بسم الله الرحمن الرحيم

Graduation Project

Sustainable Planning of land and infrastructure in Hebron district using Remote Sensing and Geographic Information System

Team

Ghazi Awad

Miassar Maraqa

Yazan Hashlamoun

Supervisor:

Eng.Nidal Aburajab

Submitted to the College of Engineering
in partial fulfillment of the requirements for the degree of
Bachelor degree in Surveying Engineering

Hebron-West Bank

Palestine

December - 2018

Palestine Polytechnic University

College of Engineering and Technology
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In accordance with the recommendation of project supervisor and acceptance of all examining committee members, this project has been submitted to the 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 Geomatics Engineering.

Signature of Project Supervisor **Signature of Department Chairman**

Name…………………………… **Name ……………………………..**

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الإهداء

إلهي لا يطيب الليل إلا بشكرك ولا يطيب النهار إلا بطاعتك ولا تطيب اللحظات إلا بذكرك ولا تطيب الآخرة إلا بعفوك ولا تطيب الجنة إلا برؤيتك

الله سبحانه جل في علاه جل جلاله..

إلى من بلغ الرسالة وأدى الأمانة ونصح الأمة إلى نبي الرحمة ونور العالمين ، معلم البشرية ومنبع العلم

سيدنا محمد صلى الله عليه وسلم..

إلى من حاكت سعادتي بخيوط منسوجة من قلبها يا بسمة الحياة وسر الوجود يا من كان دعائها سر نجاحي وحنانها بلسم جراحي وركع العطاء أمام قدميها..

أمي الغالية..

إلى من أحمل اسمه بكل فخر ومن استلمت منه قيم الإنسانية وعلمتني ارتقي سلم الحياة بحكمة وصبر ستبقى كلماتك نجوم أهتدي بها اليوم وفي الغد وإلى الأبد *يا صاحب القلب الكبير*

والدي..

إلى رياحين حياتي يا من تطلعتم إلى نجاحي بنظرات الأمل ورافقتهم منذ أن حملت حقائب صغيرة

أخوتي..

إلى من معهم وبرفقتهم سرت وكانوا على طريق النجاح والخير وأمضيت معهم ذكريات الأخوة الذين تسكن صورهم وأصواتهم أجمل لحظات الأيام التي عشتها

أصدقائي..

إلى من هم أفضل منا جميعا الذين رووا بدمائهم ثرى فلسطين

كل الشهداء..

إلى من عشقوا الحرية وخاضوا بأمعائهم حربا *من اجلك*

اهدي هذه الثمرة المتواضعة لك

قدسي..

واخيراً وليس اخراً إلى جميع الأساتذة في دائرة الهندسة المدنية والمعمارية الذين لم يبخلوا بنصائحهم وتوجيهاتهم علينا

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Sustainable Planning of land and Infrastructure in Hebron District Using Remote Sensing and GIS

Prepared By:

Ghazi Awad Miassar Maraqa Yazan Hashlamoun

Supervised By:

Eng.Nidal Aburajab

Abstract

The aim of this project is to make a Comprehensive study to find solution for spatial issues in Hebron, such as the situation of the natural reserves, the situation of roads, the spatial analysis of schools and facilities, the expansion of urban areas and change detection and settlements.

The project starts by collecting data of satellite imagery (Landsat from USGS earth explorer, Sentinel from ESA Open access hup, municipalities), facilities locations (schools, dumping sites, and hospitals), as well as Arial photos of the year 2014.

The data of satellite imagery are classified according to Corrine classifications, then analyzed the current facilities of Hebron District, made Spatial analysis to suggest new facilities locations, and centerlines of roads were digitized on Arial photos and analyzed to make new roads network .

At the end, the results show that there is a big growth of urban areas, shrinkage of the natural reserves areas, and an expansion of the Israeli settlements during the years of this study (1984; 1998; 2002; 2015, 2017). The researchers suggest new places for roads and facilities (such as schools, and dumping sites).

Sustainable Planning of land and Infrastructure in Hebron District Using Remote Sensing and GIS

عمل الطلاب

غازي عوض ميسر مرقة يزن هشلمون

بإشراف:

م.نضال أبو رجب

الملخص

الهدف من هذا المشروع هو إجراء دراسة شاملة لإيجاد حل للقضايا المكانية في الخليل، مثل وضع المحميات الطبيعية، وحالة الطرق، والتحليل المكاني للمدارس والمرافق، والتوسع في المناطق الحضرية والكشف عن التغير والمستوطنات.

يبدأ المشروع بجمع بيانات صور الاقمار الصناعية (Landsatمن USGS Earth Explorer، Sentinelمن ESA Open access hup والبلديات)، مواقع المرافق (المدارس، مواقع مكبات النفايات، والمستشفيات)، بالإضافة إلى صور جوية لعام 2014.

ثم تم تصنيف بيانات صور الأقمار الصناعية وفقًا لتصنيفات كورين، ثم تحليل المرافق الحالية لمنطقة الخليل، وتحليل مكانيًا لتشير إلى مواقع جديدة للمرافق، وتمت ترسيم الخطوط المركزية للطرق على الصور الجوية وتحليلها لإنشاء شبكة طرق جديدة.

في النهاية، تظهر النتائج أن هناك زيادة كبيرة في المناطق الحضرية، وتقلص مناطق المحمية الطبيعية، وتوسع المستوطنات الإسرائيلية خلال سنوات هذه الدراسة (1984؛ 1998؛ 2002؛ 2015، 2017). يقترح الباحثون أماكن جديدة للطرق والمرافق (مثل المدارس ومواقع الإغراق) .

Table of Contents

List of Figures

List of Tables

1. Introduction

1.1 Background

1.2 Objectives

1.3 Study area

1.4 Timetable

1.5 Literature review

1.6 Methodology

1.7 Scope

1.1 Background

Hebron district is considered as one of the most important districts of Palestine, it’s the economical capital of the west bank so its utilities must satisfy people needs and suit the population growth and development.

Due to its importance, Hebron district faces many challenges and endures many violations, including, the situation of the natural reserves, the situation of roads.

From this came the idea of assessing the situation of this district by noticing the changes that happened in it through the years, and assessing the current situation by analyzing the roads, services and facilities, to solve the problems that occurs in this district.

1.2 Objectives

The main objective of this project is to analyze existing facilities in Hebron district to come up with recommendations to solve the problems that exists in the study area, in order to do that a set of objectives has been set:

1. To find the changes that occurred in Hebron district through time.
2. Study the current facilities of Hebron District, and use GIS Spatial analysis to suggest new facilities location to help future demands.
3. Build route network for the district to determine the best routes between locations and study the probability of suggest new roads within the district under certain conditions and criteria.

1.3 Study area

1.3.1 Location and topography

Hebron is a Palestinian district lies in the far south of the west bank 36 Km south of Jerusalem and lies at 930 m above sea level, with an area of 1060 square Kilometers, this makes it the largest district in the west bank, and with a population of about 600000.

Hebron district dates back more than seven thousand years, as mentioned by historians, is a holy land in the three religions. It includes sanctuaries of many prophets and messengers, peace be upon them, and many of the shrines of the Companions may God's prayers and peace be upon them. It is divided into several cities and villages including: Hebron, Yatta, Dhahiriya, Halhul, Samu, Azna and Bani Na'im.

The mountainous terrain is prevalent in the Hebron governorate, some of which are more than 1032 meters above sea level. The heights of the governorate range from 300 meters in the west to 1,000 meters in the center of Halhul and the Sheikhs. The largest mountain range in Hebron stretches from Hebron East to Palestinian coast west and from Beit Ammar north to Al Dhahiriya in the south in addition to some hills and hills, which are abundant in the west of Hebron.

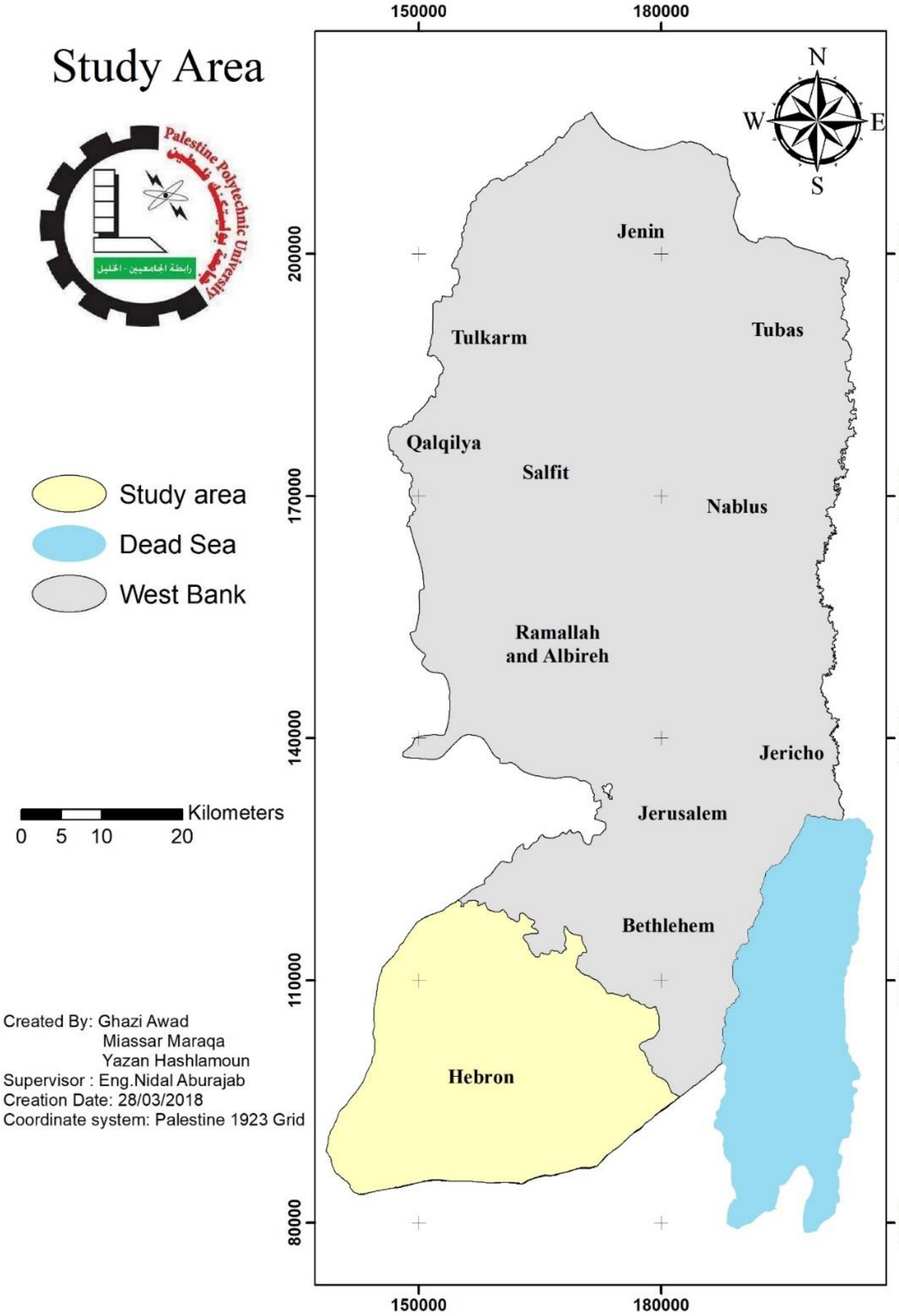


Figure 1-1 Hebron district Location in west bank

1.3.2 Political overview

Hebron district under the Oslo Accord

This agreement was signed in September 1995 between the two sides Palestinian Liberation Organization (PLO) and Israel, the terms of the agreement concluded that Israel withdraw from areas of the West Bank, and that the Occupied Territory be classified into Areas “A,” “B” and “C,” in different levels of control. And hebron district was divided into areas (A=24%), (B=22%) and (C=48%), in addition to 6% as a nature reserve area Like the other Palestinian governorates. [1]

"C" areas are lands that Palestinians has no control and their existence is little with comparison to the population in "A" and "B". [2]

Hebron (H1&H2 Protocol)

This protocol is signed In January 1997, between the two sides Israel and the Palestinian Liberation Organization (PLO), according to this protocol Hebron was divided into two parts H1 and H2. In H1 areas there are around 130000, covers approximately 20 % of the municipal boundary and Palestinian Authority has limited autonomy. But H2 areas falls completely under the control of the Israeli Army. [2]

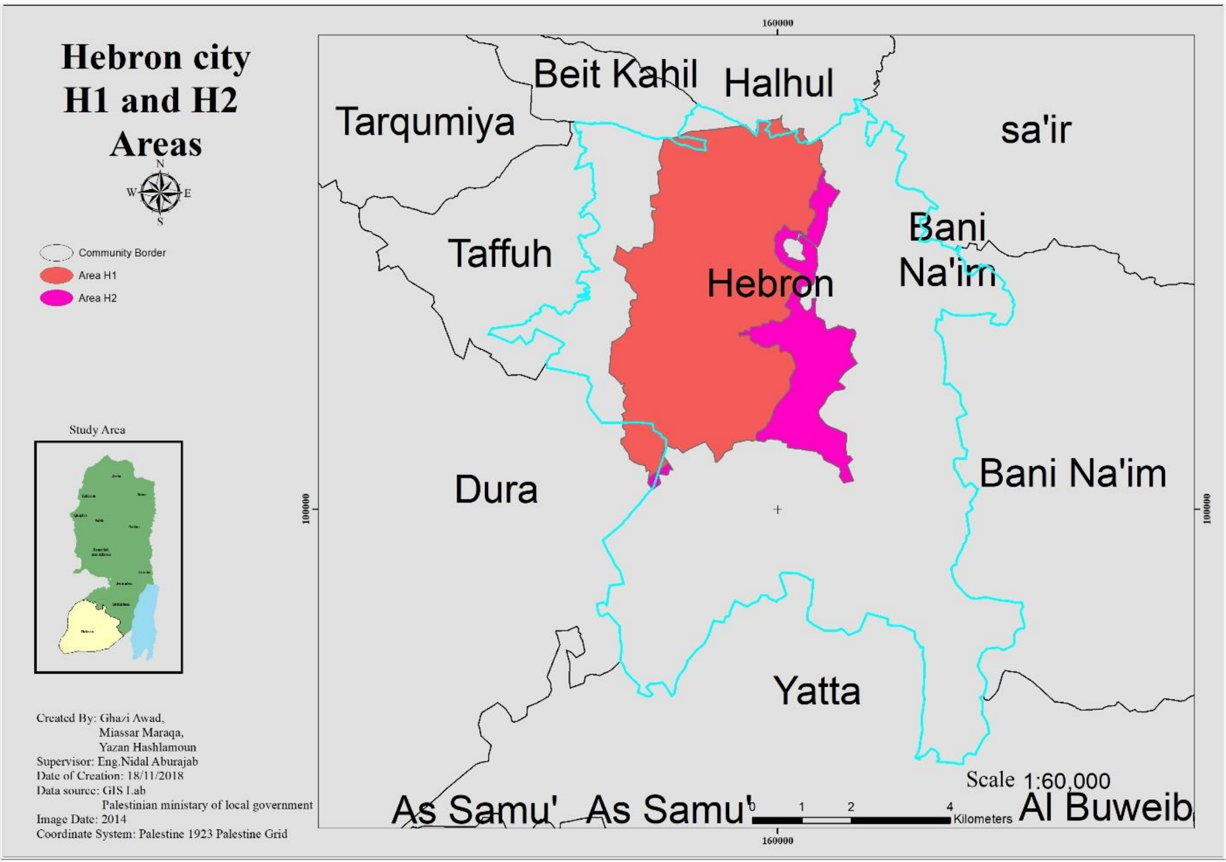


Figure 1-2 Shows the H1 and H2 areas at Hebron city *[1]*

Settlements

There are 24 Israeli settlements in Hebron Governorate with a built up area of 3.7 km2 (about 0.4% of the total area of Hebron Governorate). This number does not include the municipal area estimated at 39.9 km2 (3.7% of the total area of Hebron district). The overall number of built up area and municipal area is 43.6 km 2 (4.1% of the total area of the district) –Source- Foundation for Middle East Peace, Washington- Settlement Report, June 2006. These settlements are distributed along three nearly parallel lines, in addition to the existence of a settlement belt at the southern section of the Governorate. The settlement of Kiryat Arba and its

Northern neighborhood, Kharsina (Ramat Mamre), are the largest settlements in the Governorate with a total population of 7000 extremist settlers. As for the Israeli settlers' population in the Governorate of Hebron, it is estimated at 15,000. Most of the Israeli settlements in Hebron have been established during the early eighties except for the settlement of Kiryat Arba, which was established in 1968. The rest of the settlements were established after the right wing Likud party came to power in 1977. [1]

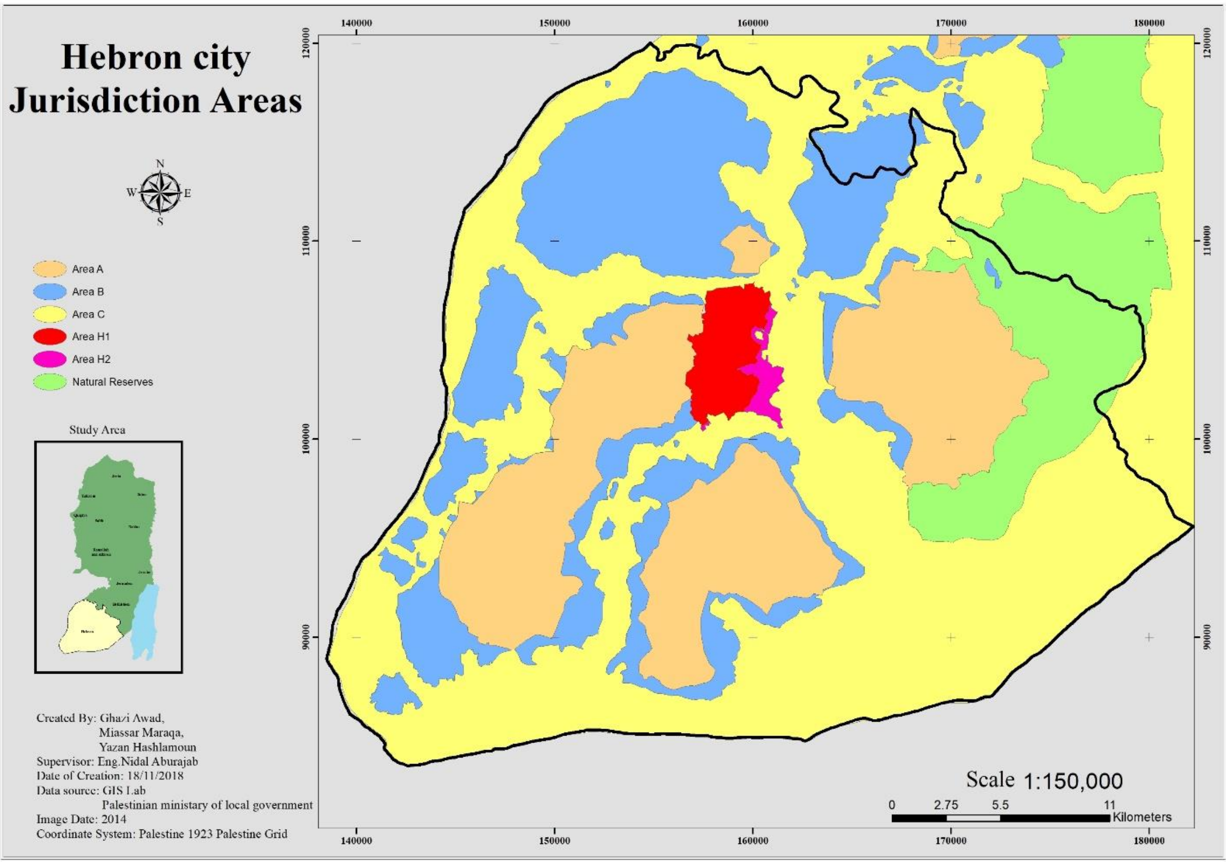


Figure 1-3 Jurisdiction Areas at Hebron District

1.4 Timetable

Tasks \ Weeks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
First semester																
Project Selection																
Define the problem																
Review																
Data collection																
Office work																
Prepare the initial version																
Prepare the final version																
Second semester																
Data preparation																
Data analysis																
Results extraction																
Preparing suggested plans																
Prepare the initial version																
Prepare the final version																

Table 1-1 Timetable shows the tasks and their endurance

1.5 Literature review

The first study is called "GIS as a Tool for Route Location and Highway Alignment" This study was done by Emad Basheer Salameh Dawwas Under supervision of Prof. Sameer A. Abu Eisheh at An-Najah National University in the year 2005.

The importance of this study comes from the use of a developed GIS model in highway alignment preliminary selection, analysis, evaluation, and final selection. The developed GIS model and its different extensions, especially 3D Analyst, have many of advantages in highway alignment selection field. [3]

The second study is called "National Highway Alignment Using GIS", and it is a scientific paper that was published by T.Subramani and S.Nanda Kumar, that was published at the International Journal of Engineering Research and Applications as the second volume and the fourth issue at July to August of 2002.

In this project the shortest and the economical path is identified using GIS software. The factors considered are mainly related to the land use, geology, land value and soil. The weights and ranks are assigned to each of the above themes, according to expert opinions, for GIS analysis. After a signing weights and ranks these themes are overlaid to get an overlaid map. The final overlaid map has the most suitable area to align the highway The first step in producing high quality alignments depends on obtaining suitable data on geology, land use, slope, soil and drainage. In addition, there are issues such as land value and ownership, social and economic impact, and identifying environmentally sensitive areas. [4]

The third is called “Roads Network for " Yatta City"”, and this study talks about using network analyst on ArcGIS software to use the results in Planning and build services in Yatta city and planning travel paths between city services centers such as hospitals, emergency , police stations. It is titled 'yatta city' and Mo’aath AbuE’ram, Rafaj Ijbor and Mohammad AbuSabha prepared and was supervised by Dr.Ghadi Zakarneh. [5]

The final study is called “Spatial multi-criteria decision analysis for safe school site selection”, and it is a scientific paper that was wrote by Zubaidah Bukhari, that was written at the university Putra at Malaysia at June 2010.

This research starts from Identification of criteria and data collection by reviewing, investigation and comparison of guidelines used by other countries to find a complete and reliable list of criteria for school site selection focusing on safe location. [6]

1.6 Methodology

In order to accomplish the objectives of this project the methodology was divided into three levels:

Level one: Choosing the project, defining what is the problem and literature survey.

Level two: Collecting data and information from field survey, satellite images and municipality like shapefiles, the main facilities, orthophoto of Hebron district.

Level three: It's about analyzing the data using GIS like finding the shortest road, best places for schools and dumping sites also making a visualization of settlements and military areas impacts on the district.

1.7 Scope

This project consists of seven chapters as follows:

The first chapter is “Introduction” which gives an introduction and defines the problem in a specified study area after making literature survey for previous studies with a timetable, scope and methodology.

The second chapter is “Geographic information system”; this chapter includes a brief introduction to the geographic information system and its basics.

The third chapter is “Remote Sensing”; this chapter talks about the remote sensing by giving it an introduction and explaining its basics and work.

The fourth chapter is “Sustainable planning using GIS and RS” this chapter talks about the various methods data processing and analysis that were used in this project and how to connect between GIS and RS.

The fifth chapter is “Analysis and Results”; this chapter includes the detailed results of the many analysis tasks that were done in this project.

The sixth chapter is “Suggested plans”; this chapter shows the plans that came as a result of this project.

The seventh chapter is “Suggestions and Recommendation”; this chapter includes a set of suggestions and recommendations that resulted from this project.

