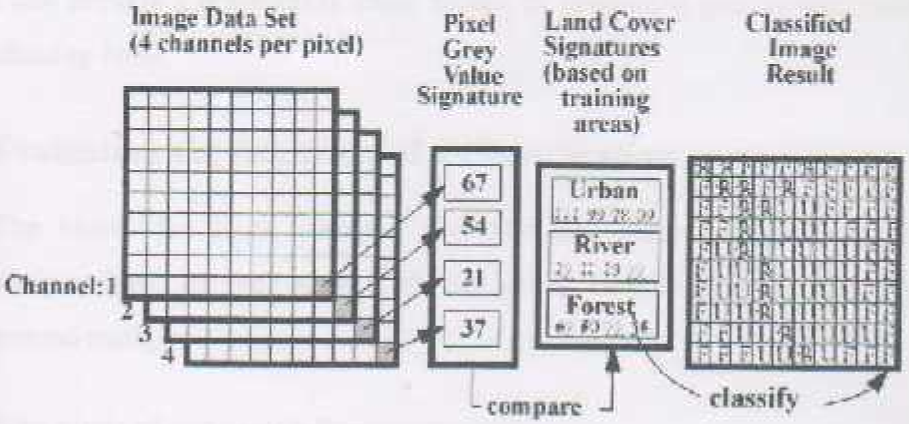


Figure (3.4): Steps in Supervised Classification, Maher Owaiwi, (2010)

### 3.5.2 Unsupervised Classification

Unsupervised classification is a method which examines a large number of unknown pixels and divides into a number of classed based on natural groupings present in the image values. unlike supervised classification, unsupervised classification does not require analyst-specified training data. The basic premise is that values within a given cover type should be close together in the measurement space (i.e. have similar gray levels), whereas data in different classes should be comparatively well separated (i.e. have very different gray levels). The classes that result from unsupervised classification are spectral classed which based on natural groupings of the image values, the identity of the spectral class will not be initially known, must compare classified data to some from of reference data (such as larger scale imagery, maps, or site visits) to determine the identity and informational values of the spectral classes. Thus, in the supervised approach, to define useful information categories and then examine their spectral separability; in the unsupervised approach the computer determines spectrally separable class, and then define their information value.

Unsupervised classification is becoming increasingly popular in agencies involved in long term GIS database maintenance. The reason is that there are now systems that use clustering procedures that are extremely fast and require little in the nature of operational parameters. Thus it is becoming possible to train GIS analysis with only a general familiarity with remote sensing to undertake classifications that meet typical map accuracy standards. With suitable ground truth accuracy assessment procedures, this tool can provide a remarkably rapid means of producing quality land cover data on a continuing basis.

### 3.5.3 Evaluating the Accuracy of a Classification

The basic idea is to compare the predicted classification (supervised or unsupervised) of each pixel with the actual classification as discovered by ground truth.

Four kinds of accuracy information:

1. Nature of the errors: what kinds of information are confused?

2. Frequency of the errors: how often do they occur?

3. Magnitude of errors: how bad are they? E.g., confusing old-growth with second-growth forest is not as 'bad' an error as confusing water with forest.

4. Source of errors: why did the error occur?

## 3.6 Landsat 7

Landsat 7, launched on April 15, 1999, is the latest satellite of the Landsat program. Landsat 7's primary goal is to refresh the global archive of satellite photos, providing up-to-date and cloud-free images. Although the Landsat Program is managed by NASA, data from Landsat 7 is collected and distributed by the USGS. The NASA World Wind project allows 3D images from Landsat 7 and other sources to be freely navigated and viewed from any angle. The satellite's companion, Earth Observing-1, trails one minute following the exact orbital characterists.

### 3.6.1 Satellite Specifications

Landsat 7 was designed to last for five years, and has the capacity to collect and transmit up to 532 images per day. It is in a polar, sun-synchronous orbit, meaning it scans across the entire earth's surface. With an altitude of 705 kilometres +/- 5 kilometres, it takes 232 orbits, or 16 days, to do so. The satellite weighs 1973 kg, is 4.04 m long, and 2.74 m in diameter. Unlike its predecessors, Landsat 7 has a solid state memory of 378 gigabits (roughly 100 images). The main instrument on board Landsat 7 is the Enhanced Thematic Mapper Plus (ETM+).See (3.5).

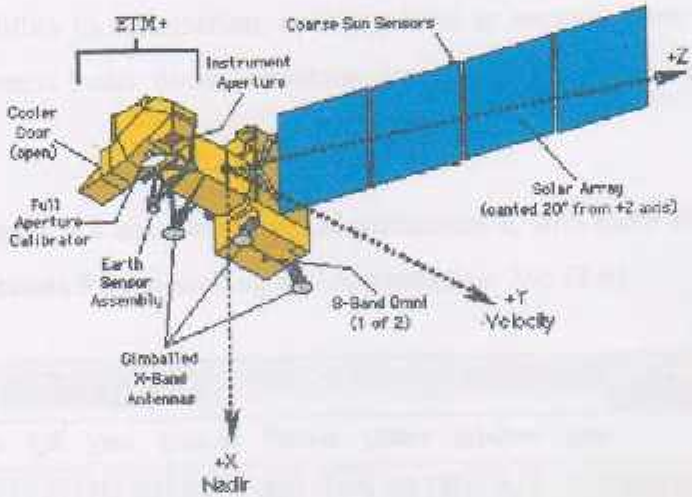


Figure (3.5): The Landsat 7 Satellite as Viewed From the Sun Side, NASA, 2005

## 3.6.2 Main Features

A panchromatic band with 15 m (49 ft) spatial resolution.

Full aperture, 5% absolute radiometric calibration.

A thermal infrared channel with 60 m spatial resolution.

## 3.7 ER Mapper

ERDAS ER Mapper provides advanced image processing and compression capabilities widely used in a variety of industries including oil, gas and mineral exploration. ERDAS ER Mapper allows you to visualize, enhance and combine images for a broad array of applications. Extracting the quantitative information you need, ERDAS ER Mapper makes your data more meaningful to solve business problems.

ERDAS creates geospatial business systems that transform our earth's data into business information, enabling individuals, businesses and public agencies to quickly access, manage, process, and share that information from anywhere.

Using secure geospatial information, ERDAS solutions improve employee, customer and partner visibility to information, enabling them to respond faster and collaborate better. It also means better decision-making, increased productivity and new revenue streams.

ERDAS ER Mapper 7.2 also has increased performance, with more efficient handling of very large datasets for mosaicking and compressing. See (3.6).


Figure (3.6): ER Mapper Program

## 3.8 Arc GIS

ArcGIS is a suite consisting of a group of geographic information system (GIS) software products produced by ESRI. At the desktop GIS level, ArcGIS can include: ArcReader, which allows one to view and query maps created with the other Arc products; ArcView, which allows one to view spatial data, create layered maps, and perform basic spatial analysis; ArcEditor which, in addition to the functionality of ArcView, includes more advanced tools for manipulation of shapefiles and geodatabases; or ArcInfo which includes capabilities for data manipulation, editing, and analysis. There are also server-based ArcGIS products, as well as ArcGIS products for PDAs. Extensions can be purchased separately to increase the functionality of ArcGIS.

### 3.8.1 Components

ArcGIS Desktop consists of several integrated applications, including ArcMap, ArcCatalog, ArcToolbox, and ArcGlobe. ArcCatalog is the data management application, used to browse datasets and files on one's computer, database, or other sources. In addition to showing what data is available, ArcCatalog also allows users to preview the data on a map. ArcCatalog also provides the ability to view and manage metadata for spatial datasets. ArcMap is the application used to view, edit and query geospatial data, and create maps. The ArcMap inferface has two main sections, including a table of contents on the left and the data frame(s) which display the map. Items in the table of contents correspond with layers on the map. ArcToolbox contains geoprocessing, data conversion, and analysis tools, along with much of the functionality in ArcInfo. It is also possible to use batch processing with ArcToolbox, for frequently repeated tasks.

# CHAPTER FOUR

# DATA PREPARION AND ANALYSIS

**4.1 Introduction**

**4.2 Remote Sensing Data**

**4.3 Image Classification Software**

**4.4 Ground Reference Data**

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**4.7 Unsupervised Classification of Image**

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## 4.1 Introduction

In the last decade, the West Bank has undergone tremendous growth, with population increasing most rapidly in the urban areas. This region of over 3 million residents is expected to be doubled in population over the next 20 years. As population growth continues, there will be increased pressure for residential development to extend into agricultural land.