2. Geographic Information System

2.1 Introduction to GIS

2.2 GIS definition and applications

2.3 GIS data models

2.4 GIS and spatial analysis

2.5 Using GIS in network analysis

2.1 Introduction to GIS

Through time, the world got through a huge development, and grew dependent on computers and computerized information so that so any action or activity can be monitored and recorded which made life go faster and easier. Due to that, the society developed a complex system of processing and representing data, these systems grew by representing the data using binary methods as in representing it in ones and zeros, using this system many types of data was represented like: numbers, letters, sounds, images, and even the content of a map in the simple, universal form. This computerized system worked out in a big way, due to its ability to store the information and easily share it and move it using many methods from floppy discs to CD-ROMs to the internet…etc., this system also got special because of its ability to process a wide range of information types in a generalized way. [7]

One of the newly developed systems to represent geographical information is the Geographical information system “GIS”, it was developed in the last 50 years or so, GIS technology represents a million dollar industry worldwide, as a new way to approach global problems. [7]

2.2 GIS definition and applications

The term geographical information system is now used to describe any computer based system that has the capability to capture, store, manipulate, analyze, manage, and present spatial or geographic data. Other than the software and hardware parts of the GIS system it includes special devices used to input maps to create map products, together with the communication system used to link various elements. The gather of these elements together gives the following functions:

- Acquisition and verification
- Compilation
- Storage
- Updating and changing
- Management and exchange
- Manipulation
- Retrieval and presentation
- Analysis and combination

These actions and operations are applied by the GIS to the geographical data to form its database. [7]

All of the data in the GIS are georeferenced, as in linked to a specific location on the surface of the earth by a coordinate system. One of the most common coordinate system is the that of longitude and latitude, in this system the locations are expressed as angles from the equator and the line of zero longitude through Greenwich. In addition, there are many other systems other than that, and any GIS system should be able to include them and transform between them. [7]

Geographical information system attaches a variety of qualities and characteristics to a geographical location. These qualities may be physical parameters such as ground elevation, soil moisture level, or atmospheric temperature, as well as classification according to the type of vegetation, ownership of land, and zoning. These qualities often are referred to as attributes and it is a basic element of the geographic information system. [7]

All of that, proves that the geographic information system is nothing less than a sea of applications, some of them are: [8]

- Crime mapping
- Economic development and investment promotion
- Historical geographic information systems
- Hydrology
- Remote sensing applications
- Road networking
- Wastewater and storm water systems
- Waste management
- Disaster Management
- Civic Planning
- Health / Medical Resource Management

2.2.1 System components

GIS have five primary components, namely: - [9]

• **People**: GIS technology is of limited value without the people who manage the system and develop plans for applying it to real-world problems. GIS users range from technical specialists who design and maintain the system to those who use it to help them perform their everyday work. GIS people can be divided into these categories: [9]

The system users: those who will use the GIS to solve spatial problems - are most often people who are well trained in GIS, perhaps in a specific GIS. [9]

System operators: are responsible for the day-to-day operations of the system, more often performing tasks that allow the system users to function efficiently. [9]

GIS suppliers: are responsible for providing software support and updates of the software as new and improved methods are put into the system the data supplier could be either private or public. [9]

Application developers: are generally trained programmers who will provide user interface to reduce the reliance on specialized GIS professionals to perform common tasks. In many cases, the programming is done in macro languages provided by the GIS supplier to support applications. [9]

GIS systems analysts: are group of people specialize in the study of systems design. [9]

• **Data**: which may be of type spatial, temporal, or attribute; The every GIS system should be able to absorb data in a variety of formats, not just in the native format of the particular GIS. For example, an outline map may be available as an AutoCAD DXF format file. The GIS should at a minimum be capable of absorbing the DXF file without further modification. Similarly, attributes may already be stored in DBF format, and should be absorbable either directly or through the generic ASCII format. Support for data formats is important to a GIS when data are to be brought in from outside (e.g. public-domain data from the Internet). Ideally, the GIS software should be able to read common data formats for both raster (DEM,GIFF,TIFF,JPEG,EPS) and Vector (TIGER,HPGL,DXF,Postscript,DLG). Some GIS packages have import functions only into a single data structure, usually either an entity-by-entity structure or a topological structure. [9]

• **Software**: that perform various data storage, retrieval, analysis, reporting, and communication functions; Data Management Database management system (DBMS) allows data entry, data editing and supports tabular or other list types of output, sometimes independent of the GIS. Data Retrieval, Analysis and Display another major area of GIS functionality is that of data retrieval. GIS supports the retrieval of features by both their attributes and their spatial characteristics. Thematic mapping Area features are classified according to their attributes. A legend acts as a look-up table with each range of attribute values being associated with a particular color or shading pattern - e.g. Shading enumeration districts according to population density. [9]

• **Methods**: A successful GIS operates according to a well-designed plan and business rules, which are the models and operating practices unique to each organization. [9]

• **Hardware**: Hardware is the computer on which a GIS operates. Today, GIS software runs on a wide range of hardware types, from centralized computer servers to desktop computers used in stand-alone or networked configurations. [9]

Figure 2-1 GIS Components *[9]*

2.3 GIS Data models

In geographic information systems the data model is a mathematical construct for representing geographic objects or surfaces as data, some of these data models are:

2.3.1 Vector data model

First, the vector data model was defined by ESRI as "A coordinate-based data model that represents geographic features as points, lines, and polygons. Each point feature is represented as a single coordinate pair, while line and polygon features are represented as ordered lists of vertices. Attributes are associated with each vector feature, as opposed to a raster data model, which associates attributes with grid cells." [10]

From that, we can conclude that Vector storage implies the use of vectors (directional lines) to represent a geographic feature. Vector data is characterized by the use of sequential points or vertices to define a linear segment. Each vertex consists of an X coordinate and a Y coordinate.

Vector lines are often referred to as arcs and consist of a string of vertices terminated by a node. A node is defined as a vertex that starts or ends an arc segment. Point features are defined by one coordinate pair, a vertex. Polygonal features are defined by a set of closed coordinate pairs. In vector representation, the storage of the vertices for each feature is important, as well as the connectivity between features, e.g. the sharing of common vertices where features connect. Several different vector data models exist, however only two are commonly used in GIS data storage. [9]

The most popular method of retaining spatial relationships among features is to explicitly record adjacency information in what is known as the topologic data model. Topology is a mathematical concept that has its basis in the principles of feature adjacency and connectivity.

The topologic data structure is often referred to as an intelligent data structure because spatial relationships between geographic features are easily derived when using them. Primarily for this reason the topologic model is the dominant vector data structure currently used in GIS technology. Many of the complex data analysis functions cannot effectively be undertaken without a topologic vector data structure. [9]

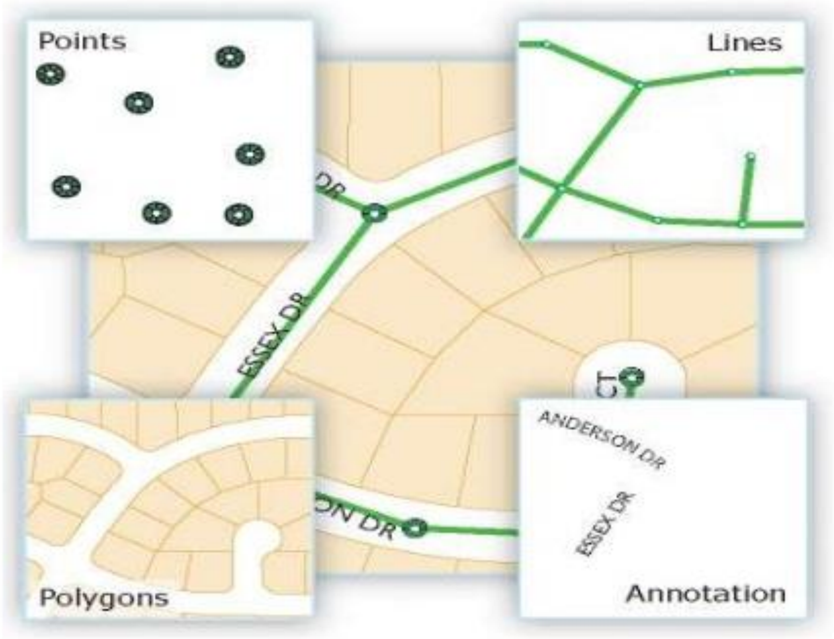


Figure 2-2 Vector data model *[10]*

2.3.2 Raster data model

Raster data in its simplest form, is a set of cells (or pixels) organized into rows and columns (or a grid) where each cell contains a value representing information, such as temperature. Rasters are digital aerial photographs, imagery from satellites, digital pictures, or even scanned maps. [10]

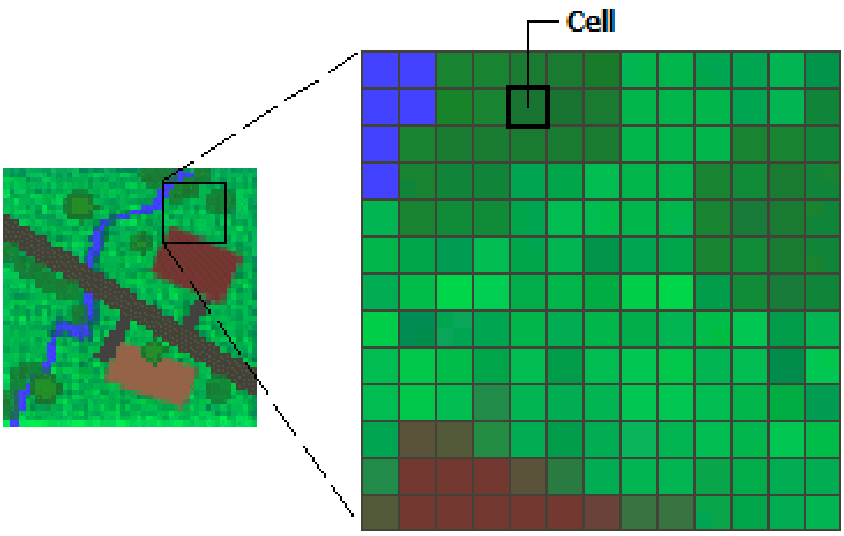


Figure 2-3 Raster data representation *[10]*

In raster datasets, each cell has a value. The cell values represent the phenomenon portrayed by the raster dataset such as a category, magnitude, height, or spectral value. The category could be a land-use class such as grassland, forest, or road. A magnitude might represent gravity, noise pollution, or percent rainfall. Height (distance) could represent surface elevation above mean sea level, which can be used to derive slope, aspect, and watershed properties. Spectral values are used in satellite imagery and aerial photography to represent light reflectance and color. [10]

Cell values can be either positive or negative, integer, or floating point. Integer values are best used to represent categorical (discrete) data and floating-point values to represent continuous surfaces. Cells can also have a No Data value to represent the absence of data. [10]

80	74	62	45	45	34	39	56
80	74	74	62	45	34	39	56
74	74	62	62	45	34	39	39
62	62	45	45	34	34	34	39
45	45	45	34	34	30	34	39

Figure 2-4 Cell values *[10]*

Each pixel in the raster represents a certain area on the surface, and has a certain width and height, this area, width, and height is equal to all the cells representing the raster. For example, a raster representing elevation (that is, digital elevation model) may cover an area of 100 square kilometers. If there were 100 cells in this raster, each cell would represent 1 square kilometer of equal width and height (that is, 1 km x 1 km). [10]

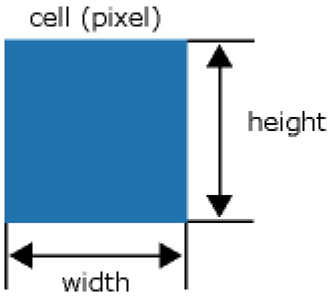


Figure 2-5 Pixel area and representation *[10]*

The location of each cell is defined by the row or column where it is located within the raster matrix. The matrix is represented by a Cartesian coordinate system, in which the rows of the matrix are parallel to the x-axis and the columns to the y-axis of the Cartesian plane. [10]

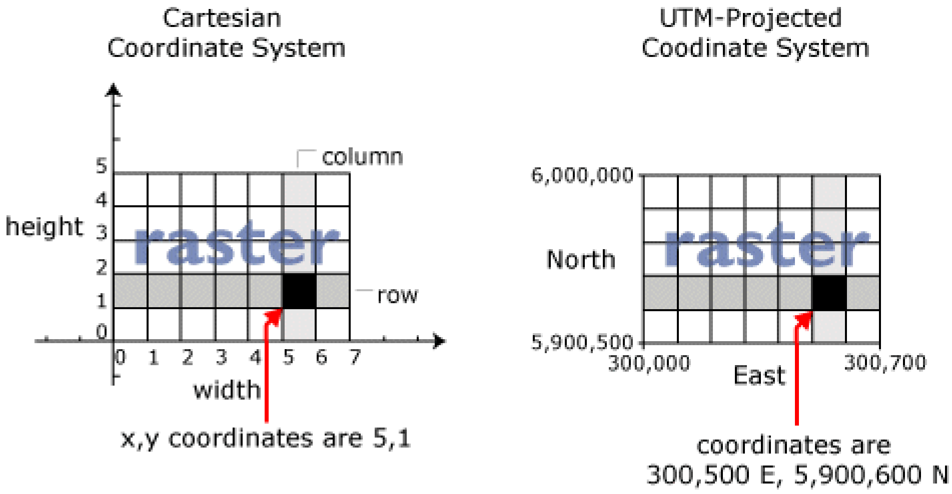


Figure 2-6 Pixel Location *[10]*

Often you need to specify the extent of a raster. The extent is defined by the top, bottom, left, and right coordinates of the rectangular area covered by a raster, as shown below.

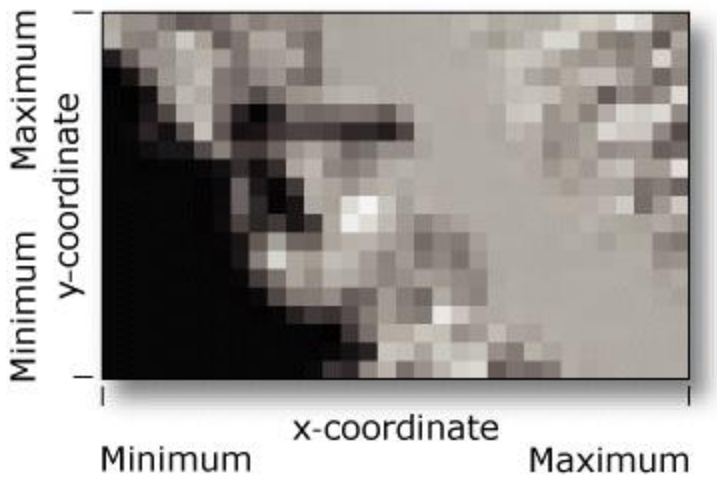


Figure 2-7 Raster extent *[10]*

While the structure of raster data is simple, it is exceptionally useful for a wide range of applications. Within a GIS, the uses of raster data fall under four main categories:

- Rasters as basemaps

A common use of raster data in a GIS is as a background display for other feature layers. For example, orthophotos displayed underneath other layers provide the map user with confidence that map layers aligned and represent real features or objects, as well as additional information. Three main sources of raster basemaps are orthophotos from aerial photography, satellite imagery, and scanned maps. [10]

Figure 2-8 Raster as a base map *[10]*

- Rasters as surface maps

Rasters are well suited for representing data that changes continuously across the surface of the study area. They also provide a regularly spaced representation of surfaces. Elevation values measured from the earth's surface are the most common application of surface maps, but other values, such as rainfall, temperature, concentration, and population density, can define surfaces that can be spatially analyzed. [10]

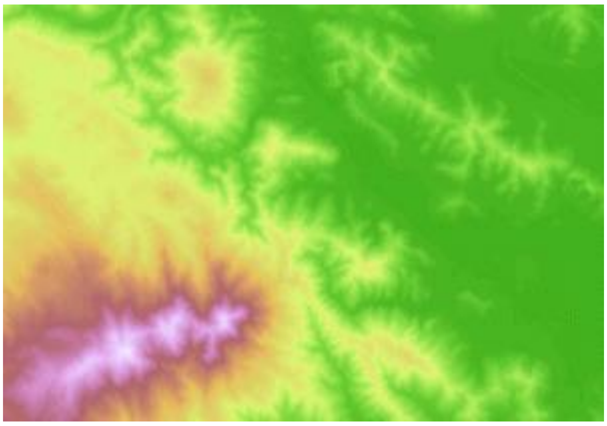


Figure 2-9 Raster as a Surface map *[10]*

- Rasters as thematic maps

Rasters representing thematic data can be derived from analyzing other data. A common analysis application is classifying a satellite image by land-cover categories. This activity groups the values of multispectral data into classes and assigns a categorical value. Thematic maps can also result from geoprocessing operations that combine data from various sources, such as vector, raster, and terrain data. For example, you can process data through a geoprocessing model to create a raster dataset that maps suitability for a specific activity. [10]

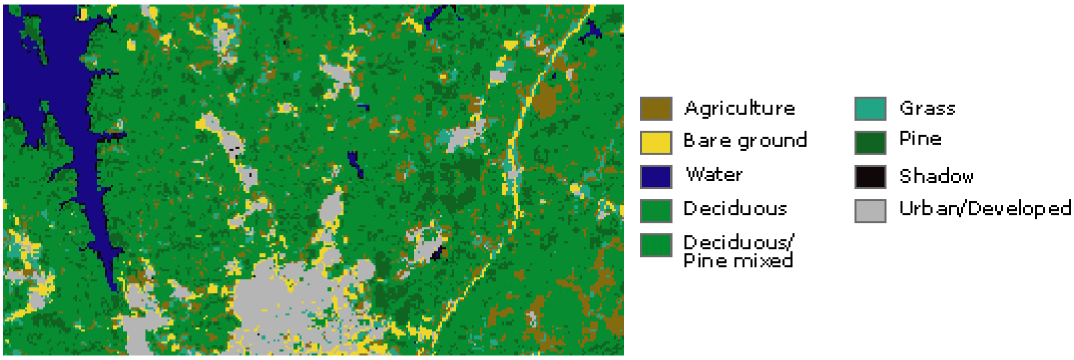


Figure 2-10 Raster as a thematic map *[10]*

- Rasters as attributes of a feature

Rasters used as attributes of a feature may be digital photographs, scanned documents, or scanned drawings related to a geographic object or location. A parcel layer may have scanned legal documents identifying the latest transaction for that parcel, or a layer representing cave openings may have pictures of the actual cave openings associated with the point features. [10]

2.3.3 Attribute data model

In most of the geographic information systems the attributes are represented as a tabular data, where the rows are called records and the columns are called fields, they intersect to form cells, which the data can be stored and represented in. These attributes can be attached to a geographical location in many ways; the simplest one is to attach it to a point with a certain coordinates, but it can also be attached to a more complex features either lines or areas. In such case the GIS must store the entire mapped shape of the feature rather than a simple coordinate location. Examples of commonly mapped features are lakes, cities, countries, rivers, and streets each with its set of useful attributes. [7]

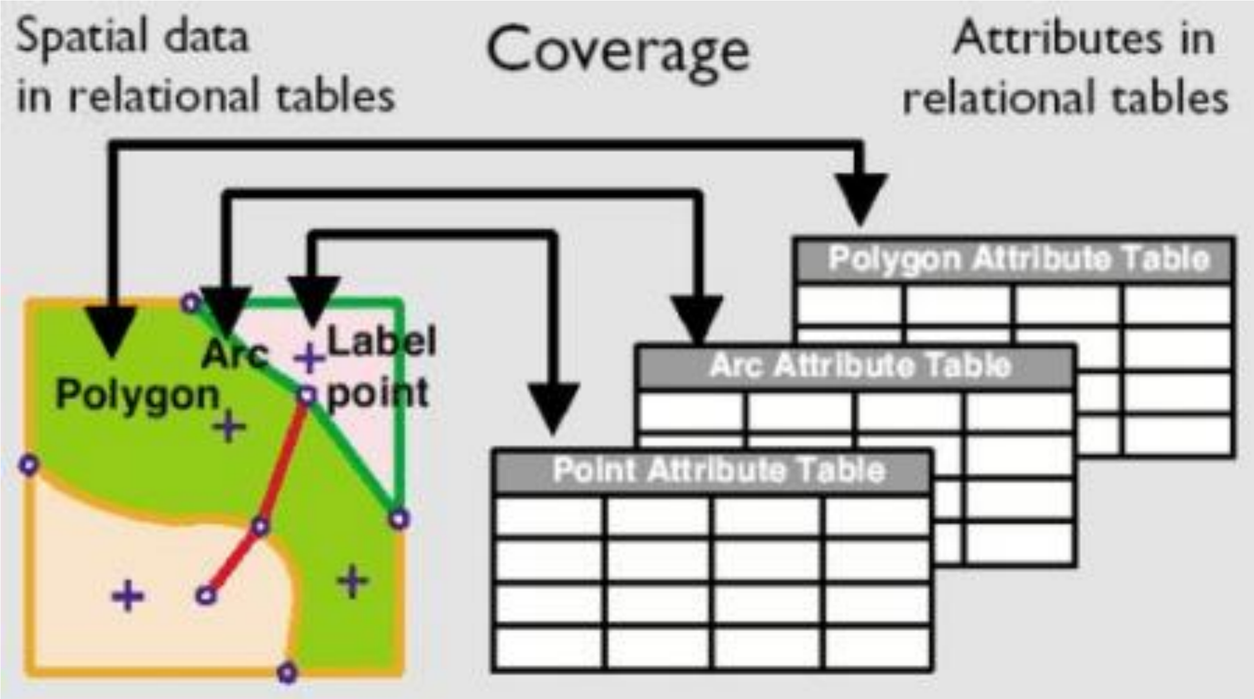


Figure 2-11 Attributes attachment to various types of geographic data *[7]*

2.4 GIS and spatial analysis

The real world can be represented as discrete data, stored by its exact geographic location, or continuous data represented by regular grids. The natural environment (elevation, temperature, precipitation) is often represented using raster grids, whereas the built environment (roads, buildings) and administrative data (countries, census areas) tends to be represented as vector data. Further information that describes what is at each location can be attached; this information is often referred to as "attributes." [10]

In GIS each dataset is managed as a layer and can be graphically combined using analytical operators. By combining layers using operators and displays, GIS enables the user to work with these layers to explore critically important questions and find answers to those questions. [10]

In addition to locational and attribute information, spatial data inherently contains geometric and topological properties. Geometric properties include position and measurements, such as length, direction, area, and volume. Topological properties represent spatial relationships such as connectivity, inclusion, and adjacency. Using these spatial properties, you can ask even more types of questions of your data to gain deeper insights. [10]

2.4.1 Spatial Analysis definition

The true power of GIS lies in the ability to perform analysis. Spatial analysis is a process in which you model problems geographically, derive results by computer processing, and then explore and examine those results. This type of analysis has proven to be highly effective for evaluating the geographic suitability of certain locations for specific purposes, estimating and predicting outcomes, interpreting and understanding change, detecting important patterns hidden in your information, and much more. [10]

The ultimate goal is to learn how to solve problems spatially. Several fundamental spatial analysis workflows form the heart of spatial analysis: spatial data exploration, modeling with GIS tools, and spatial problem solving. [10]

2.4.2 Spatial analysis tools

The ArcGIS Spatial Analyst extension provides a rich set of spatial analysis and modeling tools for both raster (cell-based) and feature (vector) data.

The capabilities of Spatial Analyst are broken down into categories or groups of related functionality. Knowing the categories will help you identify which particular tool to use. The table at the end of this section lists all the available toolsets with a description of the capabilities offered by the tools in each.

There are several ways to access Spatial Analyst functionality. With geoprocessing, operations in the Spatial Analyst toolbox can be performed through a Tool dialog box, Python (either at an interactive command line interface or with a script), or a Model. Traditional operations and workflows using Map Algebra can also be performed in the Python environment. There is also a Raster Calculator available for entering simple Map Algebra expressions that generate an output raster. [10]

Toolset	Description
Conditional	The Conditional tools allow you to control the output values based on the conditions placed on the input values. The conditions that can be applied are of two types, those being either queries on the attributes or a condition based on the position of the conditional statement in a list.
Density	With the Density tools, you can calculate the density of input features within a neighborhood around each output raster cell.
Distance	The Distance tools allow you to perform distance analysis in the following ways: • Euclidean (straight-line) distance • Cost-weighted distance • Cost-weighted distance allowing for vertical and horizontal restrictions to movement • Paths and corridors between sources with the least cost of travel
Extraction	The Extraction tools allow you to extract a subset of cells from a raster by either the cells' attributes or their spatial location. You can also obtain the cell values for specific locations as an attribute in a point feature class or as a table.