Also, a rapid growth and expansion in the urban area, add a serious and major problem on land degradation and decreasing of Palestinian agricultural land .

Availability of remote sensing satellite imagery and a previous published land use map allow a unique opportunity to validate remote sensing generated urban classifications using urban information from the published map.

## 4.2 Remote Sensing Data

A LANDSAT 5 satellite image dated of 1985 (TM) and a LANDSAT 7 satellite image dated of Aug 1999 ( ETM+) are used to produce the land use/land cover map of the study area.

The 1999 satellite image was chosen to coincide with PASSIA Land Use Map ,1996, for West Bank, which was used as the ground reference (ground truth) for this study. The specific August 1999 image was chosen based on the image quality ( i.e. little cloud cover obscuring relevant urban and agricultural areas).

The 1999 satellite image is of level 1 product and is in GeoTIFF format.

## 4.3 Image Classification Software

ERDAS ER Mapper, Version 7.2, was used to process and analyze the two LANDSAT satellite images. This image processing software can integrate raster (grid) satellite images with vector (polygon) GIS data, and has a graphical interface. Unsupercised and Supervised classification techniques (see discussion below) are available to create accurate land use map from satellite data. ER Mapper runs on a PC under Windows XP.

## 4.4 Ground Reference Data

West Bank Land Use Map was obtained from PASSIA. It contains data of 1996 about Urban Areas, Arable Land, Irrigated farming , Permanent crops and Rough grassing

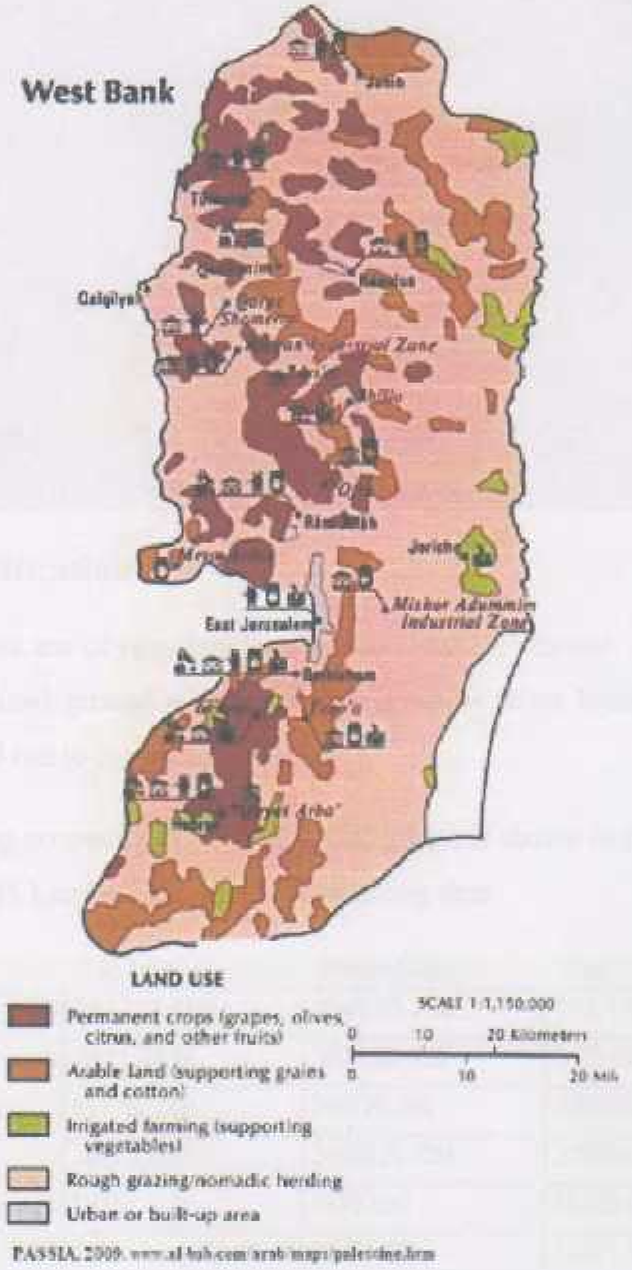



Figure (4.1): PASSIA Land Use Map

Table (4.1): The Result of PASSIA Land Use Map

| Category | Land Use | $(Km^2)$ | Percentage % |
|---|---|---|---|
| 1 | Crop Land | 968 | 16 |
| 2 | Arable land | 1012 | 17 |
| 3 | Irrigated Farming | 327 | 7 |
| 4 | Rough Grazing | 3179 | 54 |
| 5 | Built up | 104 | 2 |
| 6 | Water | 210 | 4 |
| | Total | 5800 | 100 |

## 4.5 Image Rectification

The Landsat Images are of raw data type in the GeoTIFF format. And because it is impossible to obtained ground control points for whole West Bank, no rectification process was carried out to rectify the images.

The geo-referencing properties of 1999 Landsat image is shown in figure (4.2) and (4.3), while the 1985 Landsat is of no geo-rferencing data

| | Top Left | Bottom Right | Size |
|---|---|---|---|
| Latitude: | 32:42:11.11N | 30:45:55.79N | 1:56:15.32 |
| Longitude: | 34:11:32.1E | 36:37:20.82E | 2:25:48.72 |
| Easting: | 611750.00E | 846775.25E | 235025.25 |
| Northing: | 3619000.00N | 3409225.75N | 209774.25 |
| Cell X: | 0.00 | 16493.00 | 16493.00 |
| Cell Y: | 0.00 | 14721.00 | 14721.00 |

Figure (4.2): Algorithm Geoposition Extents

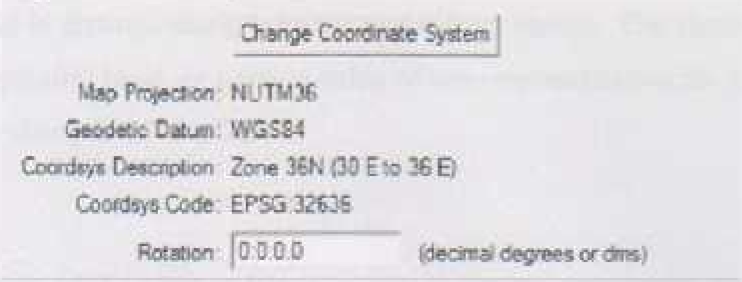



Figure (4.3):Geo-referencing Properties of Image

## 4.6 Supervised Classification of Landsat 1999 Image

A supervised classification method of the remote sensing image using ER-Mapper software were used. In supervised classification, spectral signatures are developed from specified locations in the image. These specified locations are given the generic name 'training sites' and are defined by the user ( with the help of PASSIA Landuse Map of West Bank).

Generally a vector layer is digitized over the raster scene. The vector layer consists of various polygons overlaying different land use types. The image below shows the raster image seen earlier with the addition of several training sites outlined on top of it. The training sites will help ER Mapper develop spectral signatures for the outlined areas. The land use categories of interest in this example are water, agriculture, urban, and forest. Multiple polygons are created for each land use category to help ensure that ER Mapper has sufficient information to create the spectral signatures.

### 4.6.1 Algorithm Description and Discussion

The standard ER-Mapper Maximum Likelihood classification algorithm was used on the dataset. This classifier assigns all cells of the image to a class by accounting for the distance weighted by the covariance matrix of the pixel means, and the prior probability that the cell belongs to that class. The Maximum Likelihood algorithm was chosen, because relatively reliable land use data is available for the investigation site, and this classification methodology works best for good quality training regions. So as much as the distribution of pixels for each class is normally distributed and significantly different than those of the other classes, the classification algorithm is most successful in distinguishing between agriculture classes. The algorithm also calculates a typicality band, or percent value of how representative the pixel is for the corresponding class, for each pixel

### 4.6.2 Selection of Training Sites

For the West Bank, training regions were selected by referencing data from the PASSIA West Bank Land use Map to correspondingly homogeneous regions on the satellite image

Since the algorithm classifies the entire image, training regions accounting for multi-modality were also chosen for urban areas, agricultural areas, and water areas.