Generalization	The generalization analysis tools are used to either clean up small erroneous data in the raster or generalize the data to get rid of unnecessary detail for a more general analysis.
Groundwater	The Groundwater tools can be used to perform rudimentary advection-dispersion modeling of constituents in groundwater flow. The following topics provide background information on the theoretical aspects of the tools as well as some examples of their implementation. The Groundwater tools can be applied individually or used in sequence to model and analyze groundwater flow.
Hydrology	The Hydrology tools are used to model the flow of water across a surface. The Hydrology tools can be applied individually or used in sequence to create a stream network or delineate watersheds.
Interpolation	Surface interpolation tools create a continuous (or prediction) surface from sampled point values. The continuous surface representation of a raster dataset represents some measure, such as the height, concentration, or magnitude (for example, elevation, acidity, or noise level). Surface interpolation tools make predictions from sample measurements for all locations in an output raster dataset, whether or not a measurement has been taken at the location.
Local	The local tools are those where the value at each cell location on the output raster is a function of the values from all the inputs at that location. With the local tools, you can combine the input rasters, calculate a statistic on them, or evaluate a criterion for each cell on the output raster based on the values of each cell from multiple input rasters.
Map Algebra	Map Algebra is a way to perform spatial analysis by creating expressions in an algebraic language. With the Raster Calculator tool, you can easily create and run Map Algebra expressions that output a raster dataset.
Math (general)	The general Math tools apply a mathematical function to the input. These tools fall into several categories. The arithmetic tools perform basic mathematical operations, such as addition and multiplication. There are

	tools that perform various types of exponentiation operations, which includes exponentials and logarithms in addition to the basic power operations. The remaining tools are used either for sign conversion or for conversion between integer and floating point data types.
Math Bitwise	The bitwise math tools compute on the binary representation of the input values.
Math Logical	The Logical Math tools evaluate the values of the inputs and determine the output values based on Boolean logic. The tools are grouped into four main categories: Boolean, Combinatorial, Logical, and Relational.
Math Trigonometric	Trigonometric Math tools perform various trigonometric calculations on the values in an input raster.
Multivariate	Multivariate statistical analysis allows the exploration of relationships among many different types of attributes. There are two types of multivariate analysis available: Classification (both Supervised and Unsupervised) and Principal Component Analysis (PCA).
Neighborhood	Neighborhood tools create output values for each cell location based on the location value and the values identified in a specified neighborhood. The neighborhood can be of two types: moving or search radius.
Overlay	Overlay analysis tools allow you to apply weights to several inputs and combine them into a single output. The most common application for Overlay tools is suitability modeling.
Raster Creation	The Raster Creation tools generate new rasters in which the output values are based on a constant or a statistical distribution.
Reclass	The Reclass tools provide a variety of methods that allow you to reclassify or change input cell values to alternative values.
Solar Radiation	The solar radiation analysis tools enable you to map and analyze the effects of the sun over a geographic area for specific time periods.
Segmentation and Classification	With the Segmentation and Classification tools, you can prepare segmented rasters to use in creating classified raster datasets.
Surface	With the Surface tools, you can quantify and visualize a terrain landform represented by a digital elevation model.
Zonal	The Zonal tools allow you to perform analysis where the output is a result of computations performed on all cells that belong to each input zone. A

	zone can be defined as being one single area of a particular value, but it can also be composed of multiple disconnected elements, or regions, all having the same value. Zones can be defined by raster or feature datasets. Rasters must be of integer type, and features must have an integer or string attribute field.

Table 2-1 Spatial analysis toolset *[10]*

2.5 Using GIS in network analysis

2.5.1 Introduction

Network analysis is a special type of line analysis involving a set of interconnected lines. Typical networks include themes such as roads, streams, hiking trails, and pipelines. Network Analysis can be used to answer at least four types of questions: [5]

1. Address Geocoding. Address geocoding is the process of taking addresses and estimating their locations in your GIS coordinate system. This is done by relating an house address on a GIS street view for delivery of some product, generating driving directions to a given address, or displaying customer locations in a GIS view from a list of customer addresses. Address Geocoding is not not available in Palestine. [5]

2. Optimal Routing. Optimal routing is the process of delineating the best route to get from one location to one or more locations. The “best route” could be the shortest, the quickest, or the most esthetic, depending on the GIS user's preference for defining "best". [5]

3. Finding Closest Facilities. This is a special type of optimal routing problem where you are trying to find the closet points to a given location. Typically the points are called facilities and the given location is called an event location. [5]

4. Resource Allocation. Resource allocation is the allocation of the resources from supply centers to customers on a network. [5]

2.5.2 Optimal Routing

Optimal routing is the process of delineating the best route (or path) to get from one location to one or more locations. It is not usually feasible to test all possible paths that exist in a network. Instead, a path finding algorithm is used.

The optimal routing works as follows:

Step 1: Building two tables, one of nodes that have already been processed, and one of adjacent nodes to process.

Step 2: Pick the adjacent node with the least cumulative cost and add it to the processed nodes list.

Step 3: Scan the nodes adjacent to your latest processed node, and add them to the Adjacent Nodes list.

Step 4: Repeat the last two steps until all nodes are in the processed node list.Once the nodes have been processed, all the optimal routes to a node from any node are solved. However, there may also be more than one optimal route that is not reflected in the analysis. [5]

3. Remote sensing

3.1 introduction

3.2 Electromagnetic Energy

3.3 Reflection and absorption

3.4 Sensors and platforms

3.5 Orbits and swaths

3.6 Satellite sensors characteristics

3.7 Data classification

3.8 Land use and land cover

3.1 Introduction

Remote sensing is the collection and interpretation of information about an object, area, or event without being in physical contact with the object. The most common platforms for applying the remote sensing to the earth and its natural resources are aircrafts and satellites. Aerial photography in the visible portion of the electromagnetic wavelength was the original form of remote sensing but technological developments has enabled the acquisition of information at other wavelengths including near infrared, thermal infrared and microwave. Collection of information over a large numbers of wavelength bands is referred to as multispectral or hyperspectral data. The development and deployment of manned and unmanned satellites has enhanced the collection of remotely sensed data and offers an inexpensive way to obtain information over large areas. The capacity of remote sensing to identify and monitor land surfaces and environmental conditions has expanded greatly over the last few years and remotely sensed data will be an essential tool in natural resource management. [11]

3.2 Electromagnetic energy

The electromagnetic spectrum is the continuous range of electromagnetic radiation, extending from gamma rays to radio waves and including visible light. The electromagnetic spectrum can be divided into seven different regions: gamma rays, X-rays, ultraviolet, visible light, infrared, microwaves and radio waves. [11]

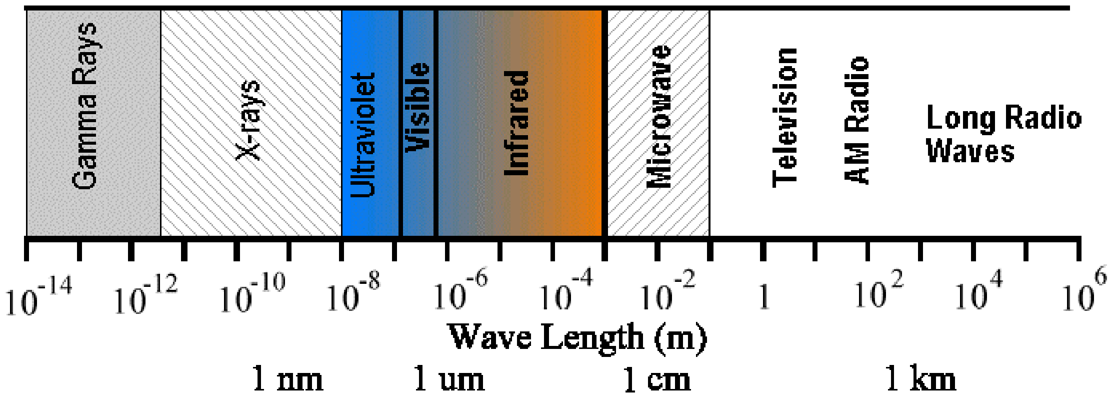


Figure 3-1 electromagnetic spectrum *[11]*

Remote sensing involves the measurement of energy in many parts of the electromagnetic spectrum. The major regions of interest in satellite sensing are visible light, reflected and emitted infrared, and the microwave regions. The measurement of this radiation takes place in what are known as spectral bands. A spectral band is defined as a discrete interval of the electromagnetic spectrum. For example the wavelength range of 0.4μm to 0.5μm is one spectral band. Satellite sensors have been designed to measure responses within particular spectral bands to enable the discrimination of the major Earth surface materials. Scientists will choose a particular spectral band for data collection depending on what they wish to examine. The design of satellite sensors is based on the absorption characteristics of Earth surface materials across all the measurable parts in the electromagnetic spectrum. [11]

3.3 Reflection and absorption

When radiation from the Sun reaches the surface of the Earth, some of the energy at specific wavelengths is absorbed and the rest of the energy is reflected by the surface material. In the visible region of the electromagnetic spectrum, the feature we describe as the color of the object is the visible light that is not absorbed by that object. In the case of a green leaf, for example, the leaf absorbs the blue and red wavelengths, while the green wavelength is reflected and detected by our eyes. [11]

In remote sensing, a detector measures the electromagnetic radiation that is reflected back from the Earth's surface materials. These measurements can help to distinguish the type of land covering. Soil, water and vegetation have clearly different patterns of reflectance and absorption over different wavelengths. [11]

The reflectance of radiation from one type of surface material, such as soil, varies over the range of wavelengths in the EM spectrum. This is known as the spectral signature of the material. All Earth surface features, including minerals, vegetation, dry soil, water, and snow, have unique spectral reflectance signatures. [11]

3.4 Sensors and platforms

A sensor is a device that measures and records electromagnetic energy. Sensors can be divided into two groups: Passive sensors, which depends on an external source of energy, usually the sun, and Active sensors, which have their own source of energy, an example would be a radar gun. These sensors send out a signal and measure the amount reflected back. Active sensors are more controlled because they do not depend upon varying illumination conditions. [11]

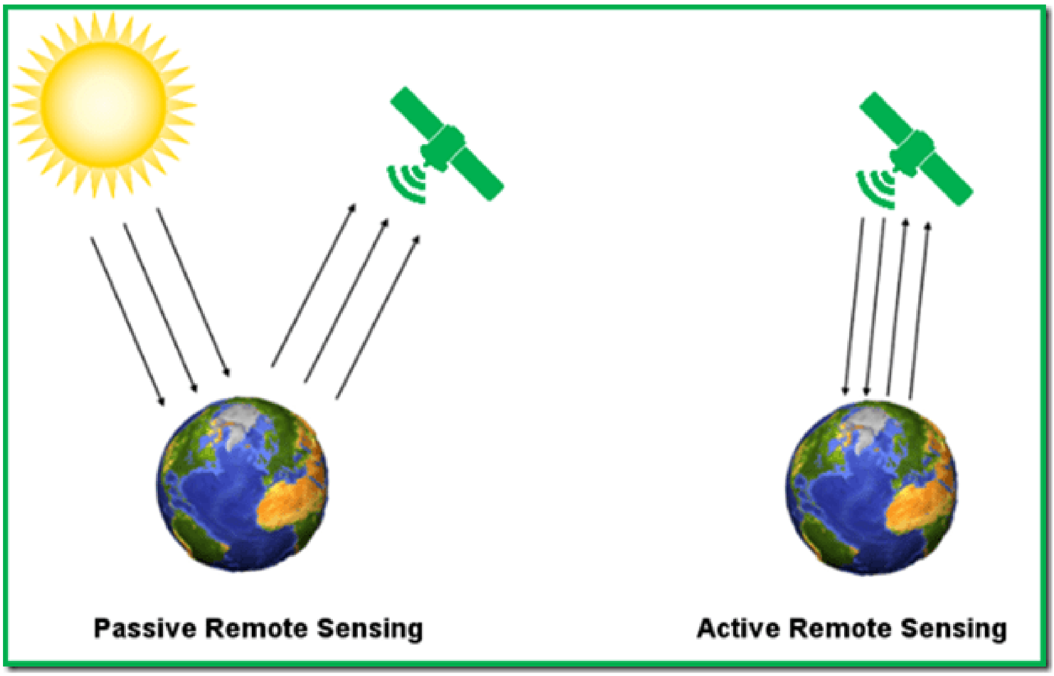


Figure 3-2 Passive and active sensors *[11]*

3.5 Orbits and swaths

The path followed by a satellite is referred to as its orbit. Satellites which view the same portion of the earth's surface at all times have geostationary orbits. Weather and communication satellites commonly have these types of orbits. Many satellites are designed to follow a near-polar orbit, which is a north south orbit, which, in conjunction with the earth's rotation, allows them to cover most of the earth's surface over a period of time. Many of these satellites orbits are also Sun-synchronous such that they cover each area of the world at a constant local time of day. Near polar orbits also means that the satellite travels northward on one side of the earth and the southward on the second half of its orbit. These are called Ascending and Descending passes. [11]

As a satellite revolves around the earth, the sensor sees a certain portion of the earth's surface. The area imaged is referred to as the Swath. The surface directly below the satellite is called the Nadir point. Steerable sensors on satellites can view an area (off nadir) before and after the orbits passes over a target. [11]

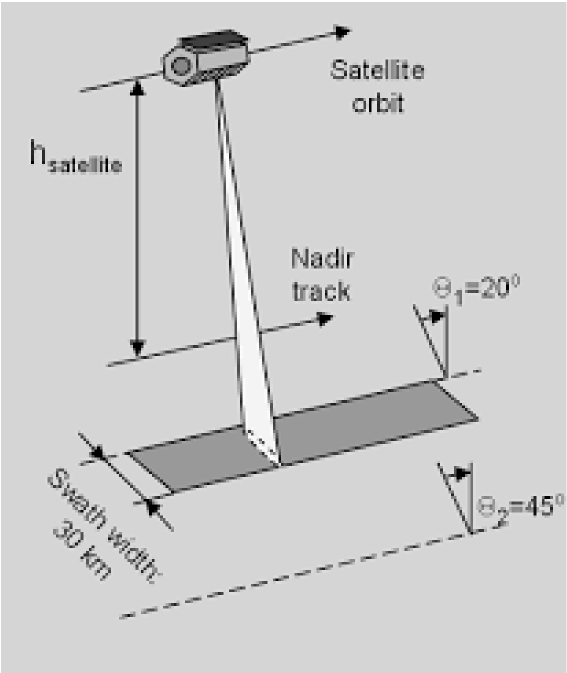


Figure 3-3 Satellite orbit and swath *[12]*

3.6 Satellite sensor characteristics

The basic functions of most satellite sensors is to collect information about the reflected radiation along a pathway, also known as the field of view (FOV), as the satellite orbits the Earth. The smallest area of ground that is sampled is called the instantaneous field of view (IFOV). The IFOV is also described as the pixel size of the sensor. This sampling or measurement occurs in one or many spectral bands of the EM spectrum. [11]

The data collected by each satellite sensor can be described in terms of spatial, spectral and temporal resolution. [11]

3.6.1 Spatial resolution

The spatial resolution is the ground area imaged for the instantaneous field of view (IFOV) of the sensing device. Spatial resolution may also be described as the ground surface area that forms one pixel in the satellite image. The IFOV or ground resolution of the Landsat Thematic Mapper (TM) sensor, for example, is 30 m. The ground resolution of weather satellite sensors is often larger than a square kilometer. There are satellites that collect data at less than one meter ground resolution but these are classified military satellites or very expensive commercial systems. [11]

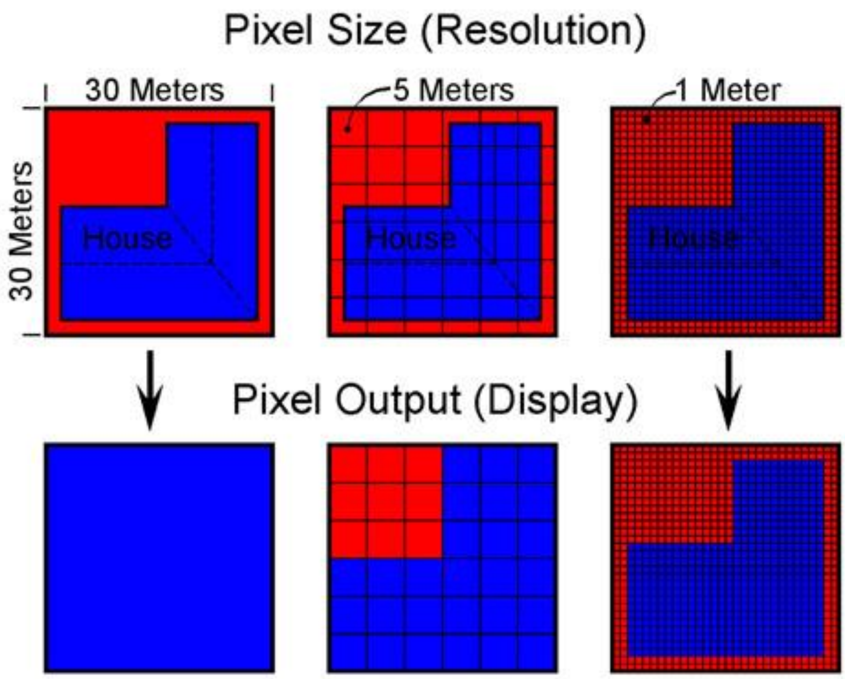


Figure 3-4 Spatial resolution *[13]*

3.6.2 Temporal resolution

Temporal resolution is a measure of the repeat cycle or frequency with which a sensor revisits the same part of the Earth's surface. The frequency will vary from several times per day, for a typical weather satellite, to eight to twenty times a year for a moderate ground resolution satellite, such as Landsat TM. The frequency characteristics will be determined by the design of the satellite sensor and its orbit pattern. [11]

3.6.3 Spectral resolution

The spectral resolution of a sensor system is the number and width of spectral bands in the sensing device. The simplest form of spectral resolution is a sensor with one band only, which senses visible light. An image from this sensor would be similar in appearance to a black and white photograph from an aircraft. A sensor with three spectral bands in the visible region of the EM spectrum would collect similar information to that of the human vision system. The Landsat TM sensor has seven spectral bands located in the visible and near to mid infrared parts of the spectrum. [11]

A panchromatic image consists of only one band. It is usually displayed as a grey scale image, i.e. the displayed brightness of a particular pixel is proportional to the pixel digital number which is related to the intensity of solar radiation reflected by the targets in the pixel and detected by the detector. Thus, a panchromatic image may be similarly interpreted as a black-and-white aerial photograph of the area, though at a lower resolution. [11]

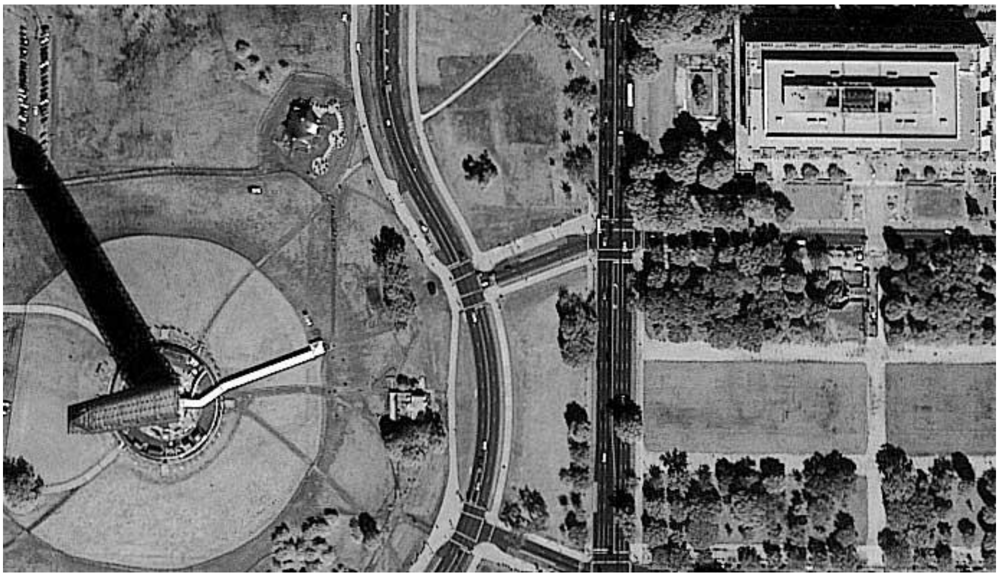


Figure 3-5 panchromatic image *[11]*

Multispectral and hyperspectral images consists of several bands of data. For visual display, each band of the image may be displayed one band at a time as a grey scale image, or in combination of three bands at a time as a color composite image. Interpretation of a multispectral color composite image will require the knowledge of the spectral reflectance signature of the targets in the scene. [11]

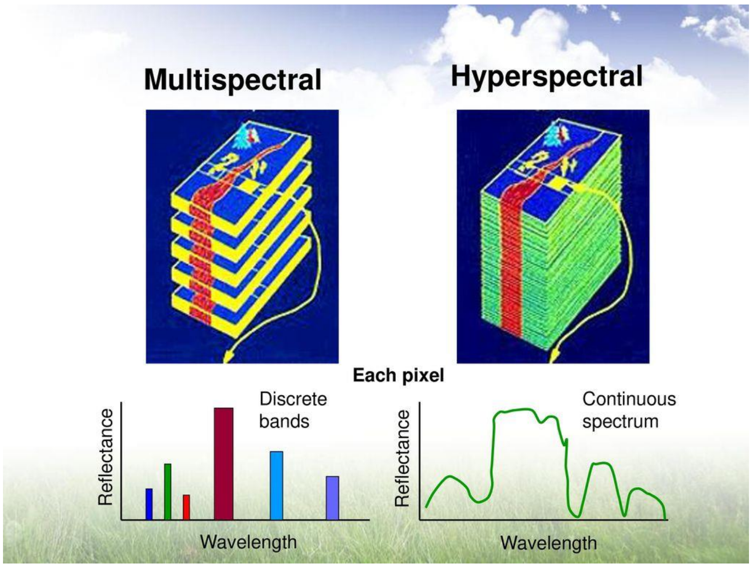


Figure 3-6 Multispectral and hyperspectral *[11]*

3.7 Data classification

Different landcover types in an image can be discriminated using some image classification algorithms using spectral features, i.e. the brightness and "color" information contained in each pixel. The classification procedures can be "supervised" or "unsupervised".

Using ENVI program classifying each pattern in the images.

The classification process as follows:

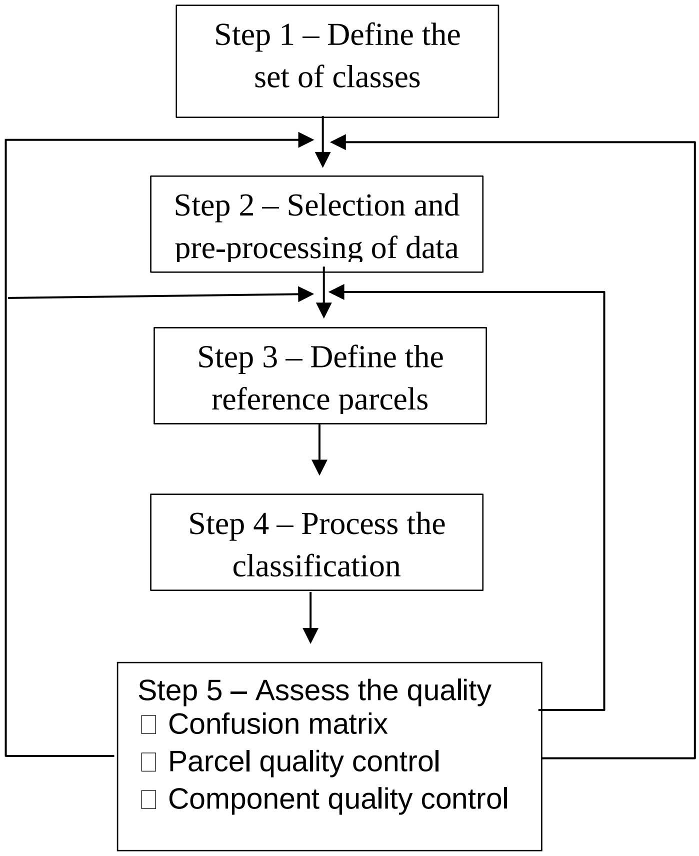


Figure 3-7 Classification Steps

Reference Parcels	Training and check parcels
Training parcels	Select areas within a scene that are representative of each class of interest, to be used in the training phase in the supervised classification [14]
Check parcels	Some fraction of the training parcels may be retained for later accuracy assessment, and are withheld from the training phase in order not to bias the subsequent evaluation [14]

With supervised classification, the analyst develops the spectral responses of known categories, such as urban, forest, water (training site development) and then the software assigns each pixel in the image to the cover type to which its spectral response is most similar. Then a raster data was produced for the land cover classification.

In this project, case CORINE level one classification was used in the training/check parcels.