Figure (4.4): Training Region

### 4.6.3 Steps of Supervised Classification

1- From tool bar click on process, then on calculate statics


Figure (4.5): Calculate Statistic

2- Select input data and determined subsampling interval

3- Click ok after this message appered.

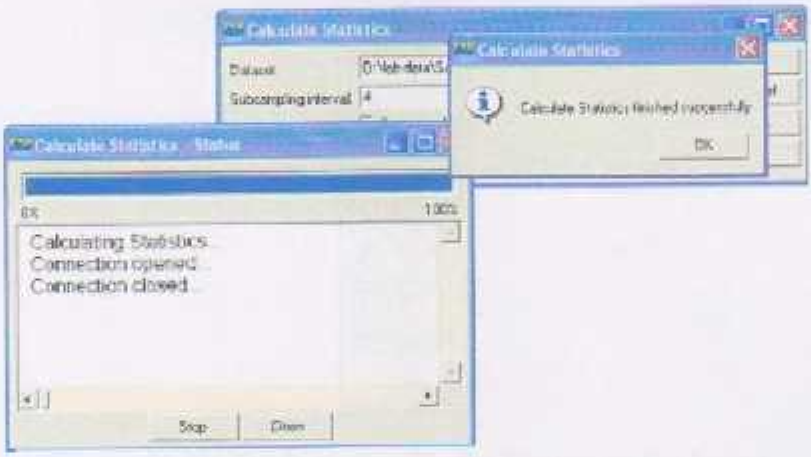



Figure (4.6): Message for Successful Calculate Statistics

4- From tool bar click on process and choose classification then select View Scattergram and choose the image will be procecced.

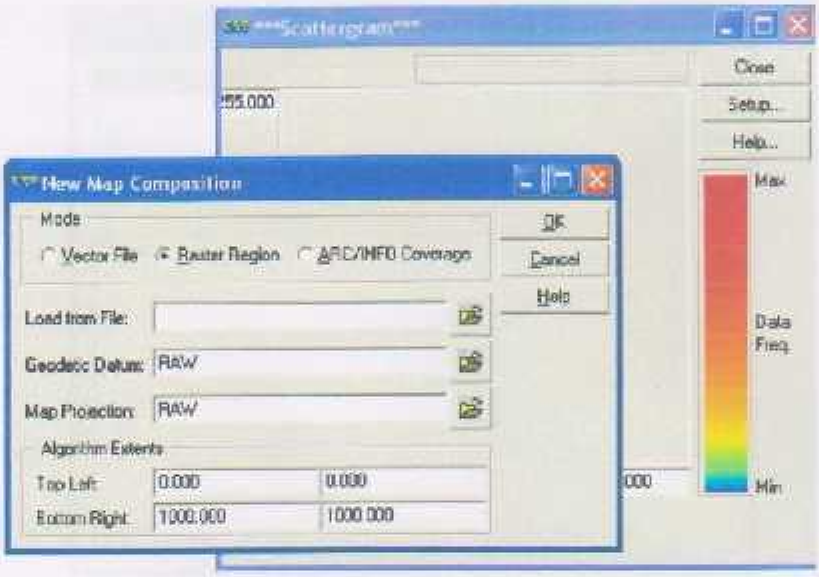



Figure (4.7): View Scattergram

5-Click ok.

6-Click on polygon button  from tools to specify the region on the image.


Figure (4.8): Tools to Specify the Region on the Image

7-Click on attribute button  and write the name of region.

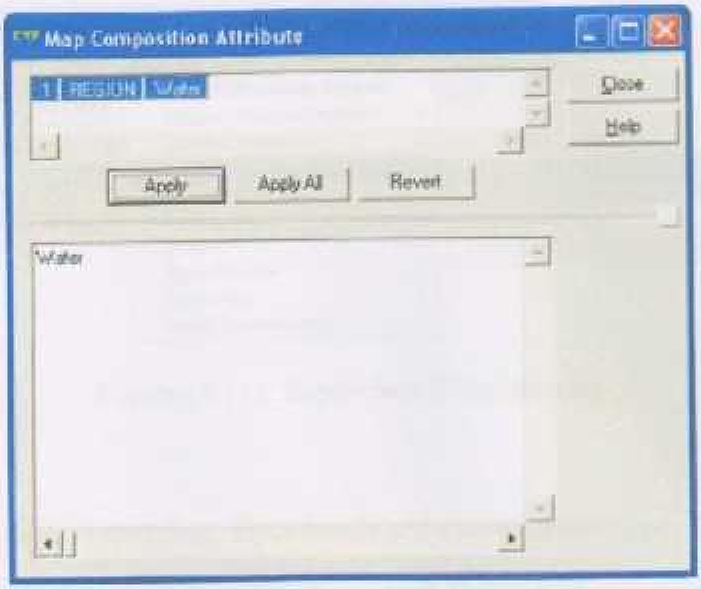



Figure (4.9): Map Composition Attribute

8-Click Apply.

9- After selecting all the required areas, click on save button .

10- Click close for tools and this report appeared.

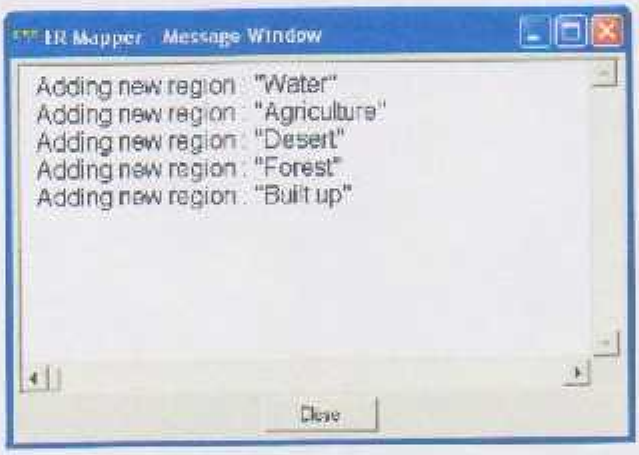



Figure (4.10): Report for Specified Region

11-Chooses supervised classification .

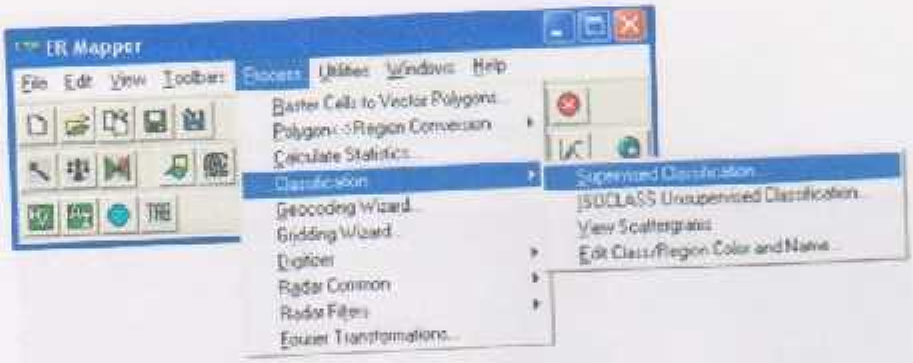



Figure (4.11): Supervised Classification

12-Select input data, output data, input bands and classification type.

13-When classification status completed successfully click ok.

Figure (4.12) shows the result of supervised classification of Landsat 1999, and table(4.2) shows the different classes and their areas.

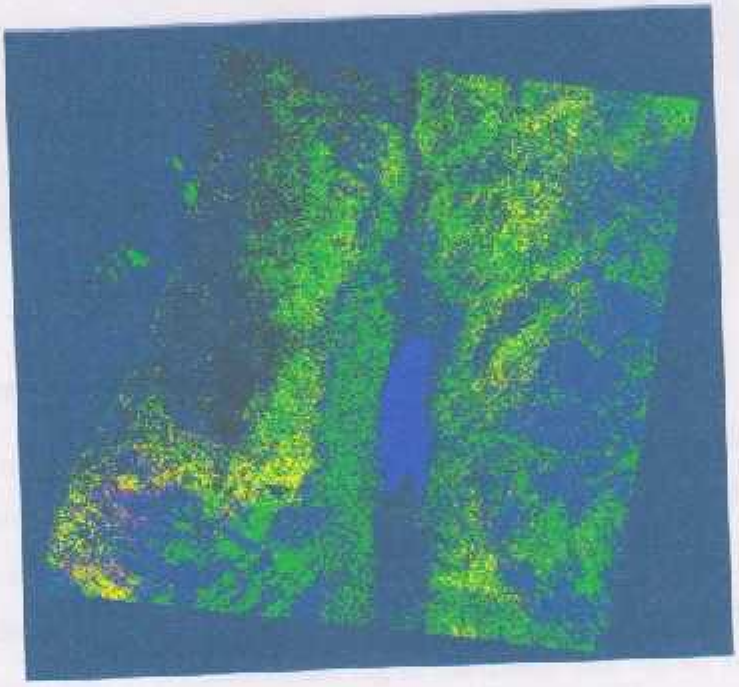


Figure (4.12): 1999 Supervised Classification Image

This information will later be compared to data generated from the unsupervised classification example.