Level 1	Level 2	Level3
1. Artificial surfaces	1.1.Urban fabric	1.1.1. Continuous urban fabric 1.1.2. Discontinuous urban fabric
	1.2.Industrial, commercial and transport units	1.2.1. Industrial or commercial units 1.2.2. Road and rail network and associated land 1.2.3. Port areas 1.2.4. Air ports
	1.3.Mine, dump and	1.3.1. Mineral extraction site 1.3.2. Dump sites

	construction sites	1.3.3. Construction sites
	1.4.Artificial, non-agricultural vegetation areas	1.4.1. Green urban areas 1.4.2. Sports and leisure facilities
2. Agricultural areas	2.1.Arable land	2.1.1. Non-irrigated arable lands 2.1.2. Permanently irrigated land 2.1.3. Rice fields
	2.2.Permanent corps	2.2.1. Vineyards 2.2.2. Fruit trees and berry plantation 2.2.3. Olive groves
	2.3.Pastures	2.3.1. Pastures
	2.4.Heterogeneous agricultural areas	2.4.1. Annual crops associated with permanent corps 2.4.2. Complex cultivation patterns 2.4.3. Land principally occupied by agriculture, with significant areas of natural vegetation 2.4.4. Agro-forestry areas
3. Forests and semi natural areas	3.1.Forests	3.1.1. Broad-leaved forest 3.1.2. Coniferous forest 3.1.3. Mixed forest
	3.2.Scrub and\or herbaceous vegetation association	3.2.1. Natural grasslands 3.2.2. Moors and heathlands 3.2.3. Sclerophyllous vegetation 3.2.4. Transitional woodland-shrub
	3.3.Open spaces with little or no vegetation	3.3.1. Beaches, duns sands 3.3.2. Bare rocks 3.3.3. Sparsely vegetation areas 3.3.4. Burnt areas 3.3.5. Glaciers and perpetual snow
4. Wetlands	4.1.Inland wetlands	4.1.1. Inland marshes 4.1.2. Peat bogs
	4.2.Maritime wetlands	4.2.1. Salt marshes 4.2.2. Salines 4.2.3. Intertidal flats
5. Waterbodies	5.1.Inland waters	5.1.1. Water courses 5.1.2. Water bodies
	5.2.Marine waters	5.2.1. Coastal lagoons 5.2.2. Estuaries 5.2.3. Sea and ocean

Table 3-1 CORINE Land Cover Classification *[15]*

3.7.1 Assess the quality

The most common tool used for the classification accuracy assessment is the confusion matrix (or error matrix). A confusion matrix is a square array of dimension pp, where p is the number of classes. The matrix shows the relationship between two samples of measurements taken from the area that has been classified. The first set represents training parcels or check parcels (both together reference parcels) that have been collected via field observation, inspection of agricultural records, air photo interpretation, or other similar means. The second sample composed of labels of the pixels, allocated by the classifier, that correspond to the training or checking parcels point. [14]

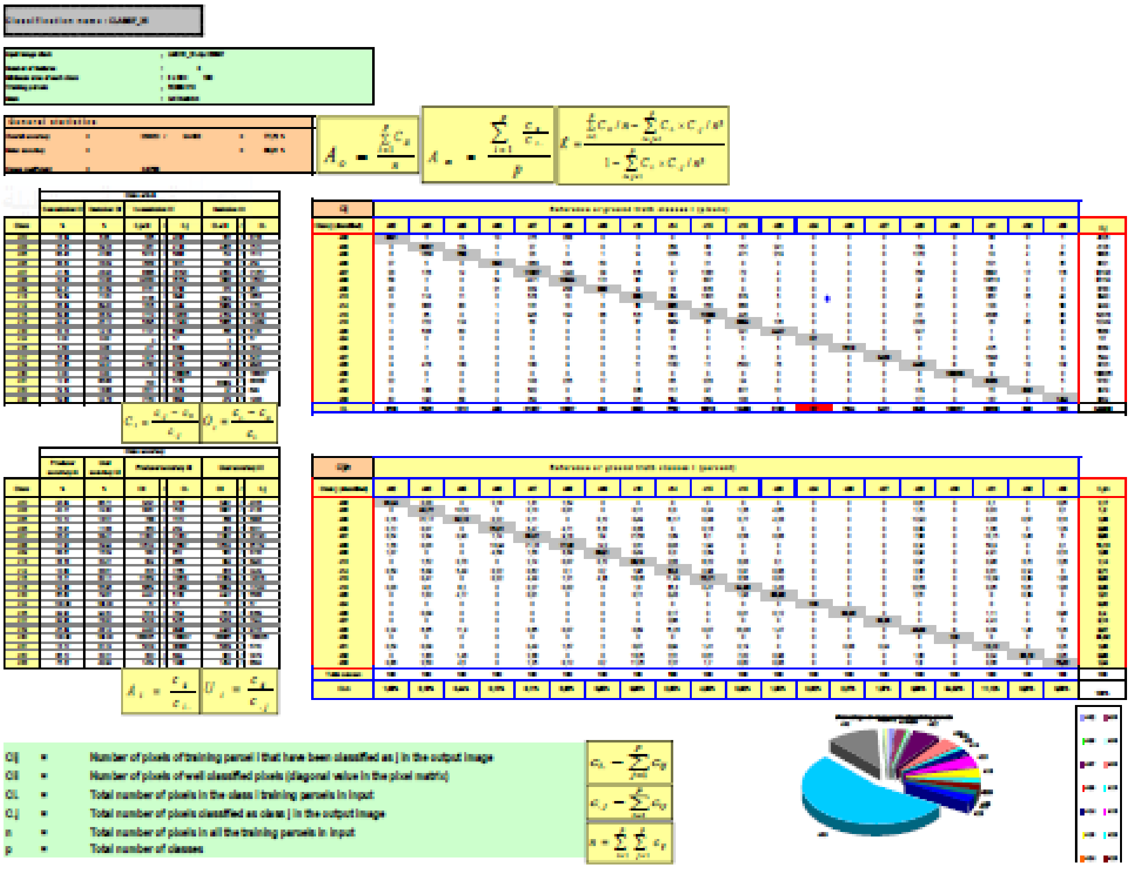


Figure 3-8 Confusion Matrix *[14]*

The core of the assessment the classification depends on the parameters derived from the confusion matrix, the derivation of the confusion matrix was through ENVI software.

3.7.2 Confusion matrix parameters

There reference parcels have to be divided upon certain criteria into training and check parcels, as a result a confusion matrix for training and another for check have to be derived. Those are the definitions of each term used in the equations.

Cij	Number of pixels of training parcels i that have been classified as j in the output image
Cii	Number of pixels of well classified pixels (diagonal value in the pixel matrix)
Ci.	Total number of pixels in the class i training parcels in input
C.j	Total number of pixels classified as class j in the output image
n	Total number of pixels in all training parcels in input
p	Total number of classes
Ci./n	Percentage of class i over all training parcels

Table 3-2 Confusion Matrix Parameters

Definition for the terms used in the equations where,

$$\text{Ci.} = \sum_{j=1}^{p} \text{Cij} \qquad 3.1$$

$$C.j = \sum_{i=1}^{p} Cij \quad 3.2$$

$$Ci. = \sum_{i=1}^{p} \quad \sum_{j=1}^{p} Cij \quad 3.3$$

Reference or ground truth classes i (pixels)

The Confusion matrix is calculated by comparing the location and class of each training parcel pixel with the corresponding location and class in the classification image. Each column of the confusion matrix represents a training parcel class and the values in the column correspond to the classification image's labelling of the training parcels pixels. [14]

Reference or ground truth classes i (percent)

The reference or ground truth classes i (percent) table shows the distribution in percent for each training parcel class. The values are calculated by dividing the pixel counts in each training parcel column by the total number of pixels in a given training parcel class. [14]

Minimum area of each class

As a rule of thumb that the number of training parcels to derive a valid confusion matrix should be at least 30 times the number of features (number of spectral bands). [14]

Overall Accuracy

The overall accuracy is calculated by summing the number of pixels classified correctly and dividing by the total number of pixels. The pixels classified correctly are found along the diagonal of the confusion matrix table, which lists the number of pixels that were classified into the correct training parcel class. The total number of pixels is the sum of all the pixels in all the training parcel classes. [14]

$$Ao = \frac{\sum_{i=1}^{p} Cii}{n} \quad 3.4$$

Kappa Coefficient

The kappa coefficient takes not just the principal diagonal entries but also the off-diagonal entries into consideration. The higher the value of kappa, the better the classification performance. If all information classes are correctly identified, kappa takes the value 1. As the values of off-diagonal entries increase, the value of kappa decreases.

It is calculated by dividing the total sum of the confusion matrix diagonals on total number of pixels in all the training parcels in input (n), subtracting from the sum of total number of pixels in the class i training parcels in input multiply by total number of pixels classified as class j in the output image, and dividing by the total number of pixels in all the training parcels squared. The previous terms divided on one subtracting from the sum of total number of pixels in the class i training parcels in input multiply by total number of pixels classified as class j in the output image, and dividing by the total number of pixels in all the training parcels squared. [14]

$$K = \frac{\sum_{i=1}^{p} \frac{Cii}{n} - \sum_{i=j=1}^{p} \frac{Ci*Cj}{n^2}}{1 - \sum_{i=j=1}^{p} \frac{Ci*Cj}{n^2}} \quad 3.5$$

Mean accuracy

The summation of all calculated producer accuracies values (proportion of pixels in the training parcel set that are correctly recognized by the classifier) for all training parcels divided by the total numbers of training parcels. [14]

$$Am = \frac{\sum_{i=1}^{p} \frac{Cii}{Ci.}}{P} \qquad 3.6$$

Commission

Errors of commission represent pixels that belong to another training parcel that are labelled as belonging to the training parcel of interest. The errors of commission are shown in the rows of the confusion matrix. It is calculated for each training parcel by subtracting the number of pixels classified as class j in the output image for the class from Number of pixels of well-classified pixels (diagonal value in the pixel matrix) for the same class divided by total number of pixels classified as class j in the output image for the same class. [14]

$$Ci = \frac{C.j - Cii}{C.j} \qquad 3.7$$

Omission

Errors of omission represent pixels that belong to the training parcel class but the classification technique has failed to classify them into the proper class. The errors of omission are shown in the columns of the confusion matrix. It is calculated for each class by subtracting number of pixels in the class i training parcels in input for the class from the number of pixels of well-classified pixels (diagonal value in the pixel matrix) for the same class divided by the total number of pixels in the class i training parcels in input for the same class. [14]

$$\mathrm{Oi} = \frac{\mathrm{Ci.} - \mathrm{Cii}}{\mathrm{Ci.}} \qquad 3.8$$

Producer accuracy

The classifier correctly recognizes the proportion of pixels in training parcel set that. This calculated by dividing Number of pixels of well-classified pixels (diagonal value in the pixel matrix) on the total number of pixels in the class i training parcels in input. [14]

$$\mathrm{Ai} = \frac{\mathrm{Cii}}{\mathrm{Ci.}} \qquad 3.9$$

User accuracy

Measures the proportion of pixels identified by the classifier as belonging to class i that agree with the training parcel. This calculated by dividing Number of pixels of well-classified pixels (diagonal value in the pixel matrix) on total number of pixels classified as class j in the output image. [14]

$$Ui = \frac{Cii}{C.j} \qquad 3.10$$

3.8 Land use and land cover

3.8.1 Land use

Land use involves the management and modification of natural environment or wilderness into built environment such as settlements and semi-natural habitats such as arable fields, pastures, and managed woods. It also has been defined as "the total of arrangements, activities, and inputs that people undertake in a certain land cover type”.

3.8.2 Importance of land use

experience with case studies has made it clear to many urban planners and environmentalists that to maximize the benefits of transit investments, and to slow growth in traffic congestion, vehicle miles traveled (VMT), and carbon emissions, you have to focus on land use issues. [16]

This knowledge has begun working its way into the policymaking world, to the extent that local and state legislatures are beginning to create rules that explicitly take the carbon impact of land use effects into decision-making about new development and infrastructure construction. In a few years’ time, the federal government may follow. [16]

However, there is not as much in the way of hard studies of the effects of land use as we might like mainly because it has been a non-issue, as far as most of the country is concerned, for much of recent history. [16]

In this project, land use is an important part because all the other parts will be built from it, as all the spatial analysis process in one way or another will use the land use data and this will be explained later on in this chapter. [16]

3.8.3 Land cover

Land cover is an observable image of the many processes taking place on the land surface. It reflects land occupation by various natural, modified or artificial systems, and to some extent, the way land is used in such systems. [17]

3.8.4 The difference between land use and land cover

Land use and land cover have some fundamental differences. Land use refers to the purpose the land serves, for example, recreation, wildlife habitat or agriculture; it does not describe the surface cover on the ground. For example, a recreational land use could occur in a forest, shrub land, grasslands or on manicured lawns. [18]

Land cover refers to the surface cover on the ground, whether vegetation, urban infrastructure, water, bare soil or other; it does not describe the use of land, and the use of land may be different for lands with the same cover type. For instance, a land cover type of forest may be used for timber production, wildlife management or recreation; it might be private land, a protected watershed or a popular state park. [18]

In short, land use indicates how people are using the land, whereas land cover indicates the physical land type. Both types of data are most often obtained from analysis of either satellite or aerial images. [18]

Understanding both the land use and land cover of a track of land provides a comprehensive picture of a particular area. This data is a fundamental component of the planning and decision-making processes for many communities because it helps them to understand better where to plan for different types of growth and where to preserve; it also helps them to understand the connectivity or fragmentation of various features in their community. [18]

4. Sustainable planning using GIS and RS

4.1 Introduction

Previously, the definition and the basics of the GIS and RS were explained. In This chapter explains how this project will be done, as in the matter of decision-making and the process of it, and how to combine between GIS and remote sensing; for that to happen, this project must be divided to these parts:

- Remote sensing
- Land use
- Roads
- Facilities study
- Geopolitical study

Each of these parts will be studied thoroughly, and analyzed in order to make decisions, conclusions, and make suggestions about each of them. The next figure (Figure 4-1) shows the methodology of this project.

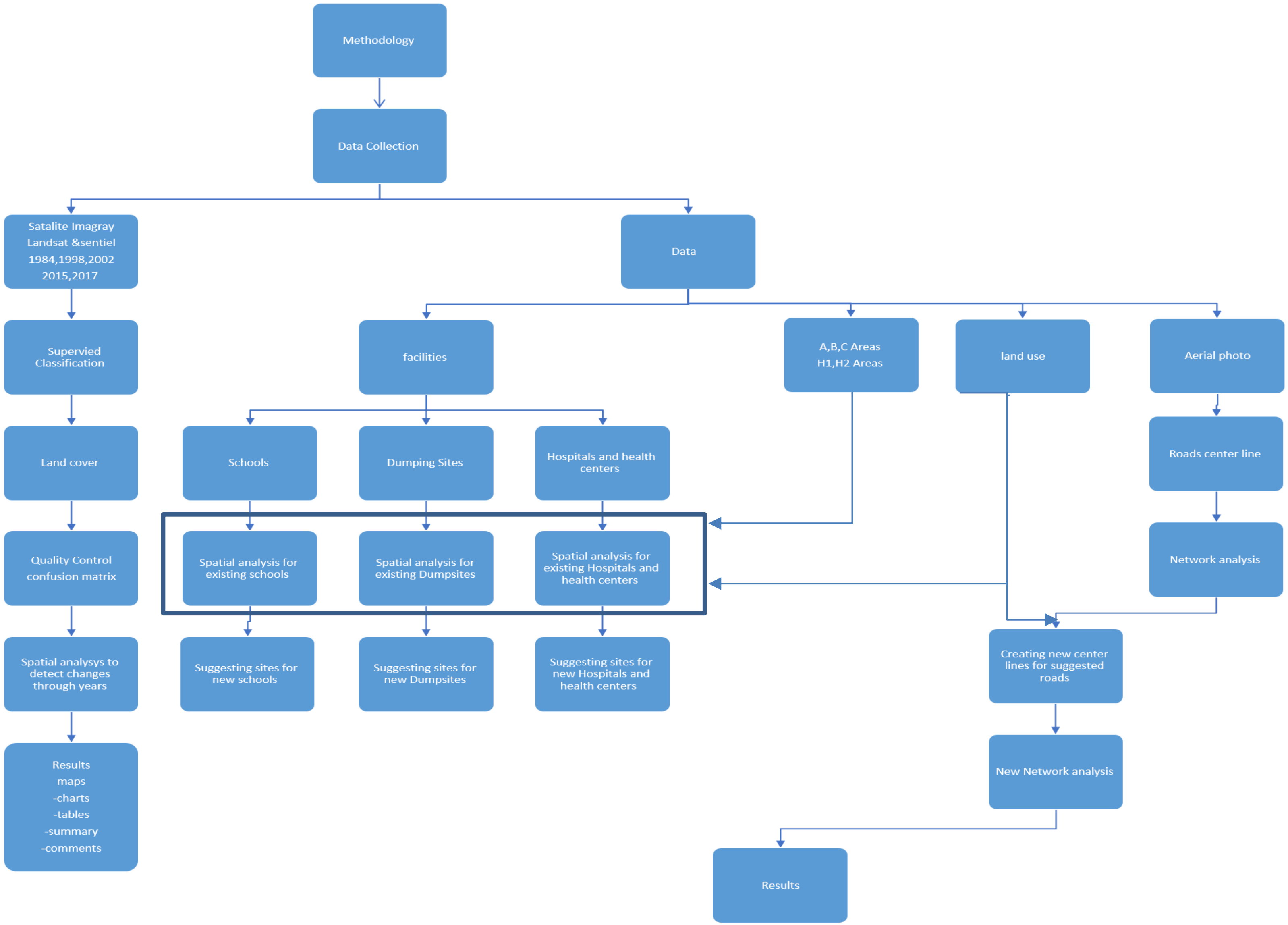


Figure 4-1 Methodology

4.2 Remote sensing

In this part of the project, the interest is concentrated on detecting the changes that happened throughout the years, especially the changes to the Israeli settlements, and natural reserves, in addition to that, it is concentrated on finding the direction of building expansion to be able to better plan for the future. In order to do that this part of the project must happen according to these steps:

- Data collection
- Building land cover
- Change detection
- Building expansion

4.2.1 Data Collection

Open source data were used to obtain the multispectral images for the study area, from both Landsat and Sentinel.

Landsat images were obtained from the United States Geological Survey website, and Sentinel images were also obtained from the European Space Agency, from the Copernicus Open Access Hub website. In this project, five images (Landsat and Sentinel) of Hebron district were obtained to detect changes through years. The years that were chosen were (1984, 1994, 2002, 2015, and 2017).

4.2.2 Constructing land cover

By using the ENVI 5.3 program and the collected imagery, the land cover can be made for each year by applying these steps:

- Add the satellite imagery to the program, making sure of the bands that were chosen, as the red, green, and blue bands must be chosen to be able to see the imagery with its true colors.
- By choosing the RGB option, and making sure that every band is in its right slot, and loading the RGB image, the image can be seen in three windows (image, scroll, and zoom windows).
- After the image has appeared, an image stake can be made by using the layer staking option, this option makes the rest of the steps easier, and helps opening the image later on, as you can open just the stake and the image in RGB will open.

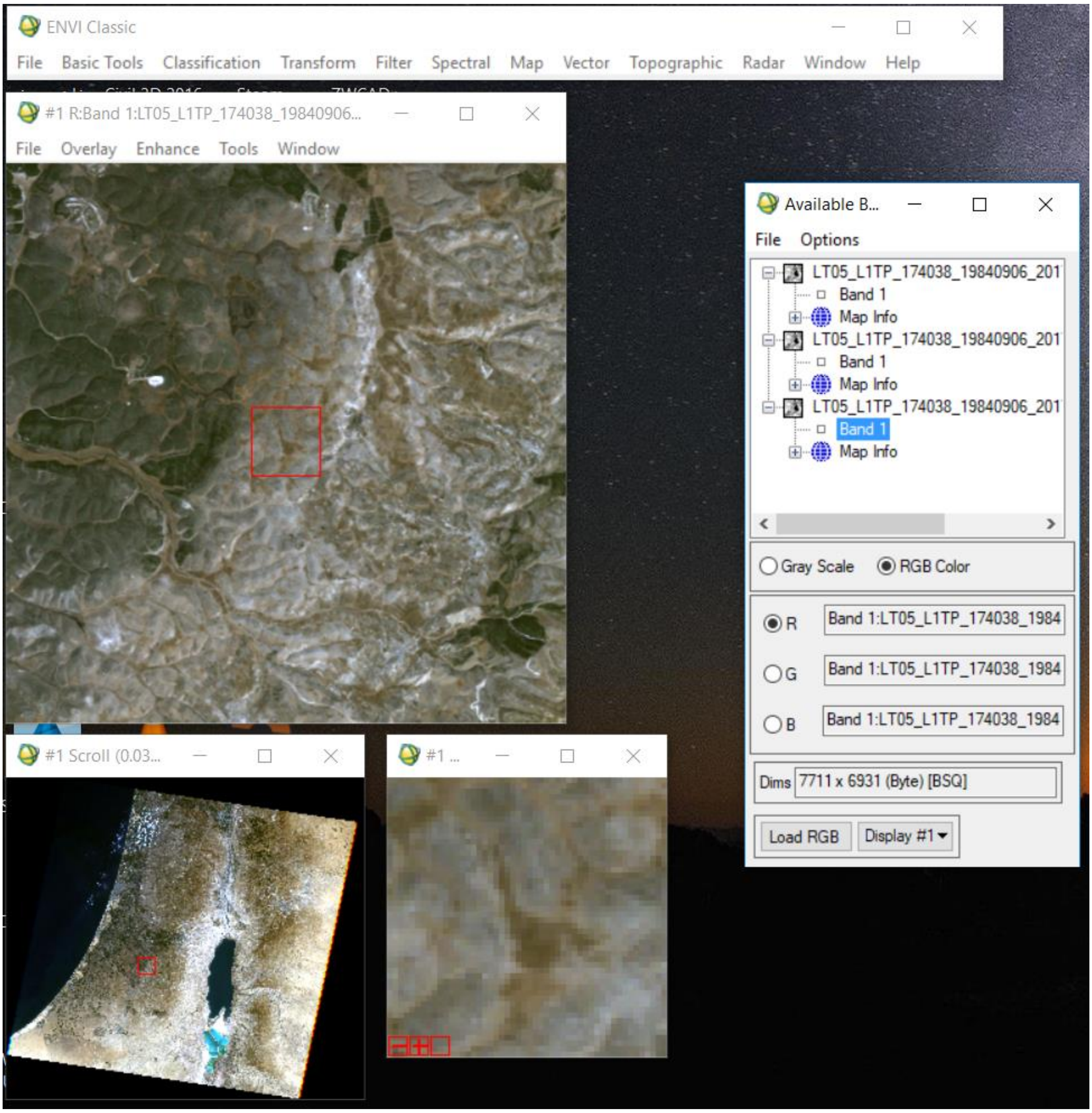


Figure 4-2 ENVI 5.3 interface with opened image

- Some satellite imagery covers a larger area than needed, but it can be resized using the resize option, but to use the option there must be a resize source, the resize source can be a region of interest made in the program itself, or it can be a shapefile saved in (EVF) format. The shapefile can be saved in (EVF) format in the arc map program.
- Some satellite imagery does not cover the needed area, this problem can be solved in the arc map program using the mosaic tool to join the photos, and then they can be resized as explained in the previous point.
- Before stating the supervised classification, it needs training parcels. This can be prepared by making a region of interest using the classes of the level one of the CORINE classification (Table 3-1). The region of interest must be well distributed over the image, and the number of pixels that each class cover must be thirty times the number of classes used.

- The supervised classification can be started using the maximum likelihood option, and selecting the image and region of interest. The result of this option is the land cover.

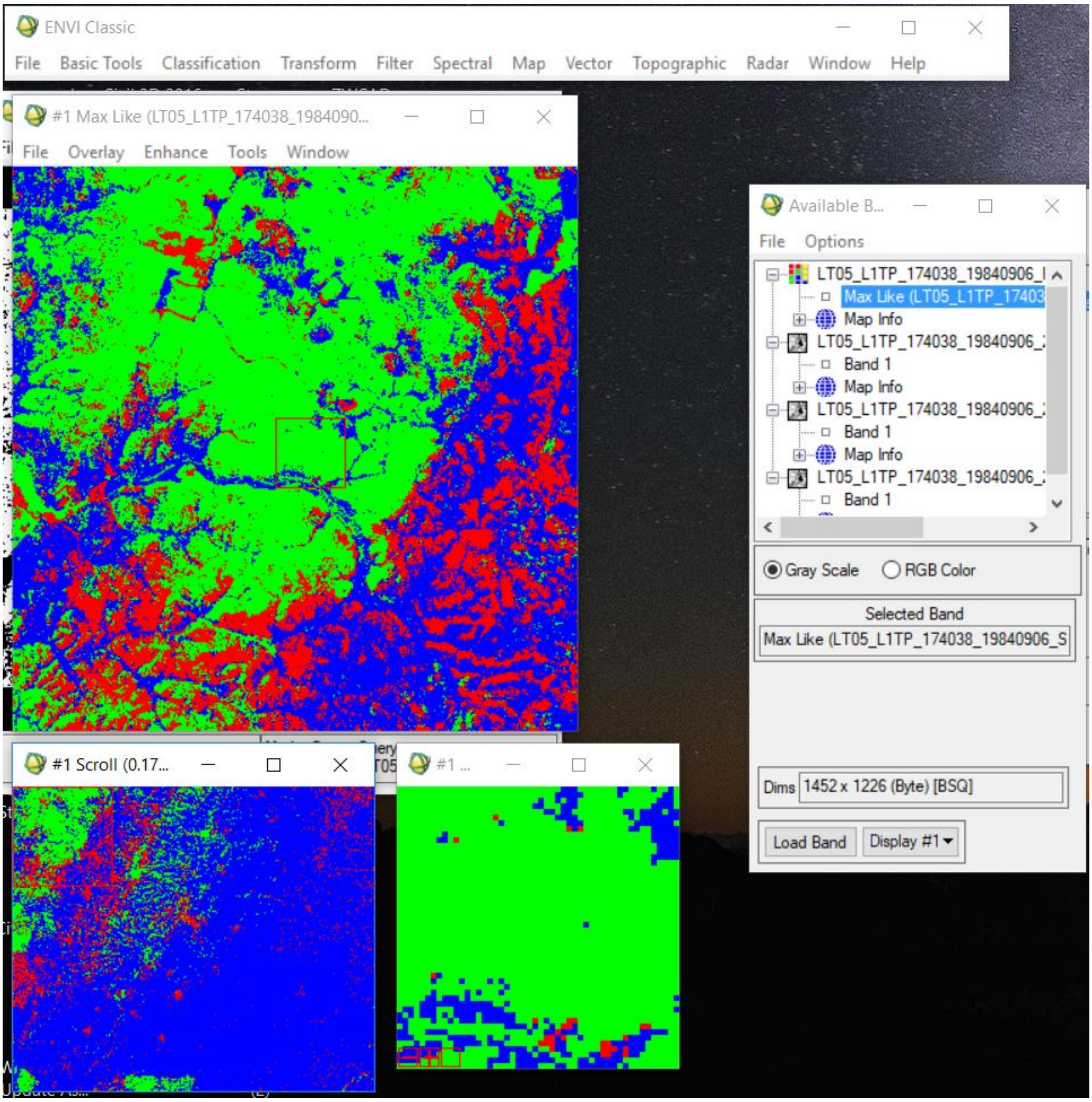


Figure 4-3 Classified Image

- To save the land cover as a shapefile, and be able to open it in arc map for analysis, the land cover must be transformed into a vector file using the raster to vector option, and then the vector file can be saved as a shapefile.

- In order to make sure that the classification is as precise as possible, the statistics and confusion matrix are needed, and they can be extracted using the statistics option for each image, and the confusion matrix option on the land cover, the region of interest, and the image.

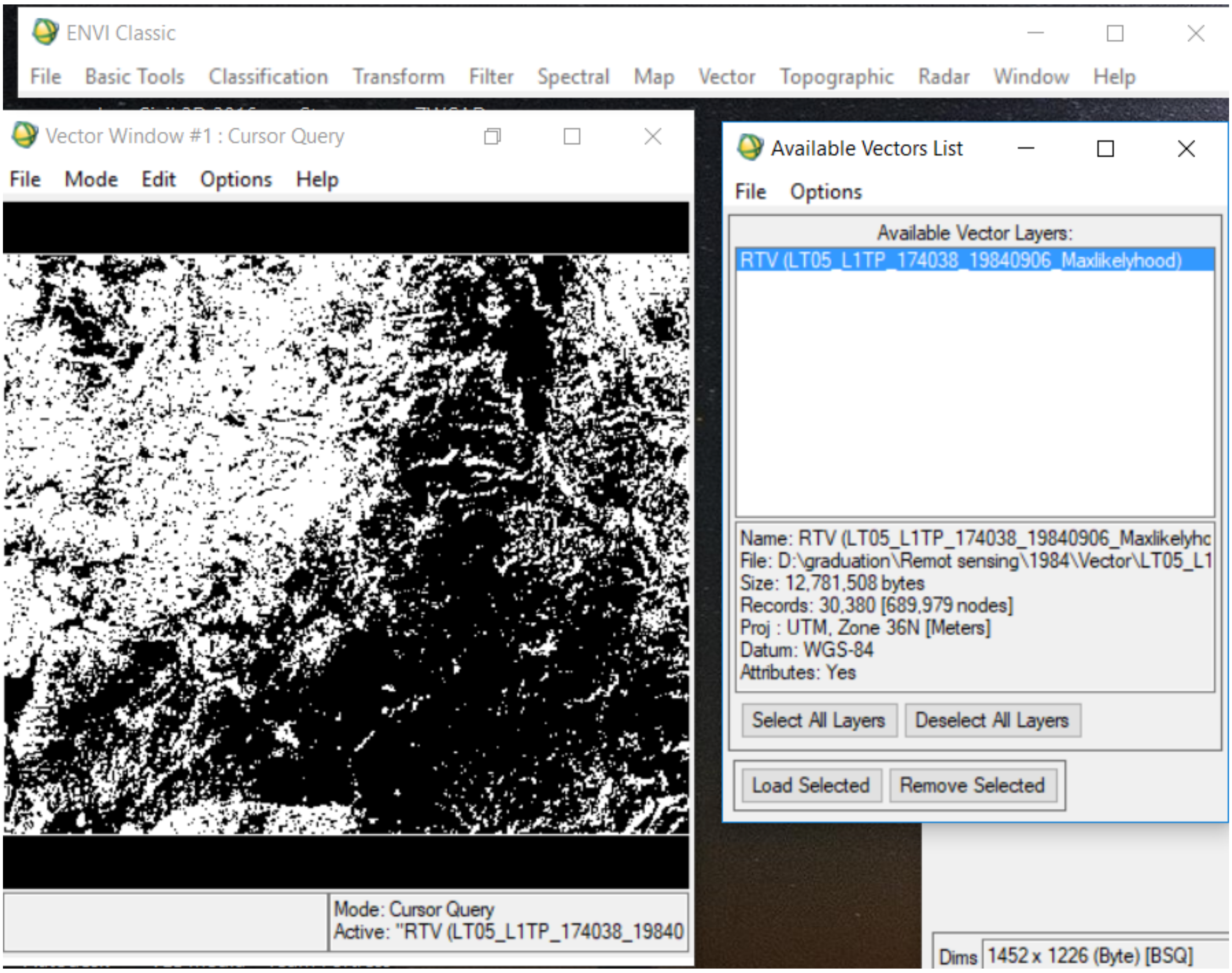


Figure 4-4 Classification as a vector file

4.2.3 Change detection

The change detection part of this project mainly depends on the land cover from the classified satellite imagery, and the resultant shape file from that. In order to analyze the changes that happen in the study area numbers, graphs, and statistics are needed, and these statistics needs to be for each area. For example, if there is more than one natural reserve the statistics needs to be for each one of these natural reserves, and this can be done by:

- Selecting the desired area and making it as a shape file itself.
- Selecting each class and merging the selected class to make it a single polygon.
- Select the area and use the create graph tool to create a chart with the desired statistics.

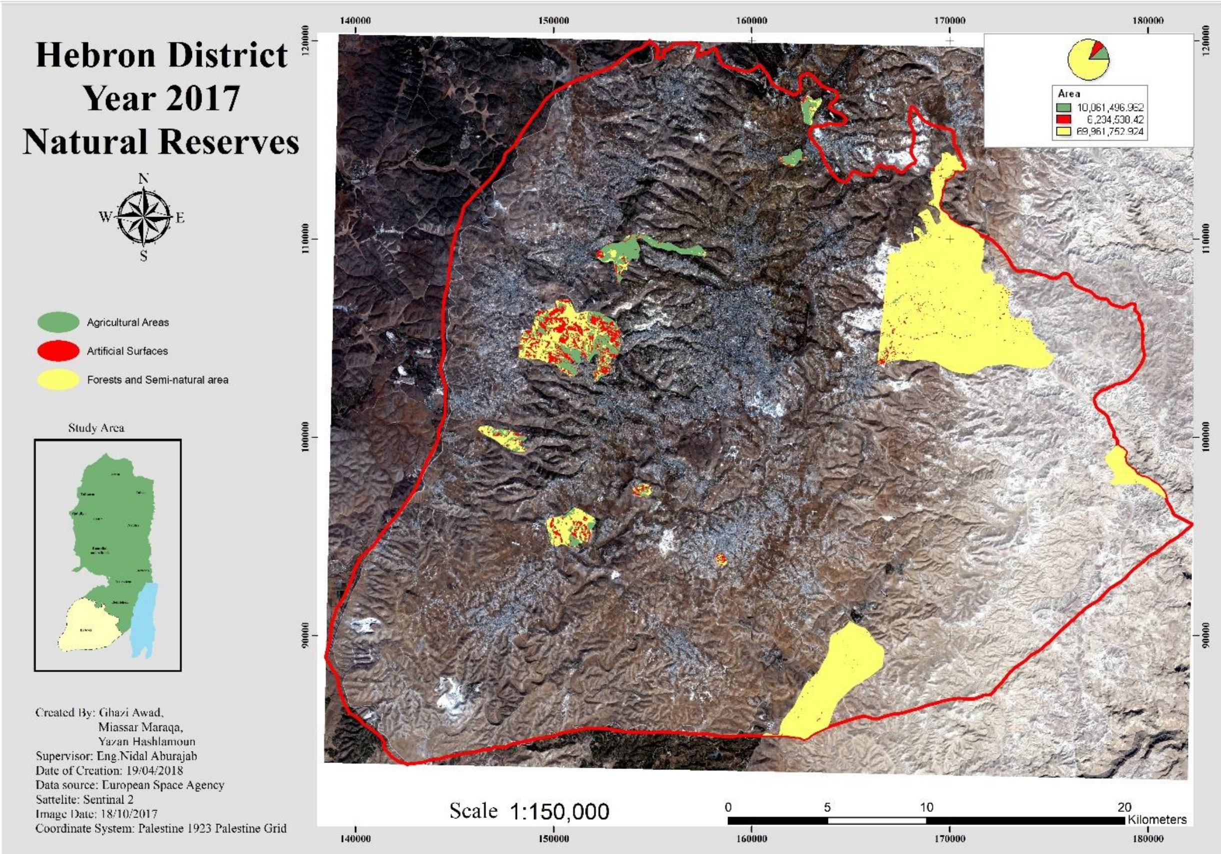


Figure 4-5 Natural reserves area statistics in 2017

4.2.4 Built up area expansion

To determine the direction of the Built up area expansion, using the arc map 10.5 program, and the land cover shapefiles, the following method was used:

- Using the polygon to raster tool, each land cover was turned into a raster file giving each class a certain value in the raster.
- Then using the raster calculator tool the raster for every two consecutive years were done using the cross product for the values of the classes.
- The raster calculator takes the two rasters, then do the wanted operation on every pixel from the first raster with the one with the same coordinates from the second raster, resulting with a new raster.
- In the result raster, the wanted values were shown and the unwanted values were hidden.

To determine the wanted values in the raster, the values before the cross product must be in mind. For example: if the artificial surfaces had the value of 1, the agricultural areas had the value of 2, and the forests and semi-natural areas had the value of 3 before the cross product. The wanted areas were the agricultural areas and forests and semi-natural areas that were turned into artificial surfaces, then the wanted values are the results of the cross product of agricultural areas or forests and semi-natural areas with the artificial surfaces. As in the cross product of the values 3 or 2 with 1, so the wanted values after the cross product are 3 and 2.

4.3 Creating land use

The land use creating starts by collecting the latest aerial photo as possible and digitizing the lands as polygons to one of these categories:

- Forests
- High value agricultural lands
- Medium value agricultural lands
- Low value agricultural lands
- Built up areas
- Roads
- Israeli settlements
- Natural reserves

After the digitizing is done, a layout for this map will be made, and all of the other spatial analysis process can begin according to the land use data.

4.4 Roads

In this part of our project, this project aims to evaluate the existing road network and try to enhance this network; in order to do the following process was followed:

4.4.1 Collecting Road centerline

By getting the latest aerial photograph possible and use the ArcMap 10.5 to digitize the centerline of every road in Hebron district and getting a full road centerline for it.

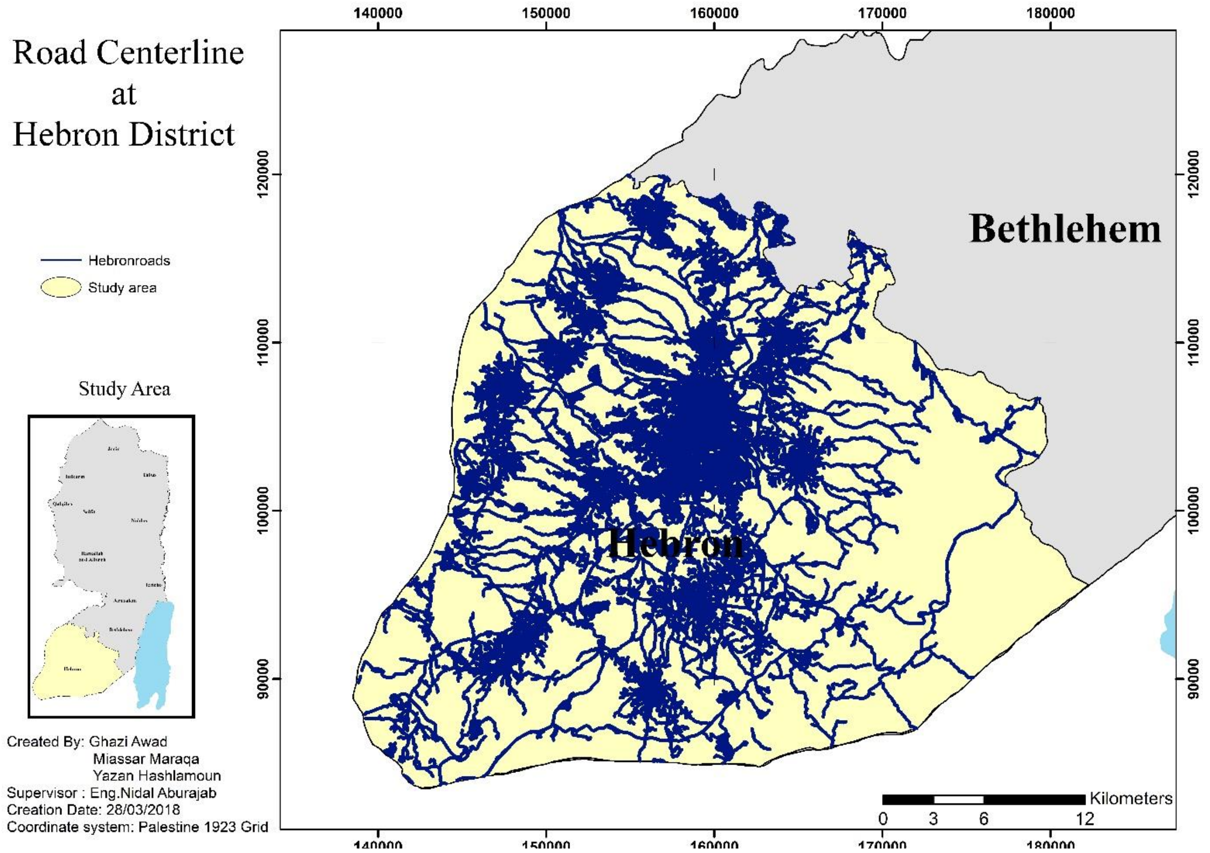


Figure 4-6 Hebron District Road Centerline

4.4.2 Studying the existing road network

The studying process includes using the ArcMap 10.5 program to perform a network analysis for the existing road network using the optimal routing process.

the network analysis can be define as a special kind of line analysis that consist of a set of interconnected typical networks with themes like roads, streams, hiking trails, and pipeline.

One of the types of the network analysis is the optimal routing, which can be defined as the process of choosing the best route to get from one location to one or more locations. Depending on the user's preference the best route could be the shortest, the quickest, or the most ethic. For this project, the best route is the route with the least time consumption that can get the user from one point to another in the shortest amount of time.

The optimal routing works as follows:

Step 1: Building two tables, one of nodes that have already been processed, and one of adjacent nodes to process.

Step 2: Pick the adjacent node with the least cumulative cost and add it to the processed nodes list.

Step 3: Scan the nodes adjacent to your latest processed node, and add them to the Adjacent Nodes list.

Step 4: Repeat the last two steps until all nodes are in the processed node list.

Once the nodes have been processed, all the optimal routes to a node from any node are solved. However, there may also be more than one optimal route that is not reflected in the analysis.

The current road network would be studied and analyzed by creating multiple points across the map and evaluating the time needed to get from one point to another; this will determine the efficiency of the road network because the roads purpose is to get the user to his destination as fast as possible.

4.4.3 Suggesting new centerline for roads

In order to enhance the existing road network and limiting the time needed to get from one point to another, we must create a new set of roads that reduces the amount of traffic jam and creates new paths that reduces the time needed from one point to another.

The selection method requires a set of parameters and restrains that defines where this road should be done, in order to limit the damage done to the land that the road will be constructed on, and avoid any archeological sites, buildings, and high value agricultural lands. These parameters are:

1. The road must not harm any archeological sites. [3]
2. The road should take away as less as possible from the high value agricultural lands and must take from low and medium value agricultural lands. [3]
3. The road must avoid built up areas. [3]
4. The road must cost as less as possible. [3]

5. The road must avoid natural reserves. [3]

6. The road must not harm any water resources. [3]

7. The road must follow the political boundaries and must not interfere with geopolitical issues. [3]

In order for this road to accomplish these rules a set of data is needed, this data consists of a set of shapefiles that includes the following:

1. Agriculture Lands: the agricultural lands in this shapefile should be classified according to the agricultural value of these lands.

2. Natural Reserves: includes their positions and boundaries.

3. Water Resources.

4. Built-up Areas.

5. Geopolitical Data.

6. Archeological sites.

After collecting these shapefiles a spatial analysis must be performed along the study area in order to decide the centerline of the new road.

After selecting the centerlines, the roads must be put to test to find out the new roads impact on the environment, how much it can take from the agricultural lands, and did it accomplish the previous conditions and limitations. This can be done by creating a weighting system that gives every condition a certain value according to their importance, as a value can be evaluated using information from the analysis process. The evaluation process is intended to provide the decision makers with a comparison of the impacts of each centerline in order to allow them to make an informed decision about the final selection.

After analyzing and evaluating the center line of the suggested roads, a final decision must be made in order to give the final centerlines of the suggested roads.

4.4.4 Testing the efficiency of the suggested roads

The suggested roads aim is to reduce the time the user needs to get from one point to another, so by adding the suggested centerlines to the existing road network. Then using the previous method and using the same set of points and performing a network analysis and comparing the results of the two network analysis procedures, it can be determine if the new set of suggested roads are useful or not.

4.5 Facility study

In this part of our project, this project aims to assess the existing facility sites and try to find new sites for facilities that would benefit Hebron district.

There are three types of facilities that will be studied:

1. Dumping site
2. Schools
3. Hospitals

These facilities was chosen due to their importance, and their effect on the district.

The study of the facilities is a process that is described in these steps:

- Data collection
- Current Facility study
- Determining a new place foe facilities

4.5.1 Data collection

The process of analyzing the current facilities requires a lot of data to be collected:

1. The position of each facility
2. Land use
3. Soil type and its position
4. Wells and water resources

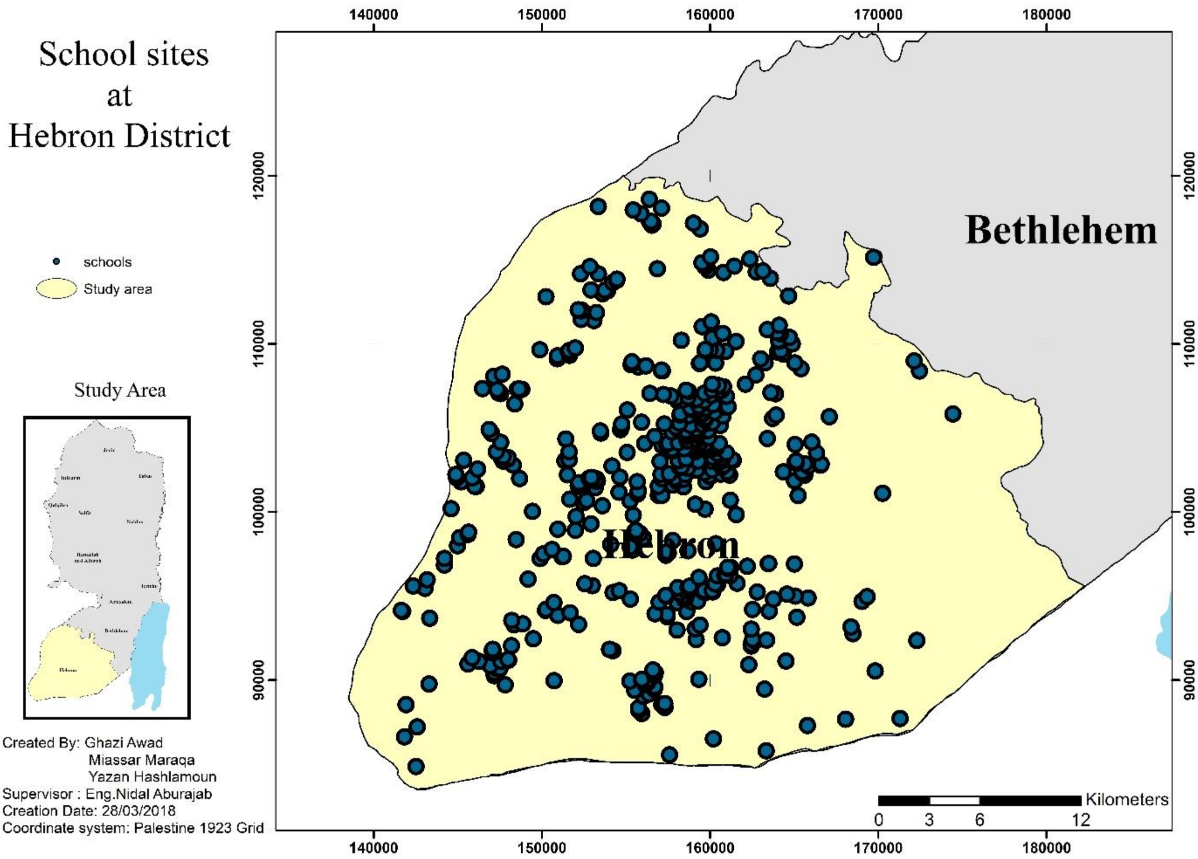


Figure 4-7 School sites in Hebron district

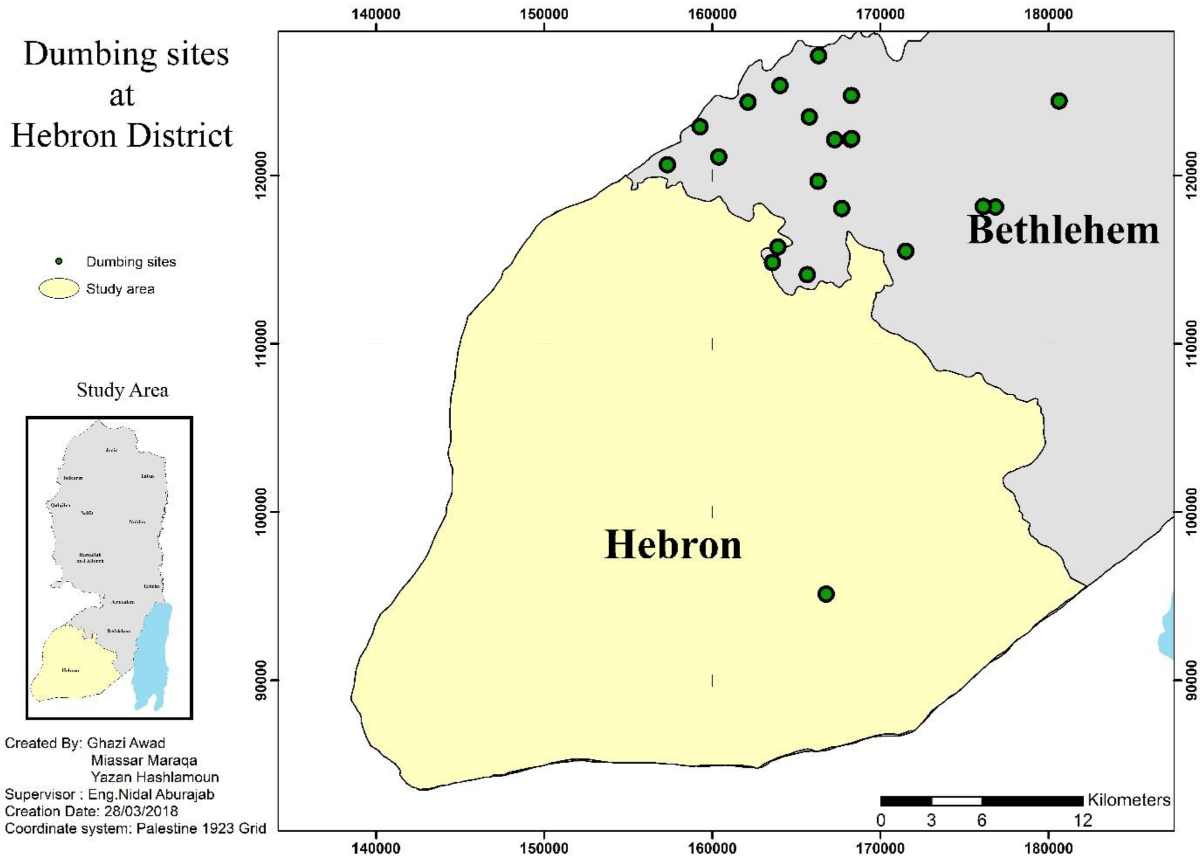


Figure 4-8 Dumbing sites in Hebron district

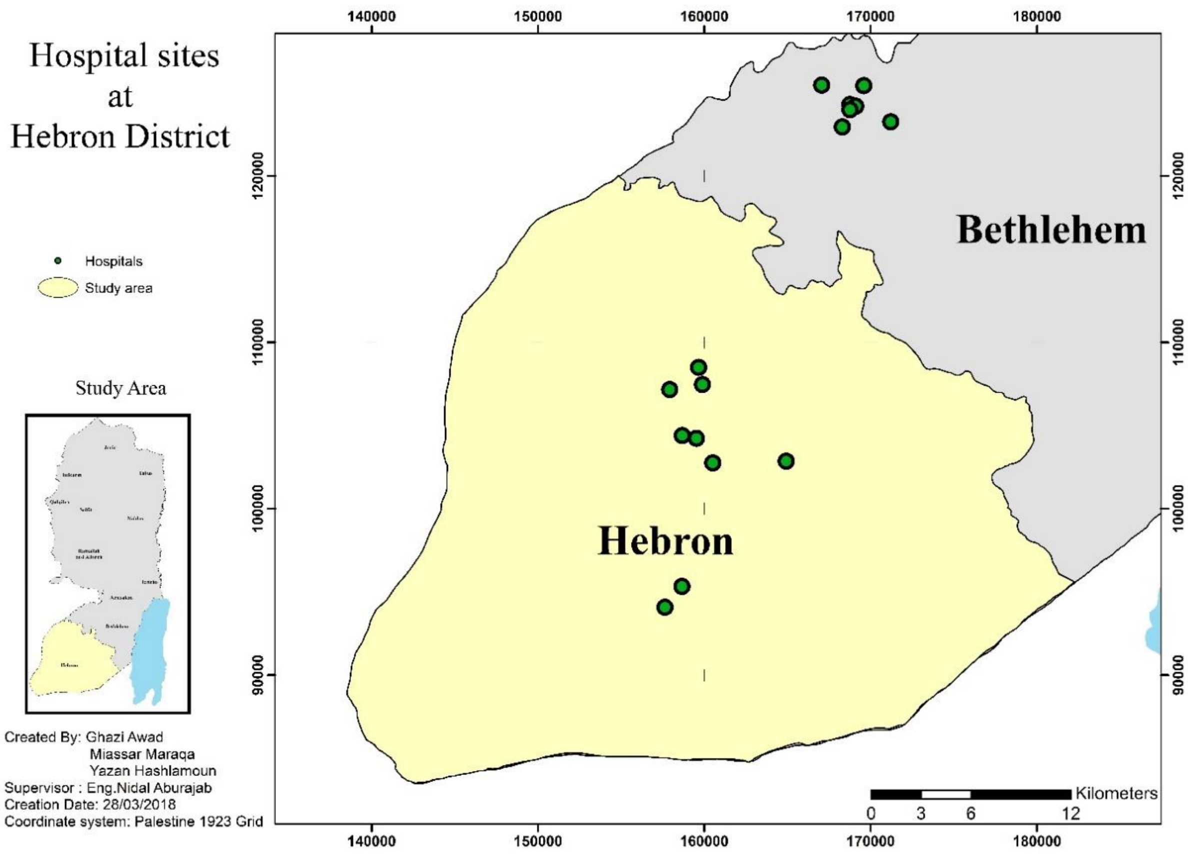


Figure 4-9 Hospital sites in Hebron district

4.5.2 Current facility study

The current facility study is used to determine the efficiency of the current facility network, and that can be done by following these steps:

Step1: selection by attribute following conditions using land use feature

Step2: do buffering for each conditions in layer.

Step 3: check where the buffer does not match the condition for each layer.

Step 4: from the buffer create a service area using network analysis that determines the area that would benefit from this facility.

Step 5: the efficiency can be determined by the areas that the facilities do not serve.

4.5.3 Determining a new place for facilities

After determining the facility service area a new service area must be made to allow the facilities to enhance their performance following these steps:

Step 1: using the conditions for each facility create a new service area in the empty areas of the current facility service area.

Step 2: from the land use determine the kind of land that the facility can be built on.

Step 3: choose points on the land use that the facility can be built on.

4.5.4 Conditions

1. Hospitals:
    a. The hospital area should not be less than 20,000 square meters. [19]
    b. The soil should not contain toxic substances such as alkali and prefer to be clay. [19]
    c. The Distance from industry area to hospital site at least 1 km. [19]
    d. The acceptable distance from the main road to hospital not more than 150m. [19]
    e. Service area of each hospitals is to be 5 km. [19]
2. Dumping sites:
    a. The landfill site is prevented to be located within 1 km from the Israeli settlements. [20]
    b. The landfill site is prevented to be located within 1 km from the any built up areas. [20]
    c. The landfill site is prevented to be located within 1 km from natural reserves. [20]
    d. The landfill site is prevented to be located within 1.5 km from the springs. [20]
    e. The landfill site is prevented to be located within 2 km from the wells. [20]
    f. The land should be low agricultural or unused. [20]
    g. The area for landfill site should be at least 10 donums.
    h. The landfill site should be placed in area "B". [20]
    i. The land fill must not be in a land which the rain water gathers in. [20]
    j. Service area of each land fill is to be 20 km. [20]
3. Schools:
    a. New school site is prevented to be located within 1 km from the industry area. [21]
    b. The New school site is prevented to be located within 150 m from the main road. [21]

c. The New school site is prevented to be on a land with higher slope than 15 degrees. [22]
d. The school site must be accessible to all students. [21]
e. Must be located in a residential area. [21]
f. The land use of the land is preferred to be a land with low agricultural value. [21]
g. Service area of each school is to be 1.5 km. [22]

5. Analysis and Results

5.1 Introduction

5.2 Remote sensing

5.3 Land use

5.4 Network analysis

5.5 Facility study results

5.1 Introduction

After the collecting the data which is five satellite photographs taken in the years ("1984","1998","2002","2015",and "2017"), a set of shape files including (the Israeli settlements borders, natural reserves borders, soil type map, ect…), and other type of data like the contour map of Hebron. The data was prepared for the analysis process. The data was analyzed using remote sensing and GIS to get the best, most accurate results as possible.

This chapter will include the results of the analysis process, and explain these results.

5.2 Remote sensing

In order to include all of the results of the remote sensing, the results must be divided according to the stage that these results appeared in, and those are:

5.2.1 Image staking and statistics

For the image to be classified the image stake must be done, and from the image stake the statistics of the image for each band can be obtained, the statistics shows the distribution of the colors, and the relationship between the bands, for example:

For the 1984 image the image stake was:

Figure 5-1 The 1984 image stack

Its statistics were:

Basic Stats	Min	Max	Mean	Stdev	Num	Eigenvalue
Band 1	31	213	95.367205	25.545754	1	1553.706896
Band 2	34	167	73.720825	17.736721	2	21.017764
Band 3	77	255	131.205934	24.666575	3	0.892053

Table 5-1 The 1948 image basic statistics

Covariance	Band 1	Band 2	Band 3
Band 1	652.585526	449.562203	609.1526
Band 2	449.562203	314.591256	431.895158
Band 3	609.1526	431.895158	608.439931

Table 5-2 The 1984 image covariance matrix

Correlation	Band 1	Band 2	Band 3
Band 1	1	0.992197	0.966715
Band 2	0.992197	1	0.98718
Band 3	0.966715	0.98718	1

Table 5-3 The 1984 image correlation matrix

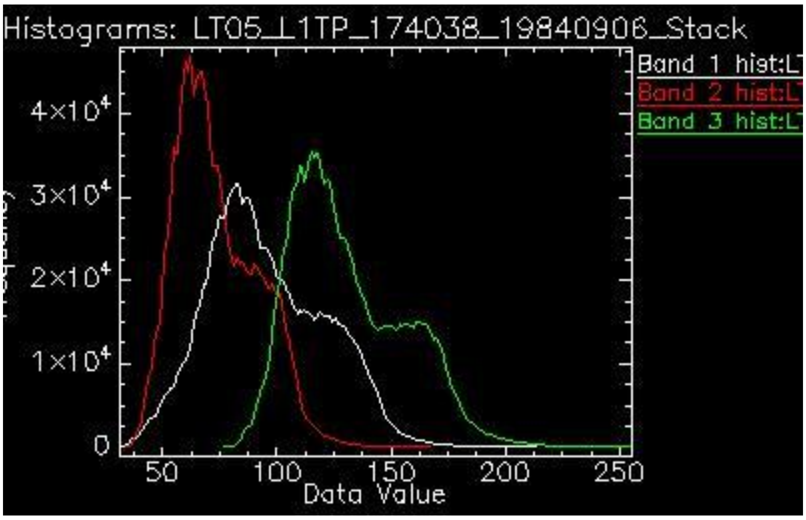


Figure 5-2 The 1984 image histogram plot

The rest of the statistics and the image stack are included in the appendix chapter Appendix-A.2 Image stack and statistics .

Note that in the histogram for each image: band 1 is the red band, band 2 is the green band, and band 3 is the blue band.

5.2.2 Classification results and confusion matrices

The land cover maps that were produced using supervised classification, and the level one from the CORINE classification. The three classes that were used (red for artificial surfaces, green for agricultural areas, and yellow for forests and semi natural areas) represent the classification result, to check if the classification was accurate the confusion matrix was calculated for each year, and these were the results:

For the year 1984 the land cove map was:

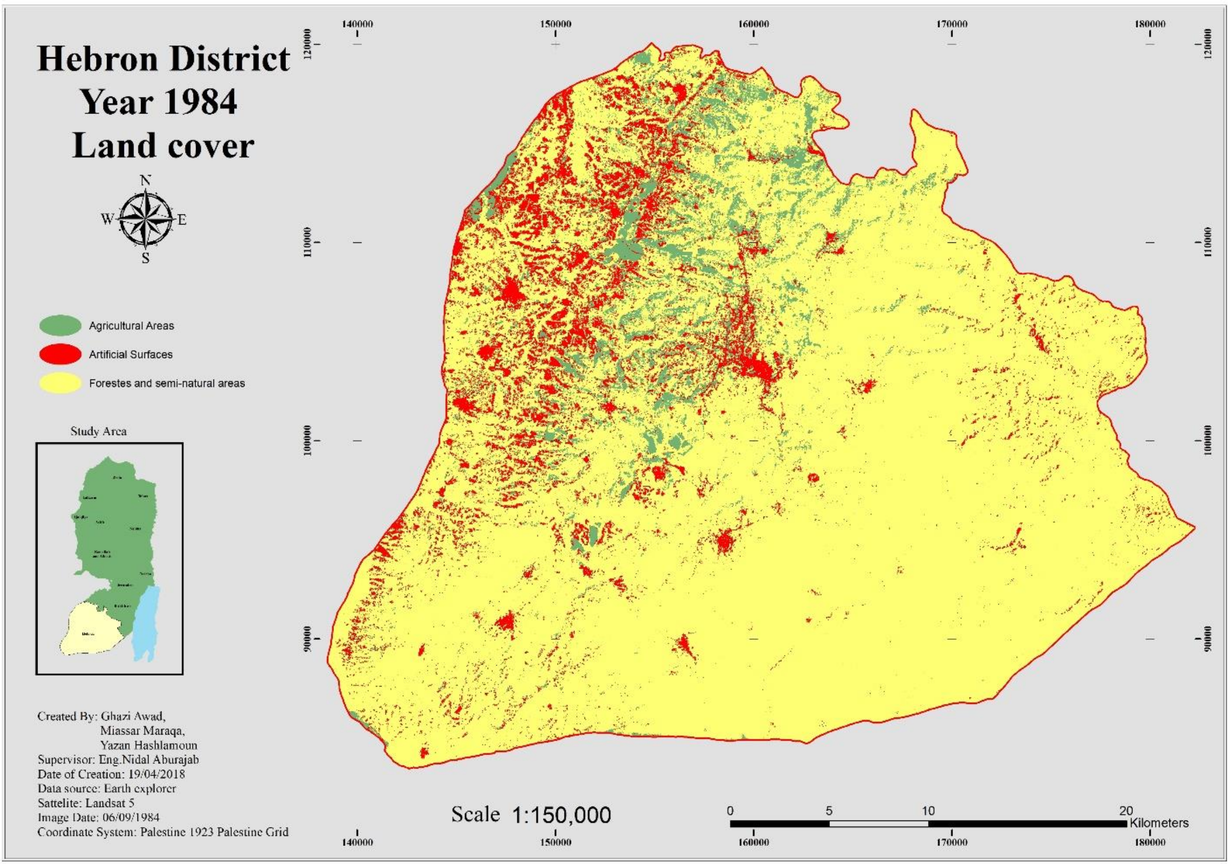


Figure 5-3 The 1984 Land cover

The confusion matrix:

General statistics

Overall accuracy	=	2213/2426	=	91.2201%
Mean accuracy	=	94.2929%		
Kappa coefficient	=	0.8111		

Cij	Referance or gound truth classes i (pixels)			
Class j (classified)	Artificial	Agricultural	Forests and semi-natural	Cj.
Artificial	213	1	176	390
Agricultural	4	402	20	426
Forests and semi-natural	6	6	1598	1610
Ci.	223	409	1794	2426

Cij/n	Referance or gound truth classes i (percent)			
Class j (classified)	Artificial	Agricultural	Forests and semi-natural	C.j/n
Artificial	95.52	0.24	9.81	16.08
Agricultural	1.79	98.29	1.11	17.56
Forests and semi-natural	2.69	1.47	89.07	66.36
Total column	100	100	100	100
Ci./n	9.19%	16.86%	73.95%	100.0%

Class errors								
	Commission Ci	Omission Oi	Commission Ci			Omission Oi		
Class	%	%	C.j-Cii	/	c.j	C.i-Cii	/	C.i
Artificial	45.38	4.48	177	/	390	10	/	223
Agricultural	5.63	1.71	24	/	426	7	/	409
Forests and semi-natural	0.75	10.93	12	/	1610	196	/	1794

Class accuracy								
	Prod. Acc.	User Acc.	Prod. Acc.			User Acc.		
Class	%	%	Cii	/	Ci	Cii	/	Cj
Artificial su	95.52	54.62	213	/	223	213	/	390
Agricultural	98.29	94.37	402	/	409	402	/	426
Forests and semi-natural	89.07	99.25	1598	/	1794	1598	/	1610

Table 5-4 The 1984 classification confusion matrix

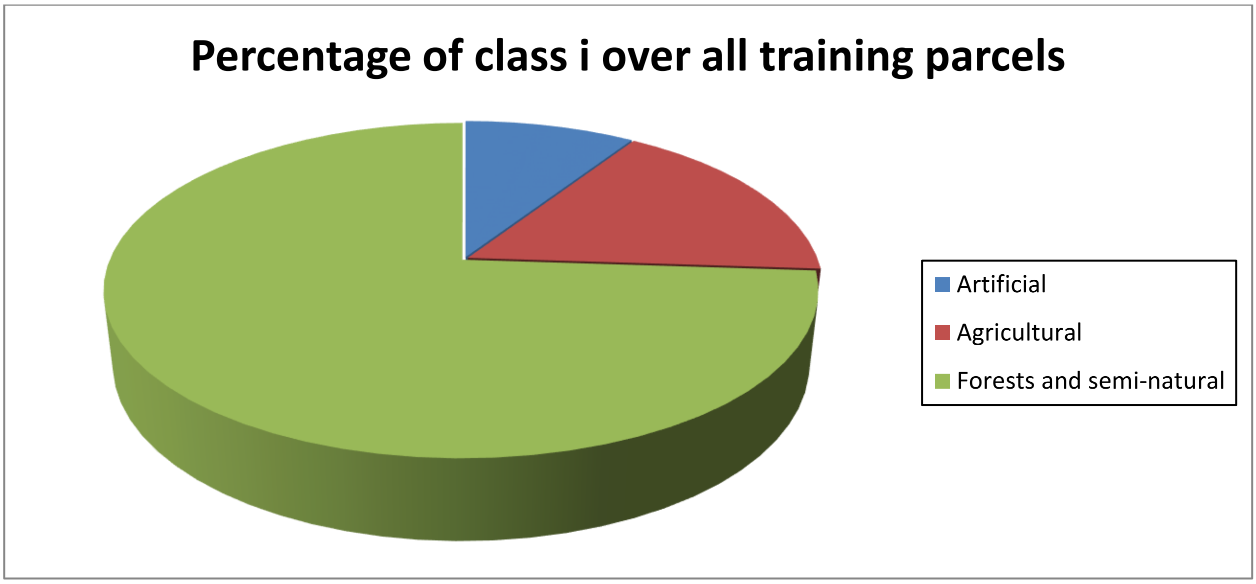


Figure 5-4 percentage of every class training parcels from the overall training parcels in the 1984 classification

For the year 1998 the land cove map was:

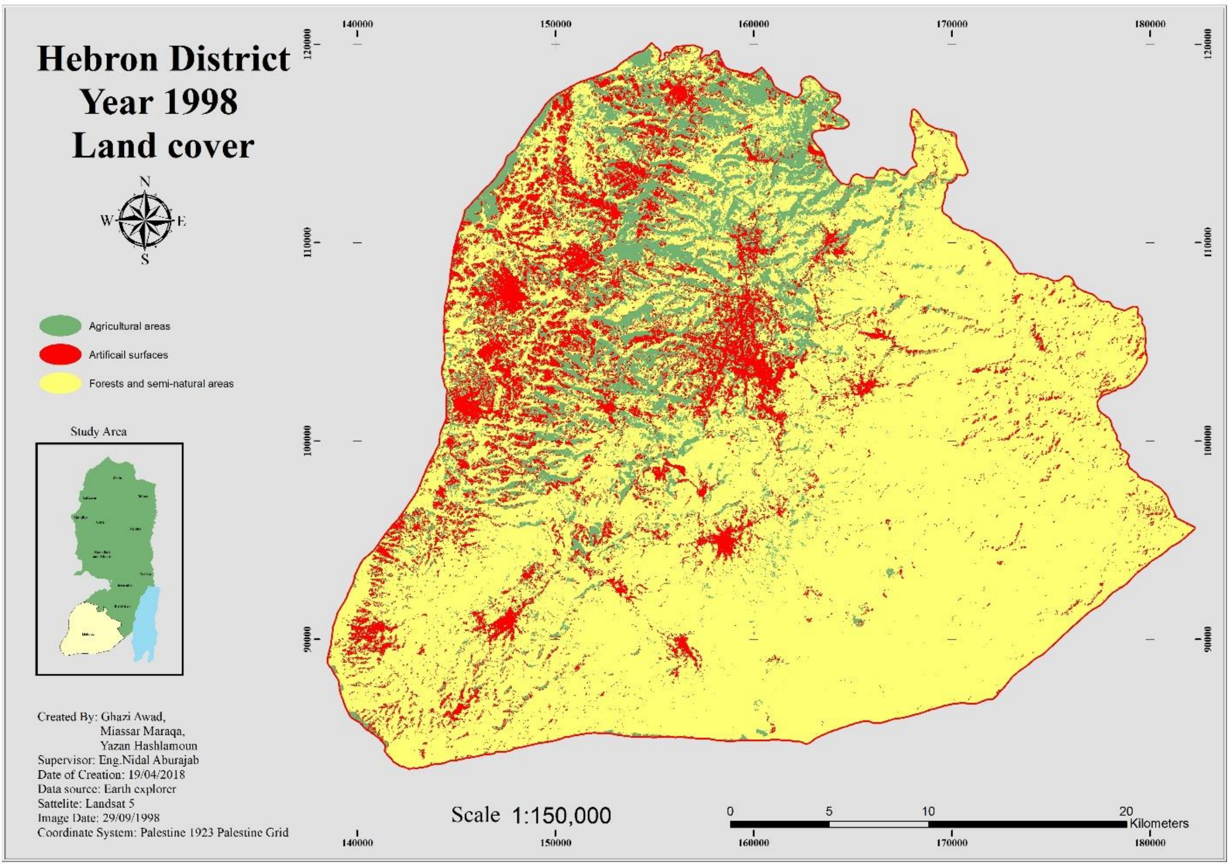


Figure 5-5 The 1998 Land cover

The confusion matrix:

General statistics
Overall accuracy = 2484/2659 = 93.4186%
Mean accuracy = 94.8682%
Kappa coefficient = 0.8763

Cij	Referance or gound truth classes i (pixels)			
Class j (classified)	Artificial	Agricultural	Forests and semi-natural	Cj.
Artificial	577	0	127	704
Agricultural	1	332	5	338
Forests and semi-natural	37	5	1575	1617
Ci.	615	337	1707	2659
Cij/n	Referance or gound truth classes i (percent)			
Class j (classified)	Artificial	Agricultural	Forests and semi-natural	C.j/n
Artificial	93.82	0	7.44	26.48
Agricultural	0.16	98.52	0.29	12.71
Forests and semi-natural	6.02	1.48	92.27	60.81
Total column	100	100	100	100
Ci./n	23.13%	12.67%	64.20%	100.0%

Class errors								
	Commission Ci	Omission Oi	Commission Ci			Omission Oi		
Class	%	%	C.j-Cii	/	c.j	C.i-Cii	/	C.i
Artificial	18.04	6.18	127	/	704	38	/	615
Agricultural	1.78	1.48	6	/	338	5	/	337
Forests and semi-natural	2.6	7.73	42	/	1617	132	/	1707

Class accuracy								
	Prod. Acc.	User Acc.	Prod. Acc.			User Acc.		
Class	%	%	Cii	/	Ci	Cii	/	Cj
Artificial su	93.82	81.96	577	/	615	577	/	704
Agricultural	98.52	98.22	332	/	337	332	/	338
Forests and semi-natural	92.27	97.4	1575	/	1707	1575	/	1617

Table 5-5 The 1998 classification confusion matrix

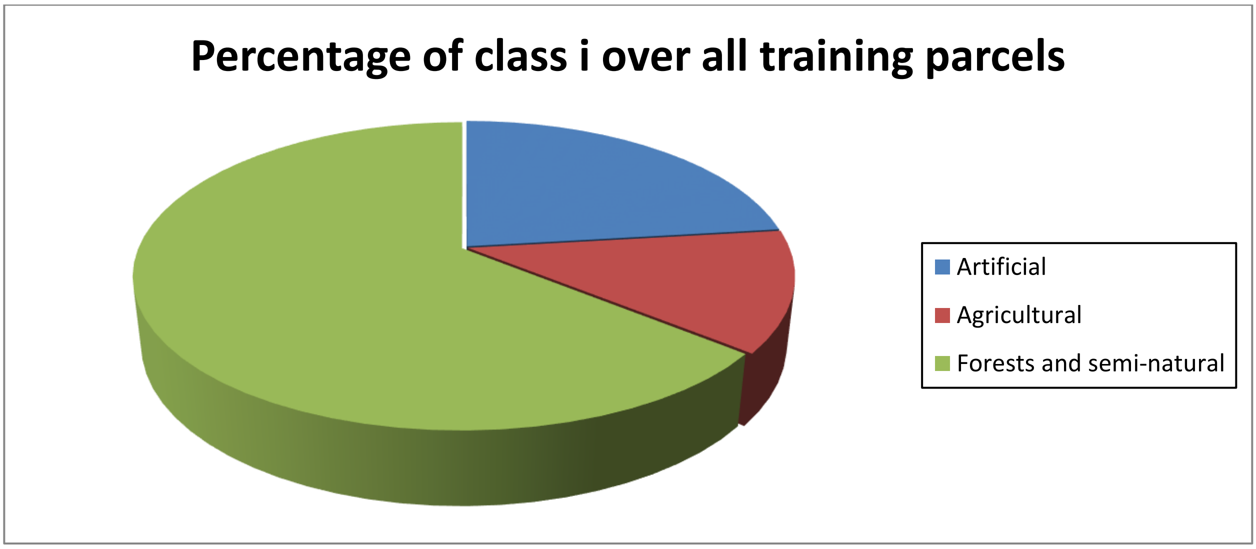


Figure 5-6 percentage of every class training parcels from the overall training parcels in the 1998 classification