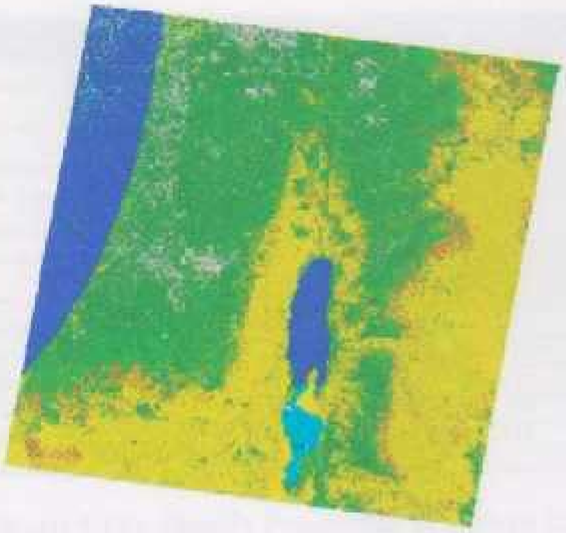
Table(4.2): Classes From Supervised Classification

| Category | Land Use | $Km^2$ | Percentage % |
|---|---|---|---|
| 1 | Built up | 487 | 8 |
| 2 | Water | 205 | 4 |
| 3 | Barren & Range Land | 2198 | 38 |
| 4 | Agriculture and Forest | 1597 | 28 |
| 5 | Crop Land | 1313 | 22 |
| | Total | 5800 | 100 |

## 4.7 Unsupervised Classification of Landsat 1999 Image

The second attempt made to classify the various land uses in ERDAS ER Mapper was done using unsupervised classification techniques. Unsupervised classification techniques do not require the user to specify any information about the features contained in the images. This example was conducted using the ER Mapper ISOCLASS algorithm to perform clustering of the image data during an unsupervised classification.

With ISOCLASS, the user simply identifies which bands ER Mapper should use to create the classifications, and how many classes to categorize the land cover features into. Again Landsat TM bands 1-5 and 7 were used. The resulting image is seen below, figure (4.13).



Figure(4.13): 1999 Unsupervised Classified Image

At this point, the image is difficult to interpret. Decisions need to be made concerning which land cover types each category falls within. To make these decisions, other materials and knowledge of the area are useful. Ground truthing is necessary to verify the result. PASSIA Landuse Map of West Bank is used as ground truthing material.

### 4.7.1 Steps of Unsupervised Classification

1-Repeat steps 1,2,3 as unsupervised classification.

2-Click unsupervised classification from process.

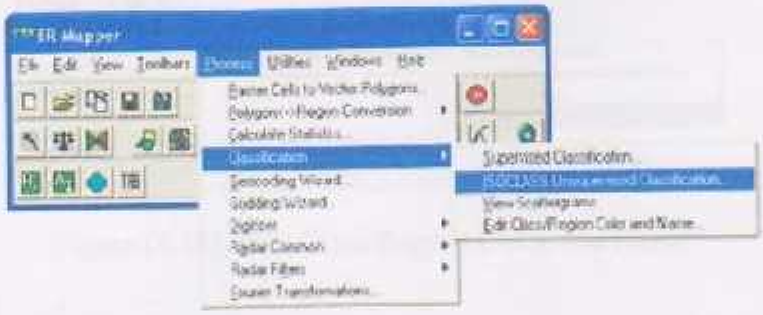
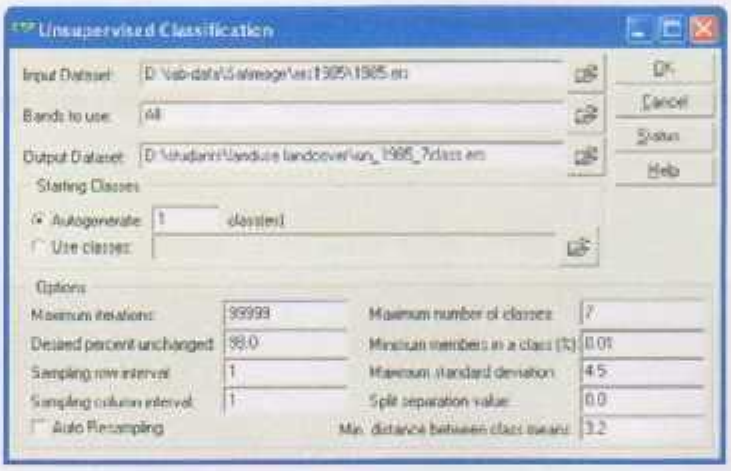



Figure (4.14): Unsupervised Classification

3-Choose input data, output data, number of band, maximum number of classes.




Figure(4.15): Specify Properities of Output Data

4- Click ok.

5-After process status, unsupervised classification will be successful.

6-Click ok

7-To show the result, click open and choose the path where classified image stored.

8-Open algorithm, right click on the name of layer  choose class display.

9-To modify the names and colors of polygons that resulted from the classification process, choose Edit Class/Region Color and Name.


Figure (4.16): Edit Class/Region Color and Name

The following classes were identify, table (4.3).

Table(4.3): Land Use Category as Assigned Using ISOCLASS Classifier in ER Mapper

| Category | Land Use | $Km^2$ | Percentage % |
|---|---|---|---|
| 1 | Built up | 556 | 10 |
| 2 | Water | 205 | 4 |
| 3 | Barren & Range Land | 2117 | 36 |
| 4 | Agriculture and Forest | 1545 | 27 |
| 5 | Crop Land | 1377 | 23 |
| - | Total | 5800 | 100 |

## 4.8 Combined Classification Methods of Landsat 1999

The final approach involved utilizing several different band ratios and other techniques of supervised and unsupervised classification. The steps used and how they were conducted are outlined below.

1. Isolate water and remove from image.
2. Isolate bare soil and remove from image.
3. Classify remaining vegetation in image with water and soil removed.

Step 1. Using the overlay image of bands 7 and 3, water was determined to have the smallest of ratios in the image. This was verified by viewing the histogram of the image and sampling numerous points on the image. This image was reclassified removing water from it Water appears in white color, figure(4.17)

Figure (4.17): Highlighted Water

Step 2. Using the overlay image of bands 7 and 3, bare soil was determined to have the greater ratios in the image. This was verified by viewing the histogram of the image and sampling numerous points on the image. This image was reclassified removing bare soil from it.

Step 3. With water and soil identified, the remaining areas of the image were overlayed with a band 4/3 image. This image (band 4/3 ratio) was chosen since at this point vegetation was the focus of the classification efforts. This image contained vegetation only. Using the ISOCLASS module in ER Mapper, 6 clusters were formed and grouped into 2 new groups. These groups were identified as forest and other vegetation. Continuous sampling of pixel values and comparison to other images aided in this process. The results of this final classification attempt are included in the table(4.4) below.

Table(4.4): Land Classification Area Comparison

| Land Use | Supervised ($Km^2$) | Unsupervised ($Km^2$) | Combined Methods ($Km^2$) |
|---|---|---|---|
| Built up | 487 | 556 | 406 |
| Water | 205 | 205 | 205 |
| Barren & Rang Land | 2198 | 2117 | - |
| Agriculture and Forest | 1597 | 1545 | - |
| Crop Land | 1313 | 1377 | - |
| Total | 5800 | 5800 | |

Looking at the data generated from the two classification attempts side by side, it can easily be seen that differences in land use areas are present. Furthermore, the data generated with the unsupervised technique contains additional land use classes. The reason that additional classes are present in the unsupervised method is due to the many classes created (25) and the fact that they did not fall into one of the classes used in the supervised technique.

## 4.9 Post-processing

### 4.9.1 Filtering

Post-processing kernels or filtering were undertaken for two reasons: (1) to reclassify pixels that were "confused" by the classification algorithm, and (2) to smooth out the dataset and reclassify stray pixels so that clusters of pixels belonging to the same class could have a vector ("polygon") region drawn around them. These vector regions were created to be exported to be able to be used in a GIS and for subsequent classification validation with ground-truthing.

Throughout the image, the "urban" class was confused by the classifier when the correct classification should have likely been areas of desert or bare land. This is a common problem with supervised classifications, since an urban area can have various signatures (trees, structures, roads, bare areas, etc.). Many of these confused areas had a typicality of less than 10%. In other words, these pixels had a probability of up to 10% in terms of being representative of the "urban" class. Since this probability was significantly low, these pixels were reassigned to the "desert/bare land" class. The resulting reclassification was much more representative of our perception and experience of where urban areas lie.

On visual inspection, the "majority" filter provided in the ER Mapper package produced a classification sufficiently smooth and contiguous for exporting to vector polygons.

### 4.9.2 Steps of Post-processing

1- Click on Edit Filter button 

2- Select filter filename.

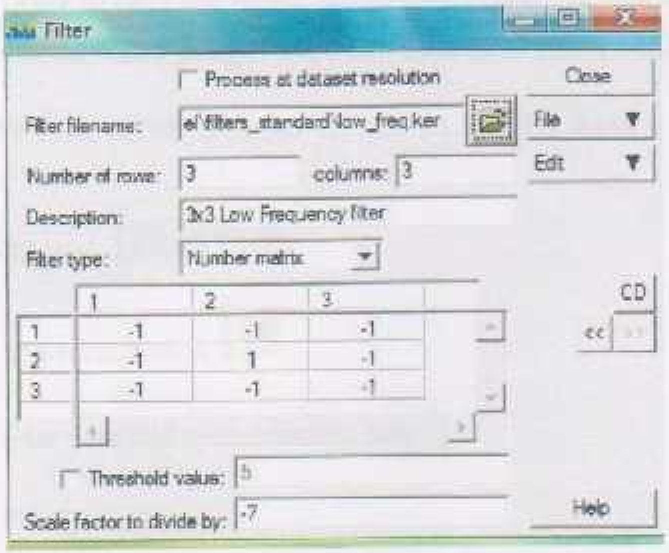
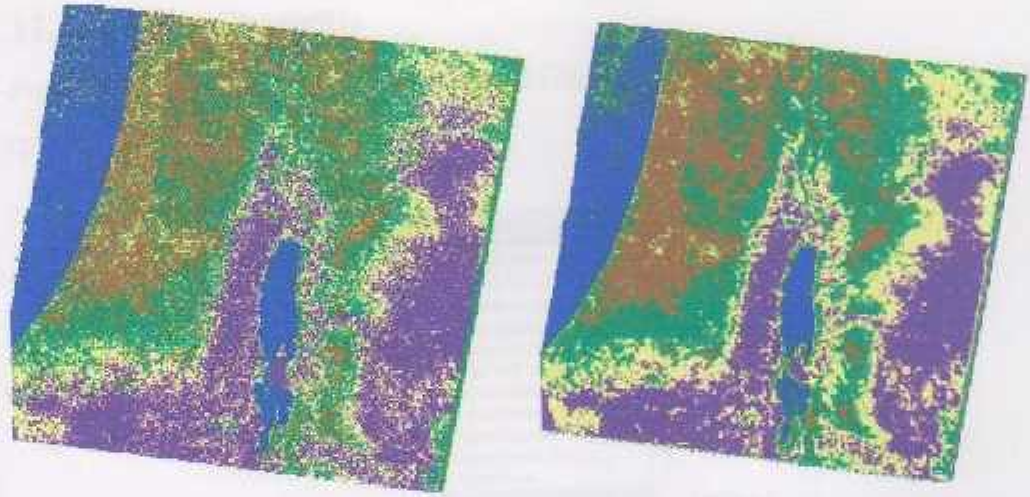



Figure (4.18): Load Filter

3-Notice the difference that happened in image.



Before After

Figure (4.19): Image Before and After Using Filter

## 4.10 Conversion from Raster to Vector Format

The standard ER Mapper raster ("grid") cells conversion to vector polygons process was used on the classified dataset for all resultant Land Use classes. The regions were increasingly smoothed by drawing nodes for the polygons through the halfway points of each pixel. In order to have the vector polygons available for use in a GIS, the supervising and unsupervising images were exported to an ESRI Shape File.

### 4.10.1 Steps for Conversion from raster to vector data

1-Activation of GIS tool. 

2-Click on raster to vector button 

3-Choose input raster data and output vector data.

4-Click ok.

5-After conversion complete successfully click ok.

## 4.11 Export to Shapefile

1-From Utilities choose Export Vector and GIS formats then ESRI Shape File then Export.


Figure (4.20): Export to GIS

2- Select data to export and where the raster image will be stored.

3- Click ok.

## 4.12 Preparing Data on GIS

1- Click the Add Data button on the Standard toolbar to add the image shapefile.

2-Right click on the shape file name and choose properties.

3-Click on Symbology then unique values from Categories and Add All Values.

4-Labeling name of region and change the colors.

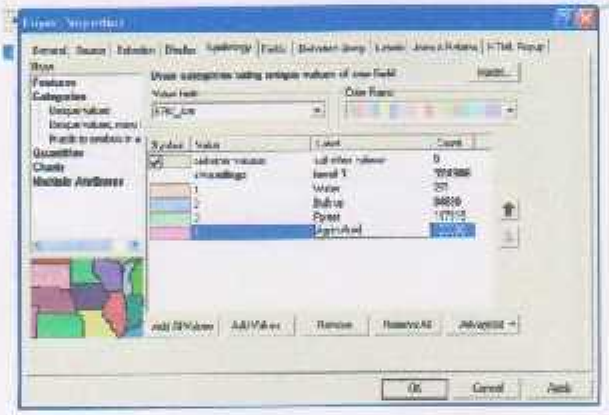


Figure (4.21): Adding and Labeling Values.

## 4.12.1 Projection of Landsat Images

1-Click on tools books .

2-Click on data mangment and analysis tools.

3-Click on feature and chose projection.

4-Specify the input data and coordinate system to transform it to correct coordinate system.

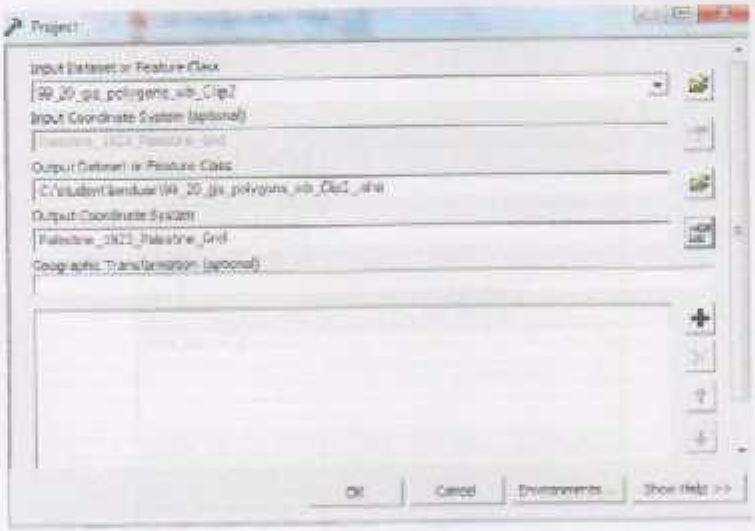


Figure (4.22): Projection of Landsat Image.

## 4.12.2 Clip of Images

1-Click on Click on tools books .

2-Click on exract and choose clip

3-Specify the image to clip .

Figure (4.23): Clip of Image

## 4.12.3 Select Specify Feature in the Images

5-Click on Selection from toolbar menu.

6-Click Selection by Attribute.

7- Select the region to be identified as shown in the figure.