For the year 2002 the land cove map was:

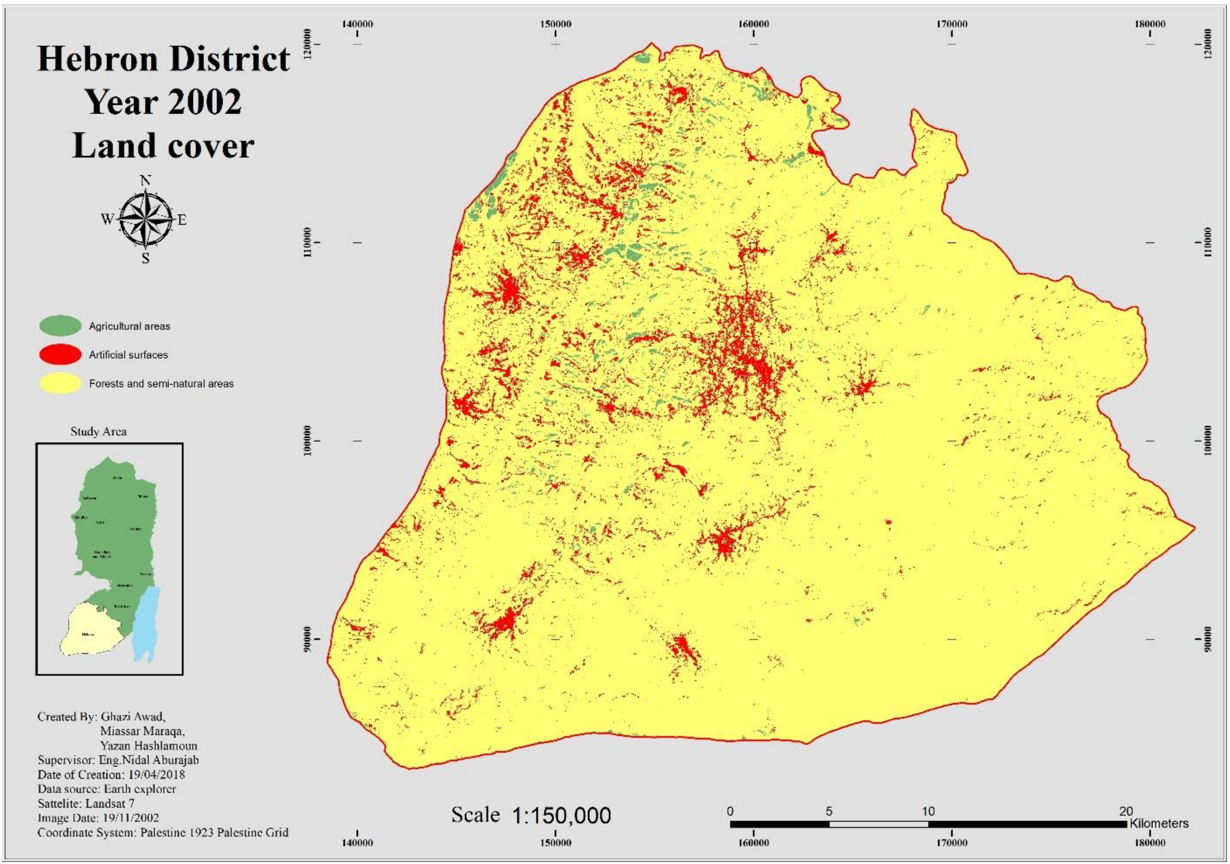


Figure 5-7 The 2002 Land cover

The confusion matrix:

General statistics

Overall accuracy	=	487/513	=	94.9318%
Mean accuracy	=	95.4435%		
Kappa coefficient	=	0.9235		

Cij	Referance or gound truth classes i (pixels)			
Class j (classified)	Artificial	Agricultural	Forests and semi-natural	Cj.
Artificial	137	1	12	183
Agricultural	0	171	10	149
Forests and semi-natural	3	0	179	181
Ci.	140	172	201	513
Cij/n	Referance or gound truth classes i (percent)			
Class j (classified)	Artificial	Agricultural	Forests and semi-natural	C.j/n
Artificial	97.86	0	5.97	16.08
Agricultural	0	99.42	4.98	17.56
Forests and semi-natural	2.14	0.58	89.05	66.36
Total column	100	100	100	100
Ci./n	27.29%	33.53%	39.18%	100.0%

Class errors								
	Commission Ci	Omission Oi	Commission Ci			Omission Oi		
Class	%	%	C.j-Cii	/	c.j	C.i-Cii	/	C.i
Artificial	8.05	2.14	12	/	149	3	/	140
Agricultural	5.52	0.58	10	/	181	1	/	172
Forests and semi-natural	2.19	10.95	4	/	183	22	/	201

Class accuracy								
	Prod. Acc.	User Acc.	Prod. Acc.			User Acc.		
Class	%	%	Cii	/	Ci	Cii	/	Cj
Artificial su	97.86	91.95	137	/	140	137	/	149
Agricultural	99.42	94.48	171	/	172	171	/	181
Forests and semi-natural	89.05	97.81	179	/	201	179	/	183

Table 5-6 The 2002 classification confusion matrix

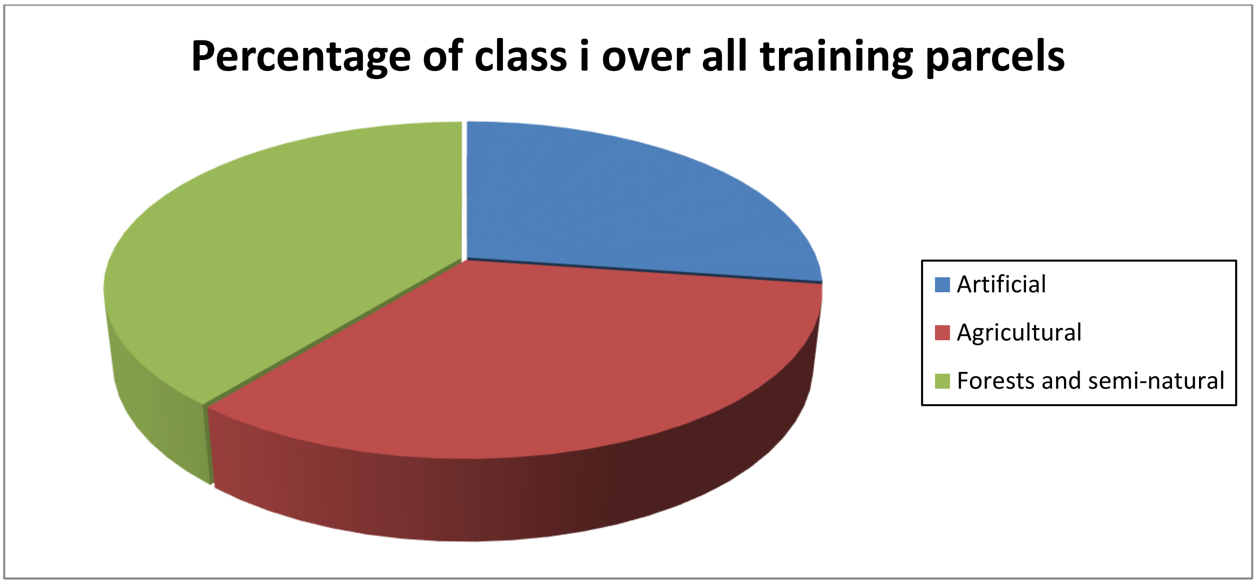


Figure 5-8 percentage of every class training parcels from the overall training parcels in the 2002 classification

for the year 2015 the land cove map was:

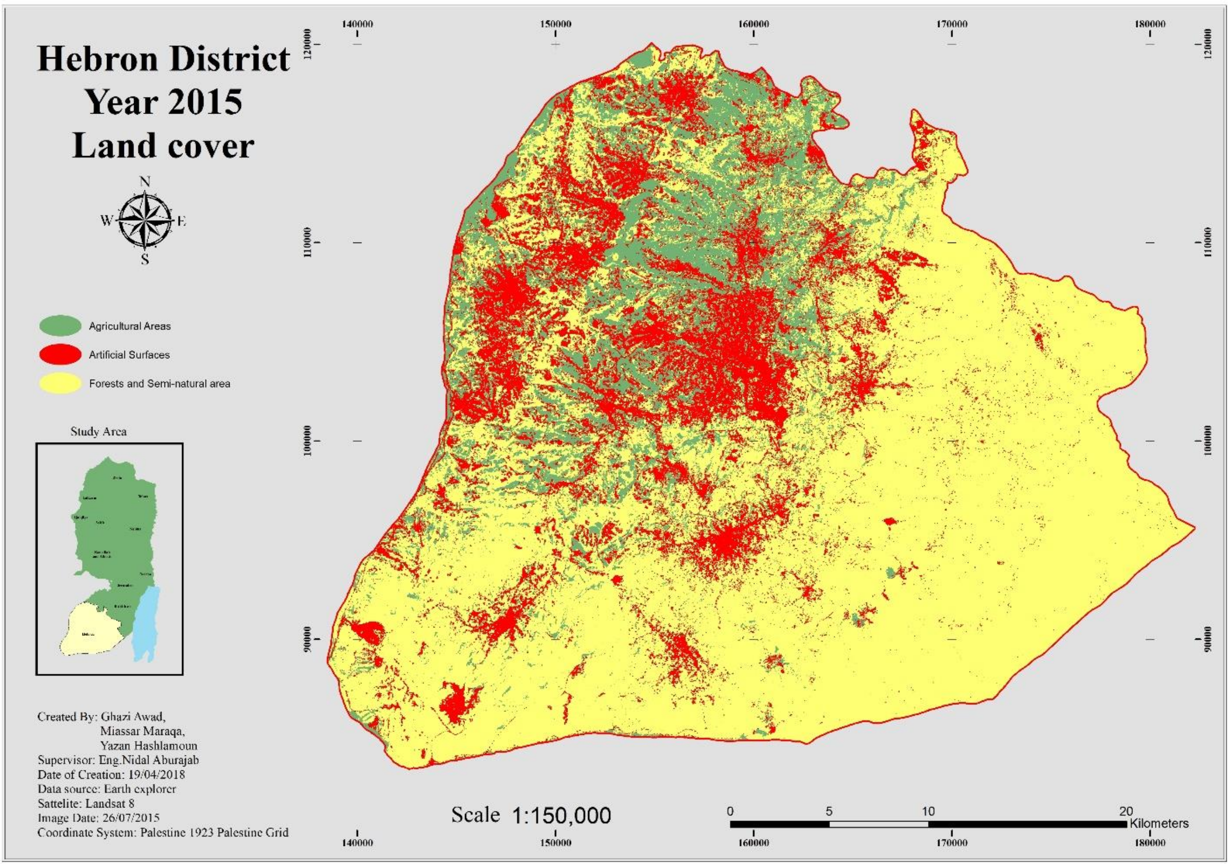


Figure 5-9 The 2015 Land cover

The confusion matrix:

General statistics
Overall accuracy = 2540/2583 = 98.3353%
Mean accuracy = 98.2571%
Kappa coefficient = 0.9743

Cij	Referance or gound truth classes i (pixels)			
Class j (classified)	Artificial	Agricultural	Forests and semi-natural	Cj.
Artificial	734	2	4	740
Agricultural	4	678	10	692
Forests and semi-natural	13	10	1128	1151
Ci.	751	690	1142	2583
Cij/n	Referance or gound truth classes i (percent)			
Class j (classified)	Artificial	Agricultural	Forests and semi-natural	C.j/n
Artificial	97.74	0.29	0.35	28.65
Agricultural	0.53	98.26	0.88	26.79
Forests and semi-natural	1.73	1.45	98.77	44.56
Total column	100	100	100	100
Ci./n	29.07%	26.71%	44.21%	100.0%

Class errors								
	Commission Ci	Omission Oi	Commission Ci			Omission Oi		
Class	%	%	C.j-Cii	/	c.j	C.i-Cii	/	C.i
Artificial	0.81	2.26	6	/	740	17	/	751
Agricultural	2.02	1.74	14	/	692	12	/	690
Forests and semi-natural	2	1.23	23	/	1151	14	/	1142

Class accuracy								
	Prod. Acc.	User Acc.	Prod. Acc.			User Acc.		
Class	%	%	Cii	/	Ci	Cii	/	Cj
Artificial su	97.74	99.19	734	/	751	734	/	740
Agricultural	98.26	97.98	678	/	690	678	/	692
Forests and semi-natural	98.77	98	1128	/	1142	1128	/	1151

Table 5-7 The 2015 classification confusion matrix

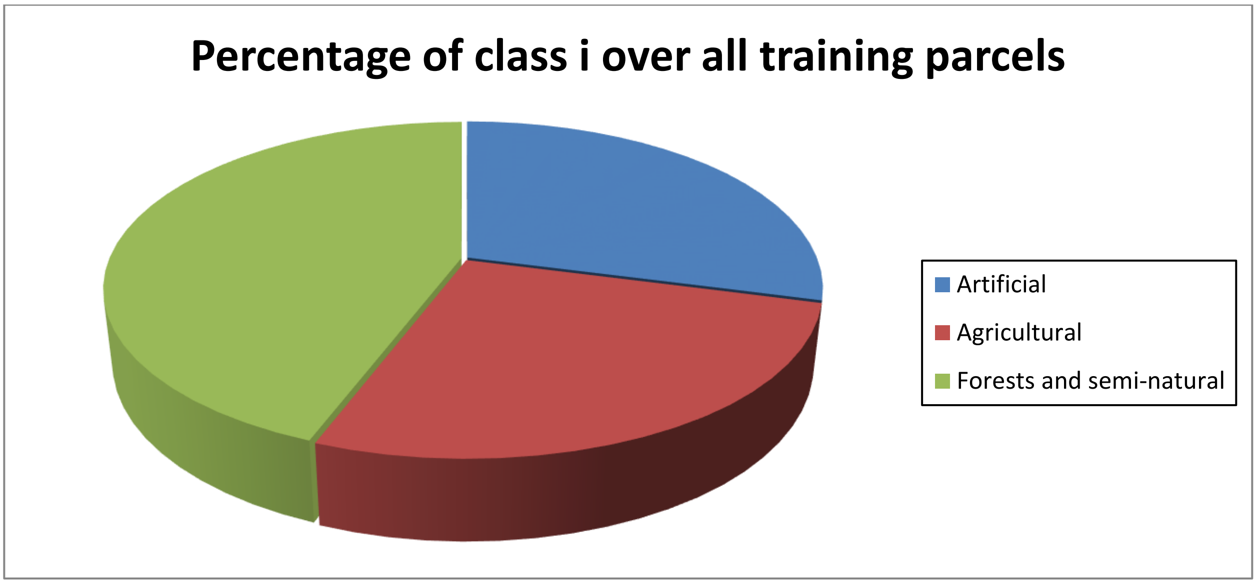


Figure 5-10 percentage of every class training parcels from the overall training parcels in the 2015 classification

For the year 2017 the land cove map was:

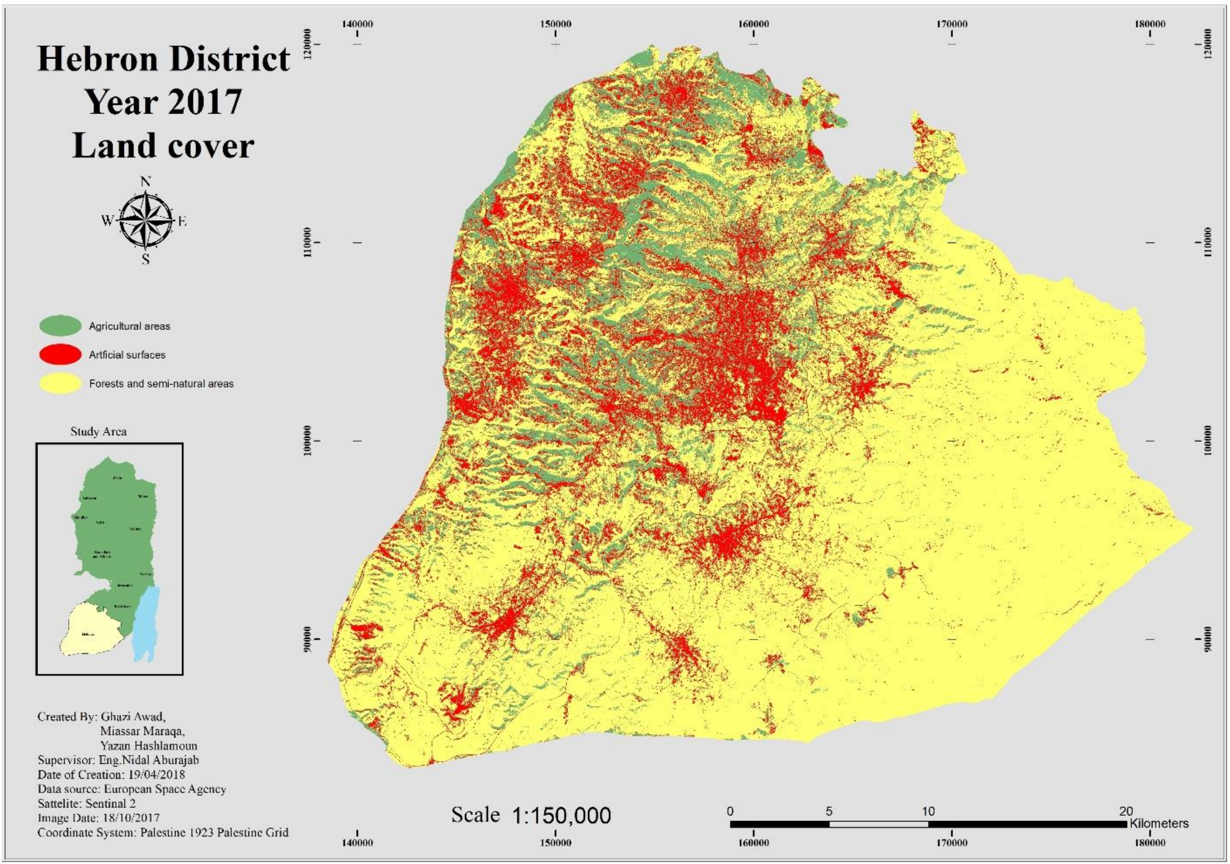


Figure 5-11 The 2017 Land cover

The confusion matrix:

General statistics
Overall accuracy = 3940/4285 = 91.9487%
Mean accuracy = 92.5942%
Kappa coefficient = 0.8705

Cij	Referance or gound truth classes i (pixels)			
Class j (classified)	Artificial	Agricultural	Forests and semi-natural	Cj.
Artificial	972	18	45	1035
Agricultural	39	935	170	1144
Forests and semi-natural	44	29	2033	2106
Ci.	1055	982	2248	4285
Cij/n	**Referance or gound truth classes i (percent)**			
Class j (classified)	Artificial	Agricultural	Forests and semi-natural	C.j/n
Artificial	92.13	1.83	2	24.15
Agricultural	3.7	95.21	7.56	26.7
Forests and semi-natural	4.17	2.95	90.44	49.15
Total column	100	100	100	100
Ci./n	24.62%	22.92%	52.46%	100.0%

Class errors								
	Commission Ci	Omission Oi	Commission Ci			Omission Oi		
Class	%	%	C.j-Cii	/	c.j	C.i-Cii	/	C.i
Artificial	6.09	7.87	63	/	1035	83	/	1055
Agricultural	18.27	4.79	209	/	1144	47	/	982
Forests and semi-natural	3.47	9.56	73	/	2106	215	/	2248

Class accuracy								
	Prod. Acc.	User Acc.	Prod. Acc.			User Acc.		
Class	%	%	Cii	/	Ci	Cii	/	Cj
Artificial su	92.13	93.91	972	/	1055	972	/	1035
Agricultural	95.21	81.73	935	/	982	935	/	1144
Forests and semi-natural	90.44	96.53	2033	/	2248	2033	/	2106

Table 5-8 The 2017 classification confusion matrix

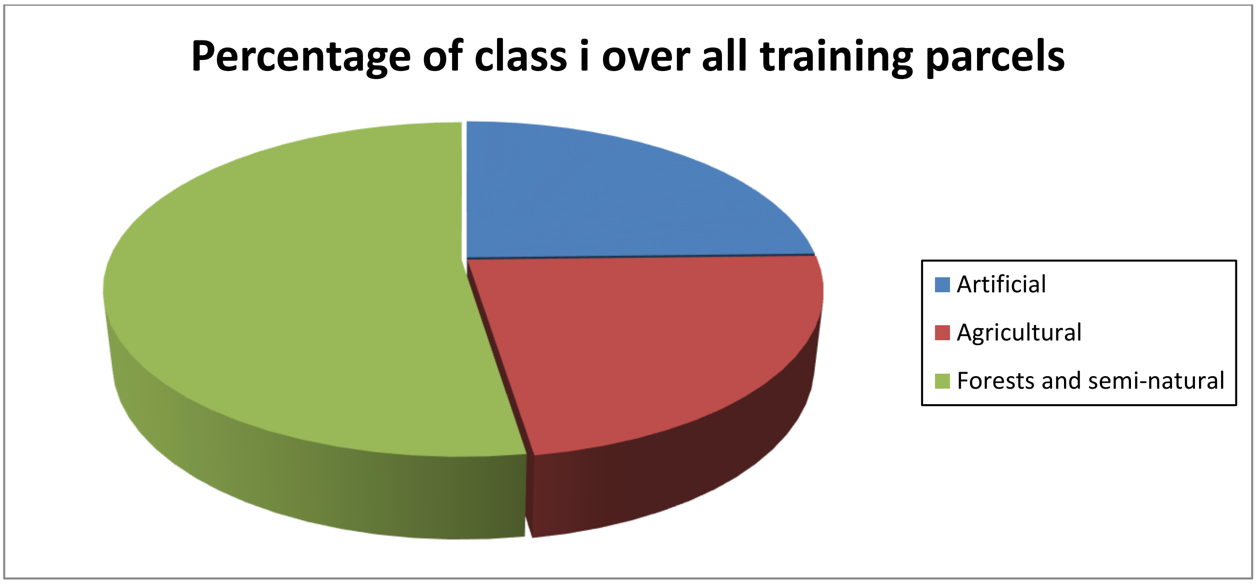
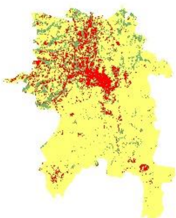
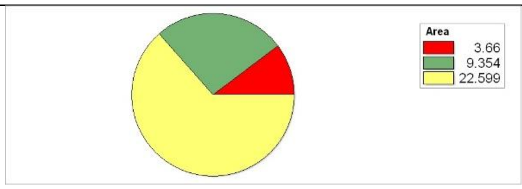
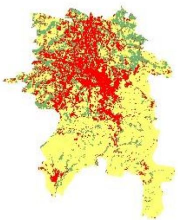
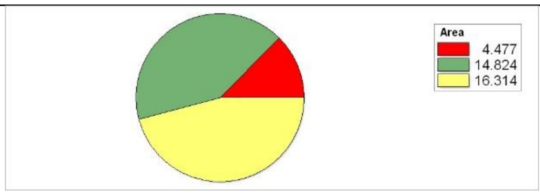
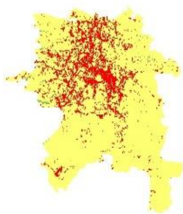
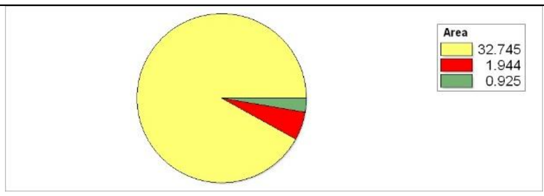


Figure 5-12 percentage of every class training parcels from the overall training parcels in the 2017 classification

After getting the land cover for each year, the land cover was used to determine the changes that happened in the main cities, Israeli settlements, and the natural reserves. These changes were observed thoroughly, and these are the results:

For the main cities, the results shows that the main expansion was in the built up area, and much less on the agricultural areas. As the built up area expand the forests and semi-natural areas are decreasing.