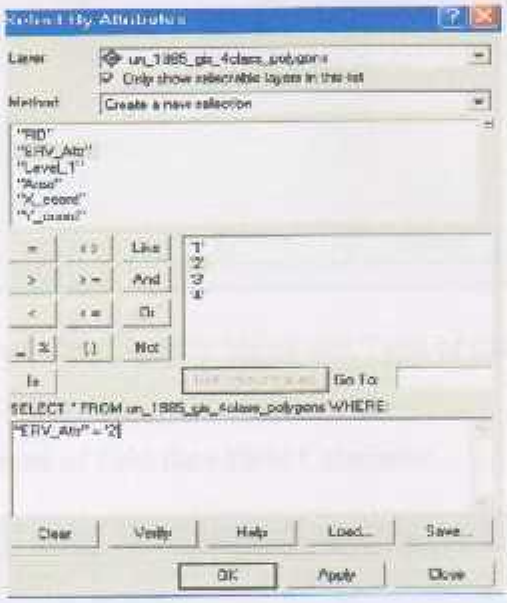


Figure (4.24): Selection by Attribute

8-Right click on the name of the layer and choose open attribute table

9-Click on options then Add Field.

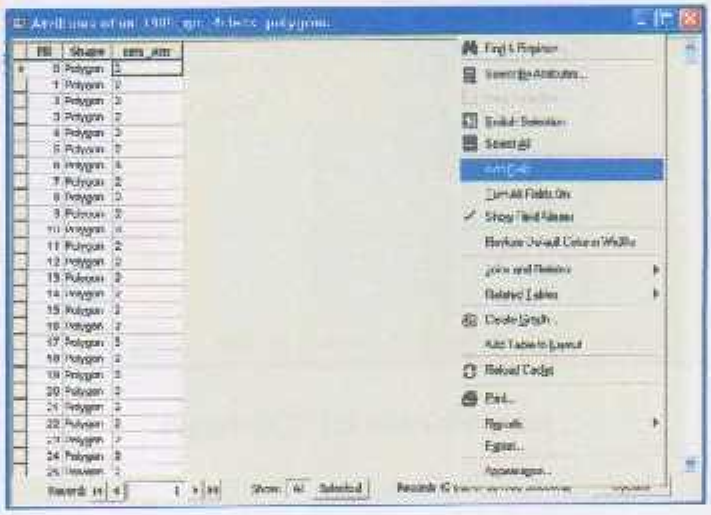


Figure (4.25): Adding Field

10-Write the name of the field and specify type of field.

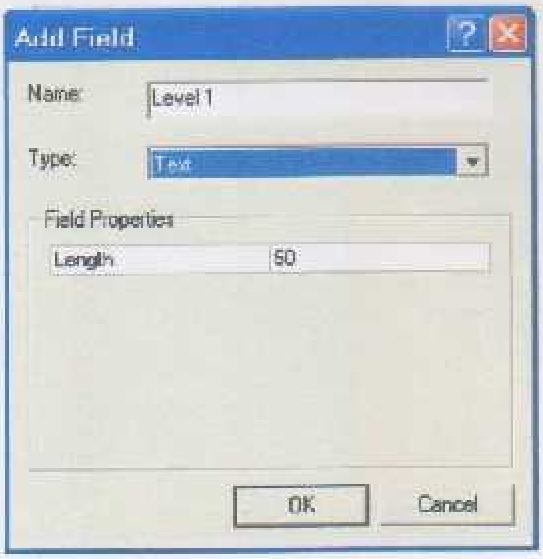



Figure (4.26): Specify Name and Type of the Field

11-Right click on the name of field then Field Calculator.

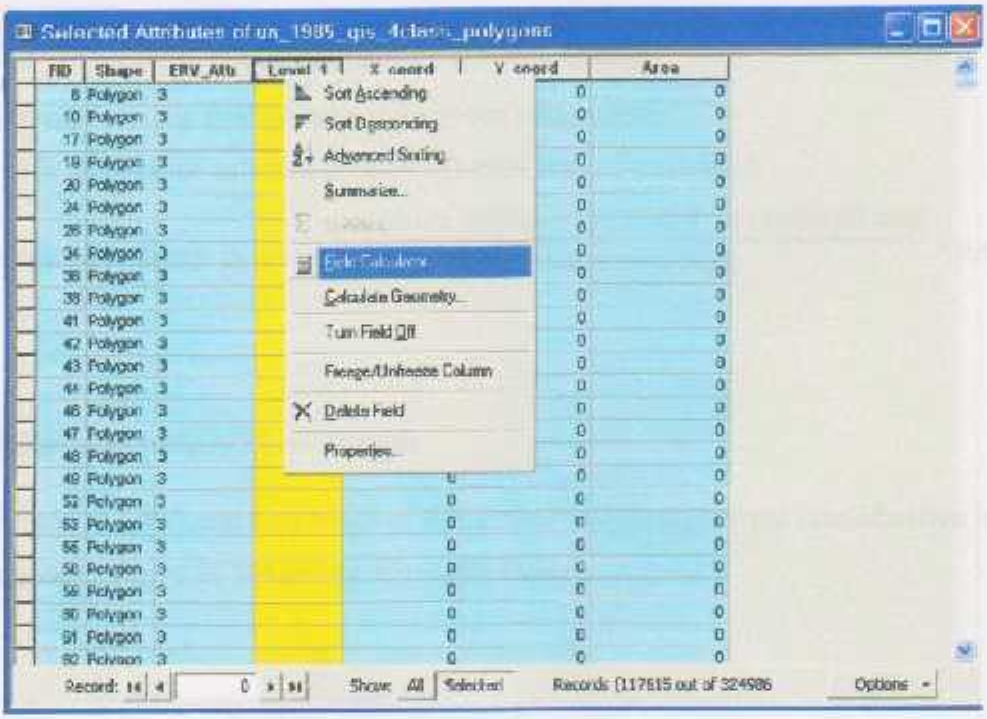



Figure (4.27): Field Calculator

12-Write name of the region will be appeared in attribute table.

13-Click on Calculate Geometry to calculate the area.

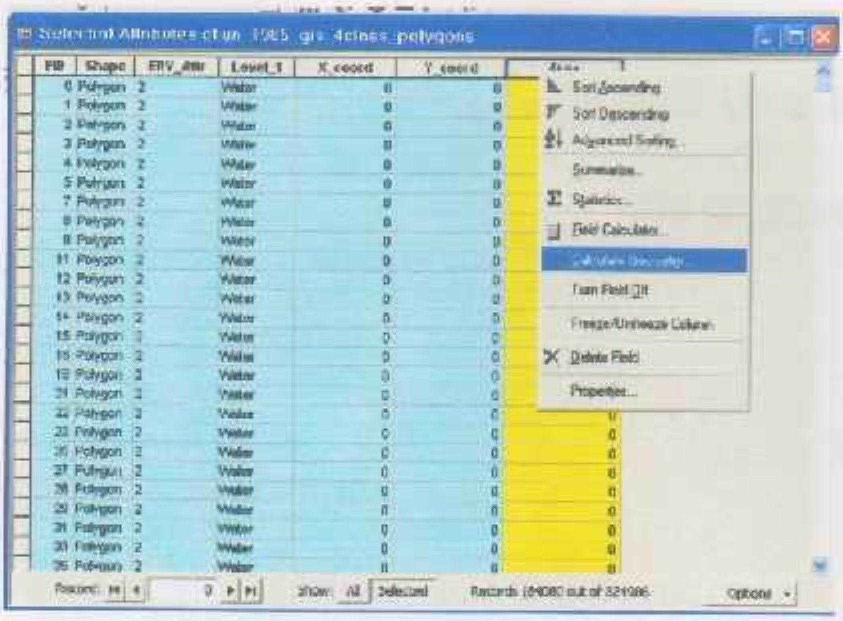



Figure (4.28): Calculate Geometry

14-Repeat step 13 to calculate (X,Y)coordinates and area.

15-To identify any region in final map click on identify button

### 4.12.4 Calculate Percentage of Area Change

1.Right click on the field of area and choose summarize.

2. Divide the sum of selected area on the total area of west bank

3. Percentage change in area = $\frac{\text{Area from PASSIA map} - \text{Area from resultatnt map}}{\text{Area of West Bank}}$ *100%

## 4.13 Resultant land Use Maps

The resultant GIS Land Use Maps of supervised and unsupervised classification are illustrated in figure (4.29) and (4.30) respectively .

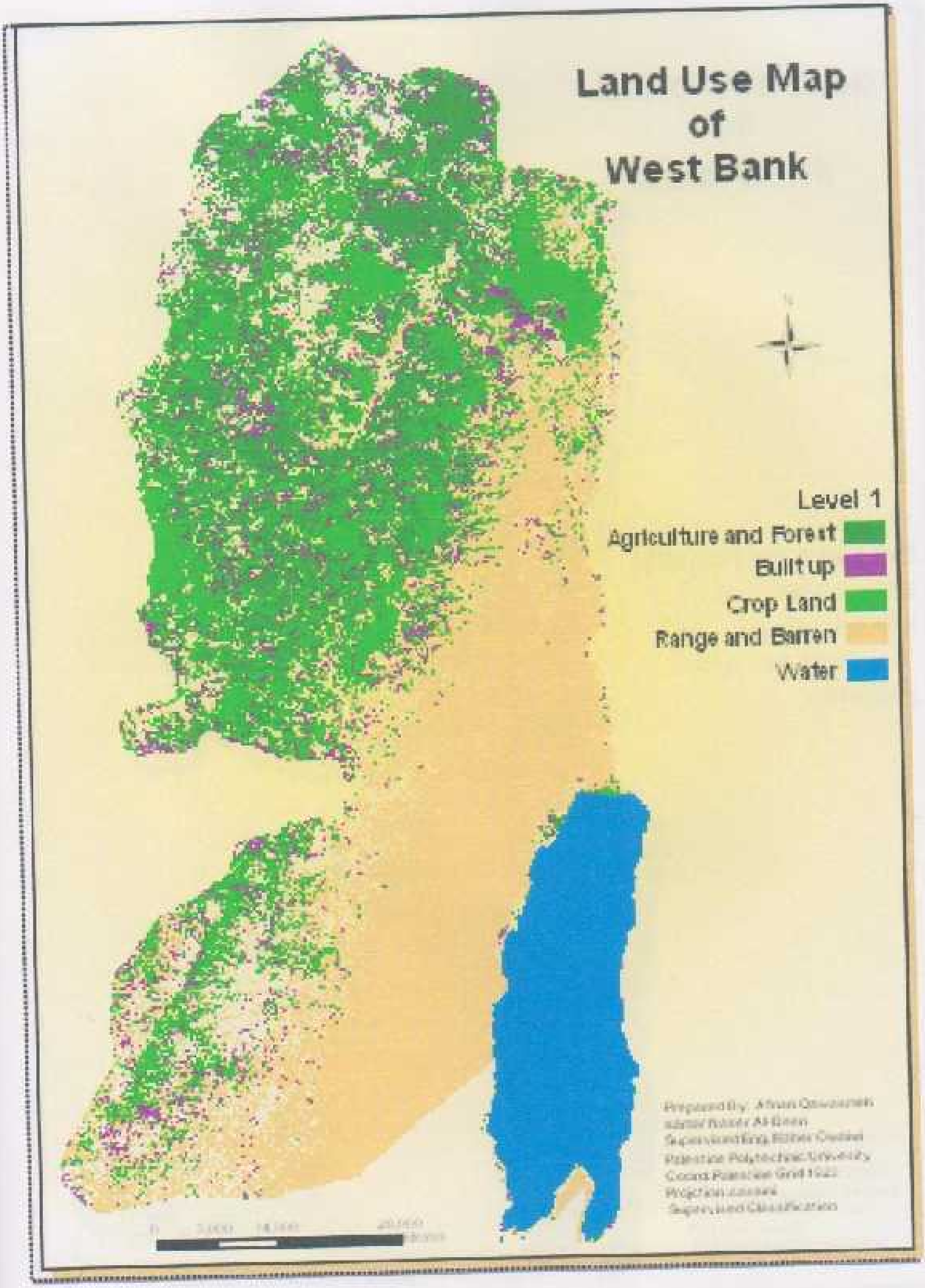



Figure (4.29): The Resultant Map of Supervised Classification

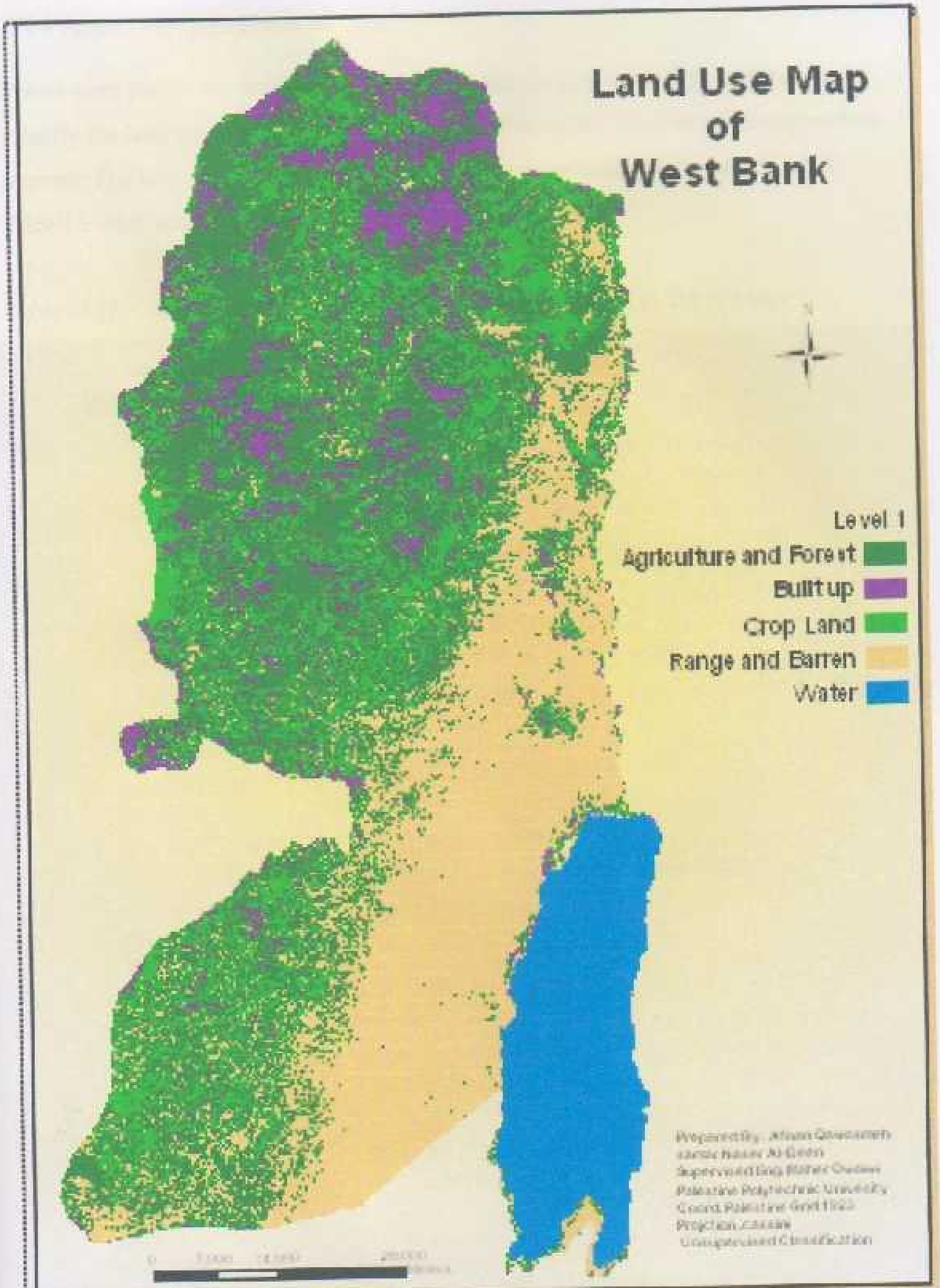



Figure (4.30): The Resultant Map of Unsupervised Classification

## 4.14 Accuracy Assessment

Points were plotted on the supervised and unsupervised classification merges to identify the land use type in each point location .The points were selected in a random manner. The land use type of each point were correlated with the land use type of PASSIA map, see table (4.5).

Table (4.5): Correlation Results Between the Resultant land Use Types Maps

| Point no | Supervised Classification | Unsupervised Classification | PASSIA |
|---|---|---|---|
| 1 | Permanent crops | Permanent crops | Permanent crops |
| 2 | Barren Land | Barren Land | Rough Land (Range & Barren ) |
| 3 | Range Land | Range Land | Permanent crops |
| 4 | Range Land | Barren Land | Rough Land (Range & Barren ) |
| 5 | Agriculture Land | Range Land | Arable Land (Agriculture ) |
| 6 | Agriculture Land | Agriculture Land | Arable Land (Agriculture ) |
| 7 | Built up Area | Built up Area | Arable Land (Agriculture ) |
| 8 | Range Land | Range Land | Arable Land (Agriculture ) |
| 9 | Permanent crops | Permanent crops | Rough Land (Range & Barren ) |
| 10 | Range Land | Range Land | Irrigated Land (Agriculture ) |
| 11 | Water | Water | Water |
| 12 | Built up Area | Built up Area | Arable Land (Agriculture ) |
| 13 | Agriculture Land | Permanent crops | Permanent crops |
| 14 | Barren Land | Barren Land | Rough Land (Range & Barren ) |
| 15 | Agriculture Land | Agriculture Land | Rough Land (Range & Barren ) |
| 16 | Range Land | Range Land | Arable Land (Agriculture ) |
| 17 | Permanent crops | Permanent crops | Rough Land (Range & Barren ) |
| 18 | Range Land | Range Land | Rough Land (Range & Barren ) |
| 19 | Built up Area | Built up Area | Built up Area |
| 20 | Range Land | Range Land | Arable Land (Agriculture ) |
| 21 | Permanent crops | Permanent crops | Rough Land (Range & Barren ) |
| 22 | Agriculture Land | Agriculture Land | Arable Land (Agriculture ) |
| 23 | Range Land | Range Land | Water |
| 24 | Range Land | Range Land | Rough Land (Range & Barren ) |
| 25 | Built up Area | Built up Area | Irrigated Land (Agriculture ) |
| 26 | Barren Land | Barren Land | Arable Land (Agriculture ) |
| 27 | Built up Area | Agriculture Land | Arable Land (Agriculture ) |
| 28 | Agriculture Land | Agriculture Land | Arable Land (Agriculture ) |
| 29 | Permanent crops | Permanent crops | Permanent crops |
| 30 | Built up Area | Built up Area | Rough Land (Range & Barren ) |
| 31 | Built up Area | Built up Area | Built up Area |
| 32 | Agriculture Land | Agriculture Land | Built up Area |
| 33 | Permanent crops | Permanent crops | Permanent crops |
| 34 | Range Land | Barren Land | Rough Land (Range & Barren ) |
| 35 | Range Land | Range Land | Rough Land (Range & Barren ) |

| | | | |
|---|---|---|---|
| 36 | Range Land | Barren Land | Rough Land (Range & Barren ) |
| 37 | Range Land | Range Land | Arable Land (Agriculture ) |
| 38 | Agriculture Land | Range Land | Rough Land (Range & Barren ) |
| 39 | Range Land | Range Land | Rough Land (Range & Barren ) |
| 40 | Permanent crops | Built up Area | Arable Land (Agriculture ) |
| 41 | Built up Area | Range Land | Rough Land (Range & Barren ) |
| 42 | Built up Area | Agriculture Land | Permanent crops |
| 43 | Permanent crops | Built up Area | Rough Land (Range & Barren ) |
| 44 | Range Land | Range Land | Rough Land (Range & Barren ) |
| 45 | Permanent crops | Range Land | Rough Land (Range & Barren ) |
| 46 | Agriculture Land | Range Land | Water |
| 47 | Range Land | Range Land | Irrigated Land (Agriculture ) |
| 48 | Range Land | Range Land | Rough Land (Range & Barren ) |
| 49 | Range Land | Range Land | Permanent crops |
| 50 | Agriculture Land | Range Land | Irrigated Land (Agriculture ) |

The Correlation shows that,

1. 42 points of supervised classification map are coincide with the PASSIA land use map. This is of about 84% .

2. 25 points of unsupervised classification map are coincide with the PASSIA land use map. This is of about 50 %.

# CHAPTER FIVE

# CONCLUSION AND RECOMMENDATIONS

## 5.1 Conclusions and Recommendations

## 5.1 Conclusions and Recommendations

1. It is a common fact that remote sensing and GIS have been extensively used for Land Use/Land Cover( LULC) information generation for years.

2. The use of remote sensing products for monitoring the expansion of urban area in West Bank has been demonstrated in this study.

3. Remote sensing end products can be one of the tools managers of protected areas that might use to support decision makers.

4. It was fond that, the Landsat image of 1985 has many problems, these are:

- No Geo-refrencing data.
- The spatial resolution is not of standard (28 m pixel size ), and as a result a pixelization error is demonated.
- No information, (meta data ) is available for this image, for that-it was not used in our project.

5. A decrease in the area of Dead Sea is detected

6. The following table summarize the expiation in each land use type.

Table (5.1):Percentage Change in Resultant Maps

| No. | Land Use Type | PASSIA (area $Km^2$) | Supervised (area $Km^2$) | Percentage Change % | Unsupervised (area $Km^2$) | Percentage Change % |
|---|---|---|---|---|---|---|
| 1 | Built up | 104 | 487 | 7 | 556 | 8 |
| 2 | Permanents Crops | 968 | 1313 | 6 | 1377 | 7 |
| 3 | Range & barren Land | 3179 | 2198 | 17 | 2117 | 18 |
| 4 | Water | 210 | 205 | 0.1 | 205 | 0.1 |
| 5 | Agriculture | 1339 | 1597 | 4 | 1545 | 4 |

7. The correlation between the PASSIA land use map and the land use map of supervised classification shows an accuracy of about 84%.

8. the resultant land use map of supervised classification can be used with scale of 1:75,000

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# Appendix

# Appendix A
# Landsat 1999 Meta Data

EROS DATA CENTER LEVEL-1 PRODUCT GENERATION SYSTEM

PRODUCT README: GEOTIFF FORMAT
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**BACKGROUND**

The launch of the Landsat-7 satellite on April 15, 1999, marks the addition of the latest satellite to the National Aeronautics and Space Administration's Landsat satellite series. The Landsat-7 satellite carries the enhanced thematic mapper plus (ETM+) sensor and is part of an ongoing mission to provide quality remote sensing data in support of research and applications activities. Information on the Landsat-7 Program, including information about the Landsat-7 satellite, the ETM+ sensor, and Landsat-7 data collection is available in the "Landsat 7 Science Data Users Handbook." The Geographic Tagged Image File Format (GeoTIFF) files are described in detail in the "Earth Science Data and Information System (ESDIS) Level 1 Product Output Files Data Format Control Book, Volume 5, Book 2." See References

**FORMAT**

(Radiometrically and geometrically corrected Landsat-7 data (level-1G products are provided in the GeoTIFF format. This format defines a set of public domain TIFF tags that describe the cartographic and geodetic information that is associated with an image. The initial tags are followed by image data, that in turn, may be interrupted by more descriptive tags. By using the GeoTIFF .format, both metadata and image data can be encoded into the same file

**ORGANIZATION**

Each band of Landsat-7 data in the GeoTIFF format is delivered as a grayscale, uncompressed, 8-bit string of unsigned integers. No other .files accompany the product

**NAMING CONVENTION**

The file naming convention for GeoTIFF is as follows

L7fppprrr_rrrYYYYMMDD_AAA.TIF

where

.L7 indicates the Landsat-7 mission

.f indicates the ETM+ data format

.ppp indicates the starting path of the product

.rrr_rrr indicates the starting and ending rows of the product

.YYYYMMDD indicates the acquisition date of an image

:AAA indicates the file type

B10 = band 1
B20 = band 2
B30 = band 3

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Data Format Control Books may be revised periodically. Visit the :following document server

Earth Science Data and Information System (ESDIS) Level 1 Product :Generation System (LPGS) Document Server at

http://lpgs-server.gsfc.nasa.gov/!LPGS_Baseline/baseline.html

Disclaimer: Any use of trade, product, or firm names is for descriptive .purposes only and does not imply endorsement by the U.S. Government

o ACRONYM LIST

EDC -- EROS Data Center

EROS -- Earth Resources Observation Systems

ESDIS -- Earth Science Data and Information System

ETM+ -- Enhanced Thematic Mapper Plus

GeoTIFF -- Geographic Tagged Image File Format

LPGS -- Level-1 Product Generation System