As an example for the expansion of the main cities, the next table shows the expansion of Hebron city:

Year	Classification	Statistics "Areas are in kilometer square unit"
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		

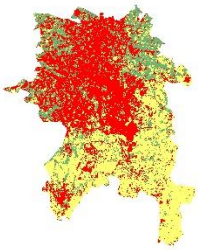
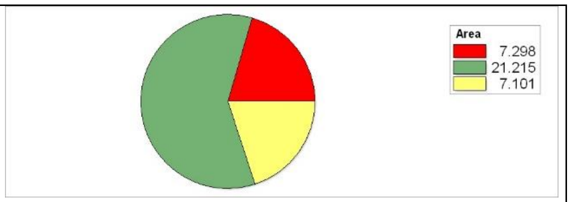
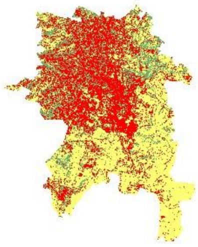
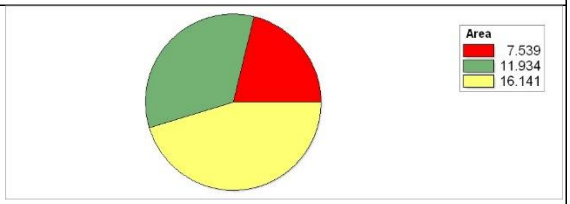
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table 5-9 The development of Hebron city through time

For the settlements, the statistics shows that many of the settlements started existing between 1998 and 2002, and its artificial surfaces area grew rabidly, some of them already existed before the study period, but all of them grew rabidly. Some of them were used as an agricultural lands were the agricultural area got bigger through time, as a proof that the land was used for planting and agricultural purposes, some of them were mainly occupational, for these settlements grew in the artificial surfaces more than the agricultural side due to their spatial position.

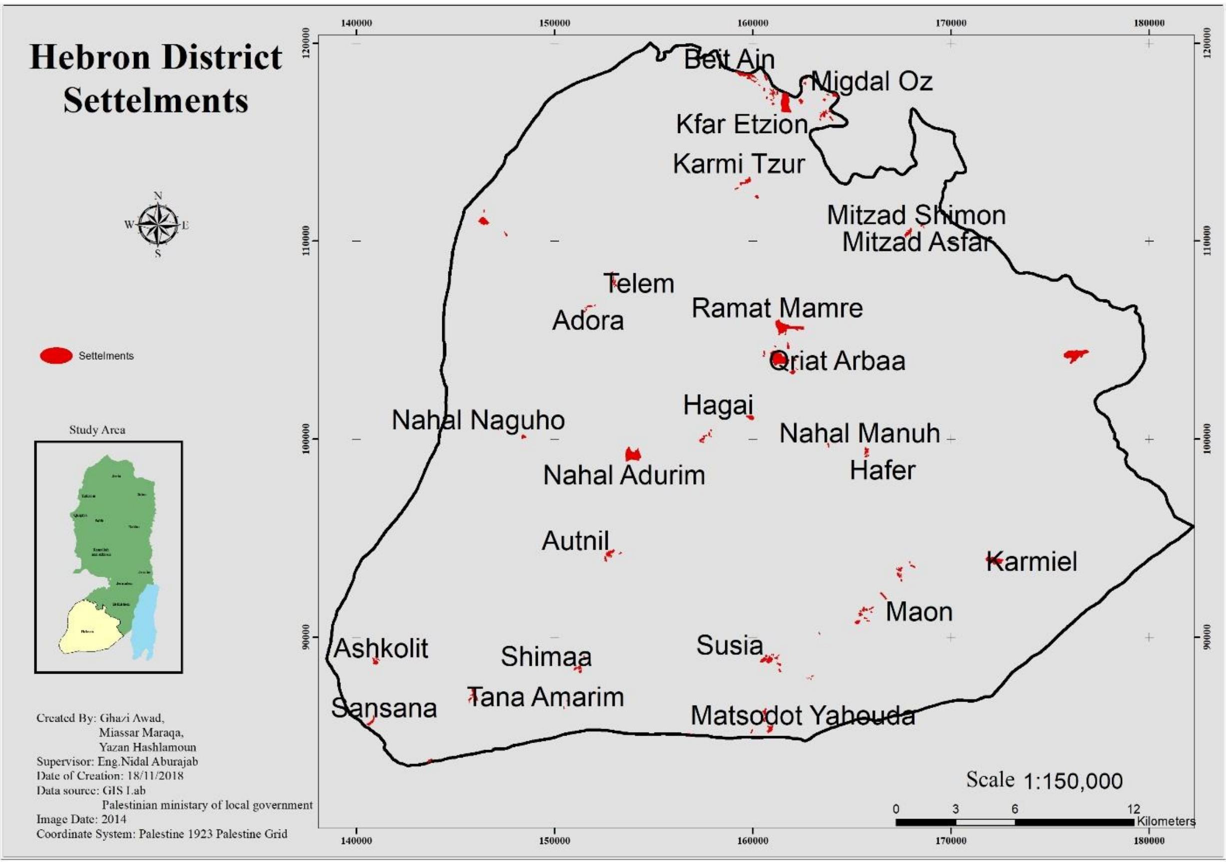
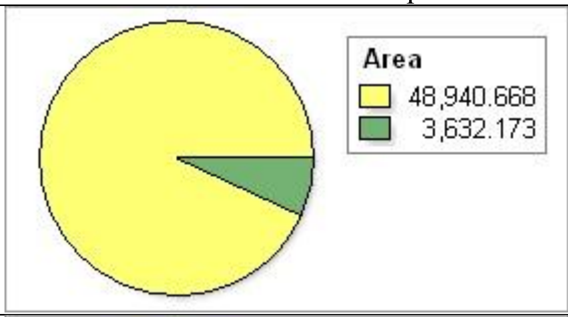
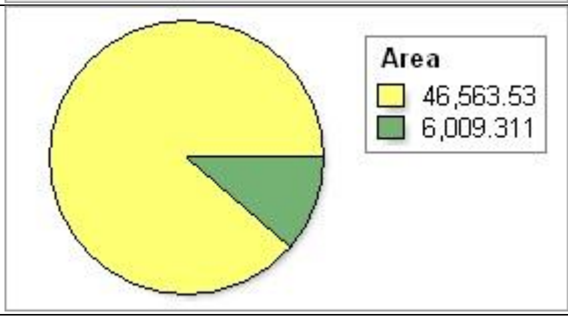


Figure 5-13 Israeli settlements sites at Hebron district

As an example for the settlements that didn't exist until later on is Adora settlement:

Year	Classification	Statistics "Areas are in meter square unit"
1984 Landsat 5		
1998 Landsat 5		

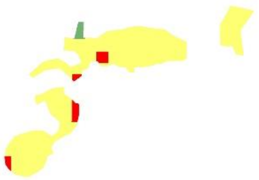
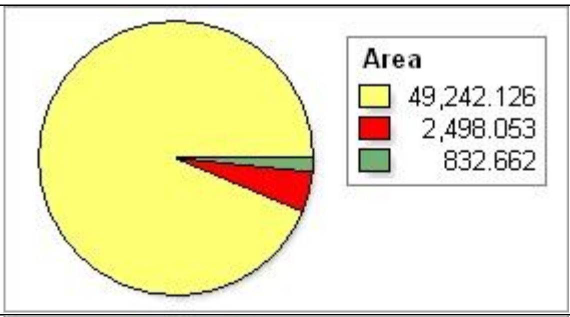
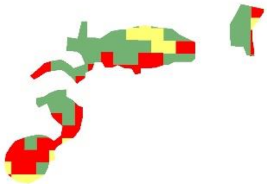
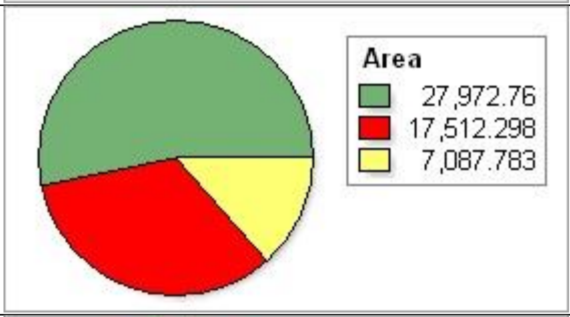
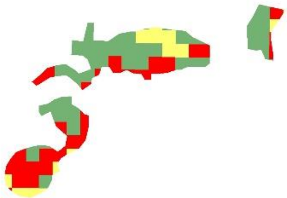
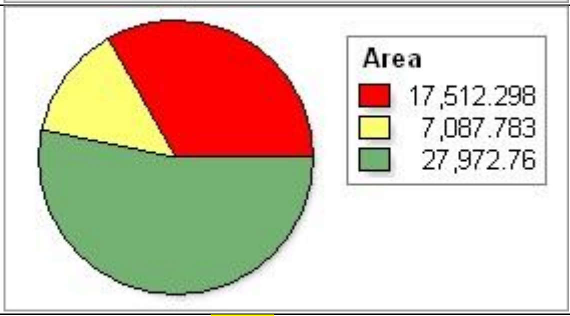
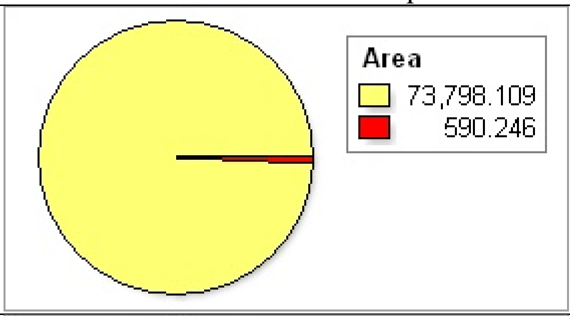
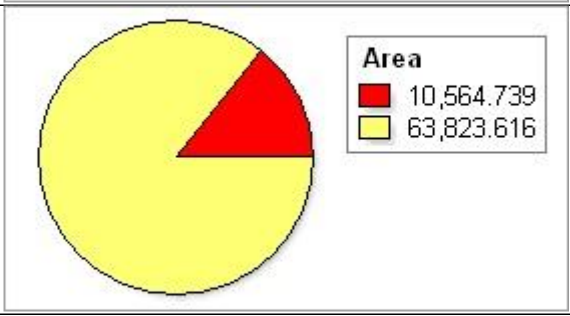
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table 5-10 The development of the Adora settlement through time

And as an example of a settlement that grew just in the artificial surface is the ashkolit Settlement:

Year	Classification	Statistics “Areas are in meter square unit”
1984 Landsat 5		
1998 Landsat 5		

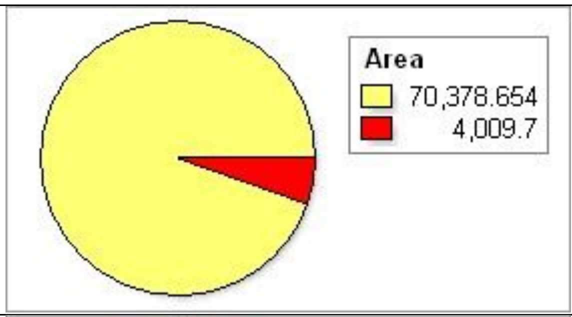
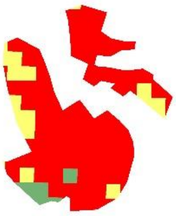
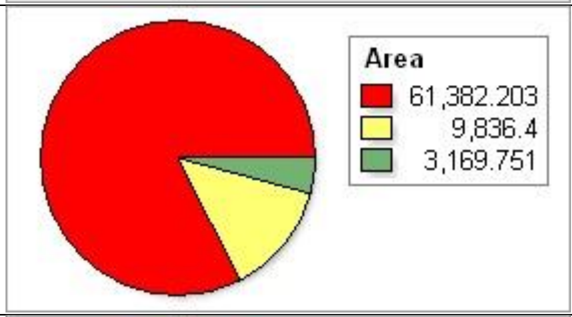
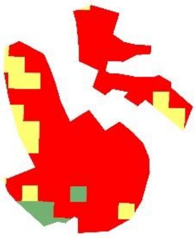
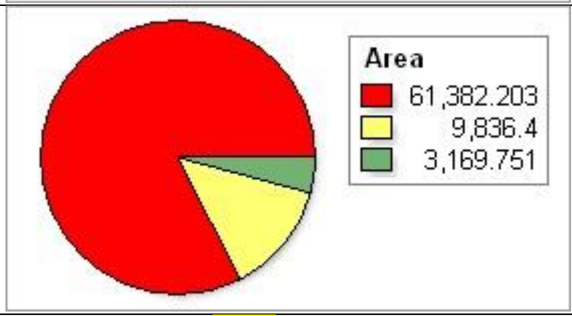
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table 5-11 The development of the Ashkolit settlement through time

For complete statistics of the development of any settlement in Hebron district, see the appendix chapter Appendix A.3.1. The Israeli settlements.

As for the natural reserves, it can be noticed that through time the natural reserves were attacked by the building expansion, and the artificial surface area increased rapidly, especially in the period between 2002 and 2017. The artificial surfaces took a lot of the natural reserves area through time.

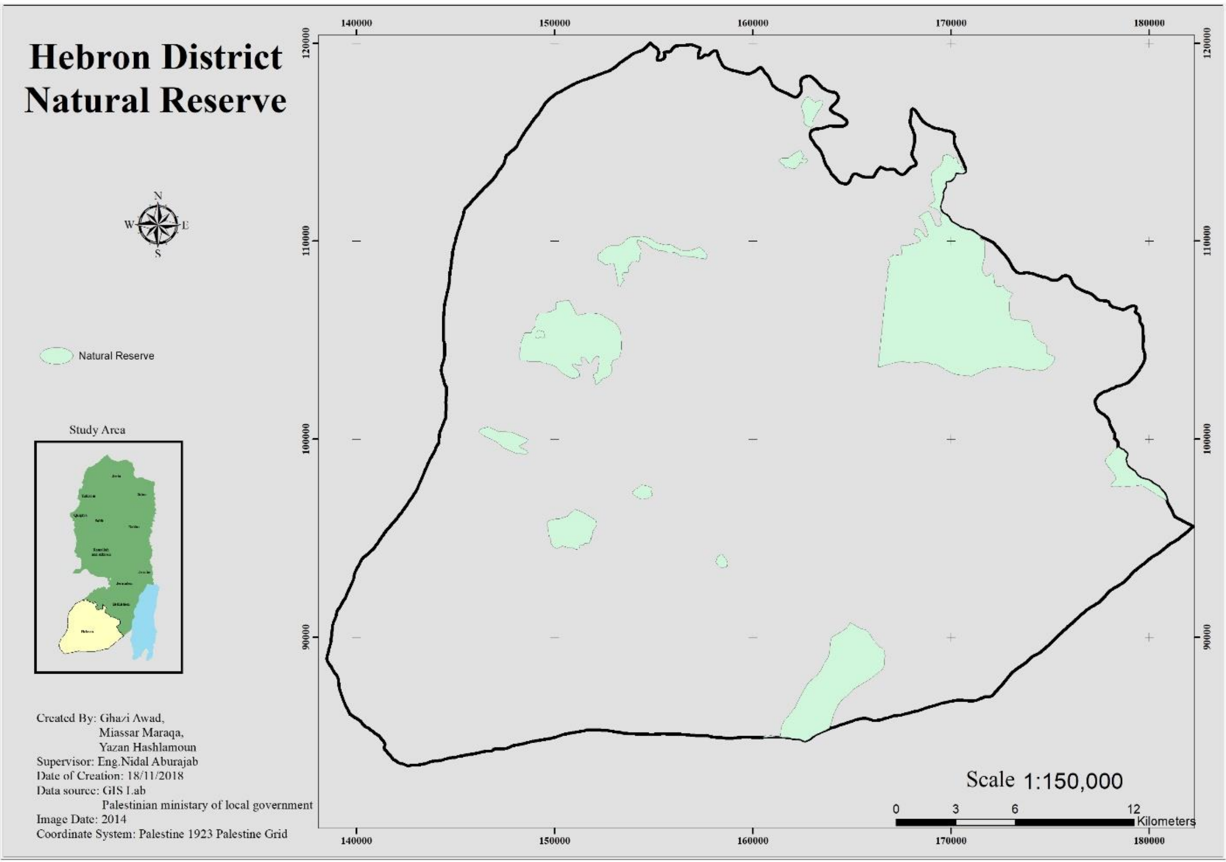
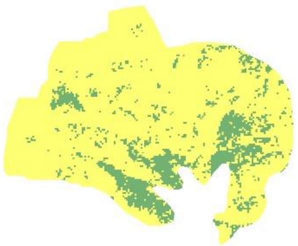
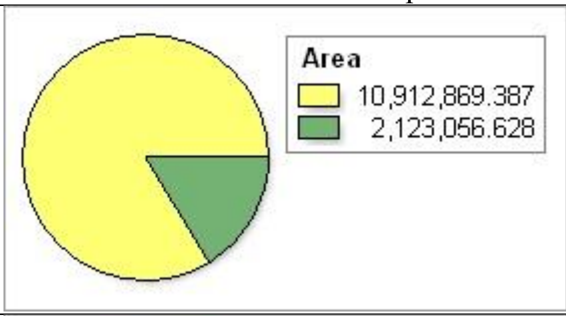
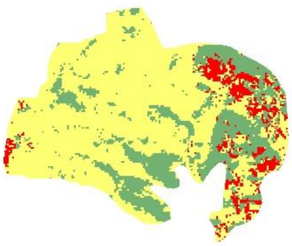
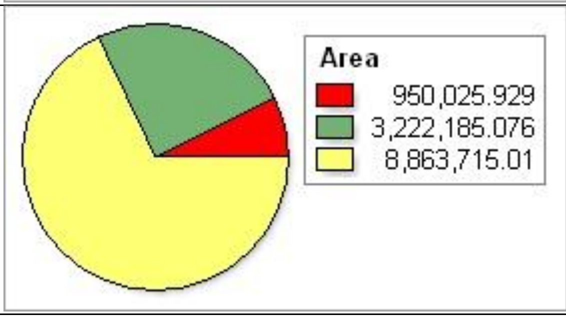


Figure 5-14 Natural reserves sites at hebron district

This is an example of what happened to most of the natural reserves:

For fifth natural reserve:

Year	Classification	Statistics “Areas are in meter square unit”
1984 Landsat 5		
1998 Landsat 5		

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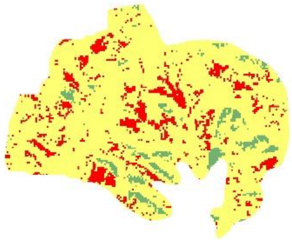
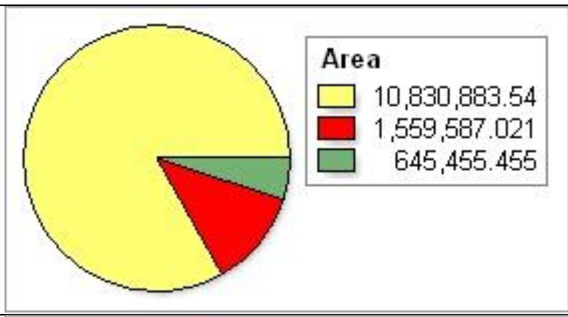
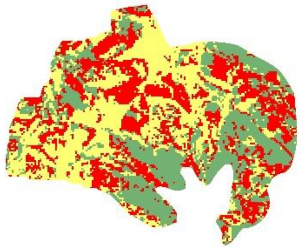
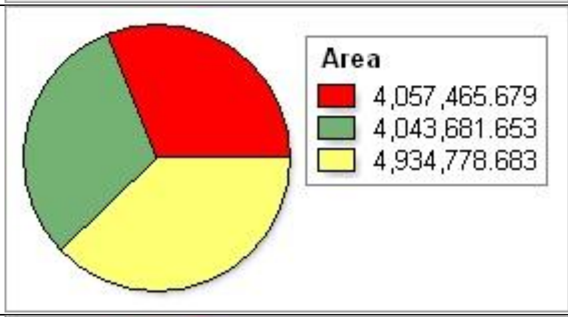
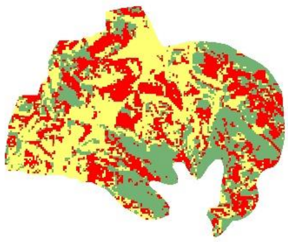
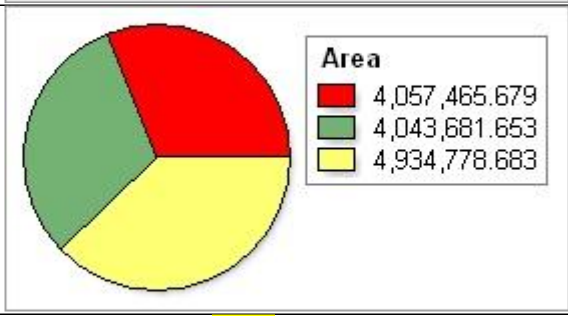
<tr><td>2002 Landsat 7</td><td></td><td>
</td></tr>
<tr><td>2015 Landsat 8</td><td></td><td>
</td></tr>
<tr><td>2017 Sentinel 2</td><td></td><td>
</td></tr>
<tr><td colspan="3">Artificial surfaces   Agricultural areas   Forests and seminatural areas</td></tr>
</table>

Table 5-12The development of one of the natural reserves through time

For complete statistics of the development of any natural reserve in Hebron district, see the appendix chapter Appendix A.3.2. Natural reserves.

5.2.3 Built up area expansion

The Built up area expansion was discovered using the raster calculator, as explained in the previous chapter. The buildings was found to expand in the direction of north-west. that is because of the Israeli occupation exists in the east and south borders of Hebron district, due to that and the peoples need of more living areas due to their increasing numbers, they had to expand in the opposite side of the Israeli occupation, and that is the to the north and the east direction. The following figures explains the building expansion:

Note that the red areas are the existing building, and the black areas are the Built up area expansion.

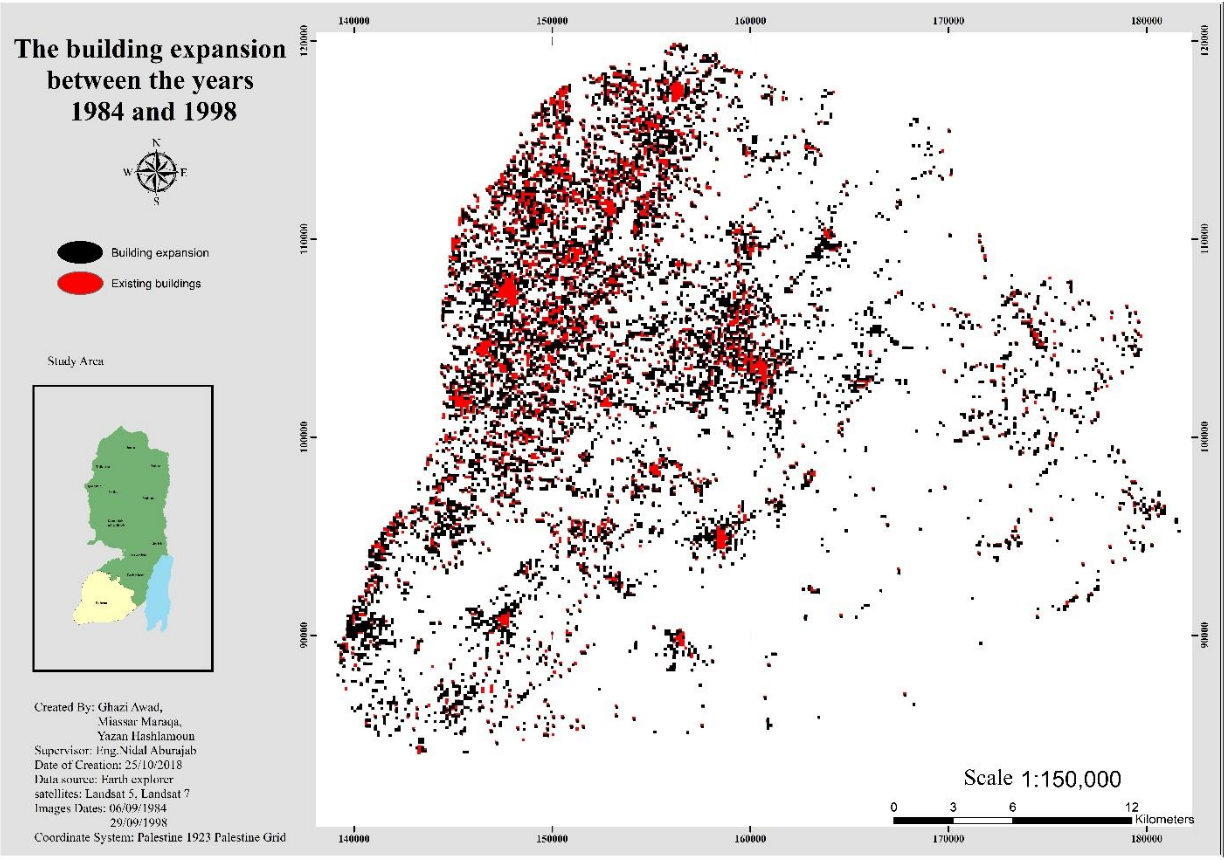


Figure 5-15 The building expansion between the years 1984 and 1998

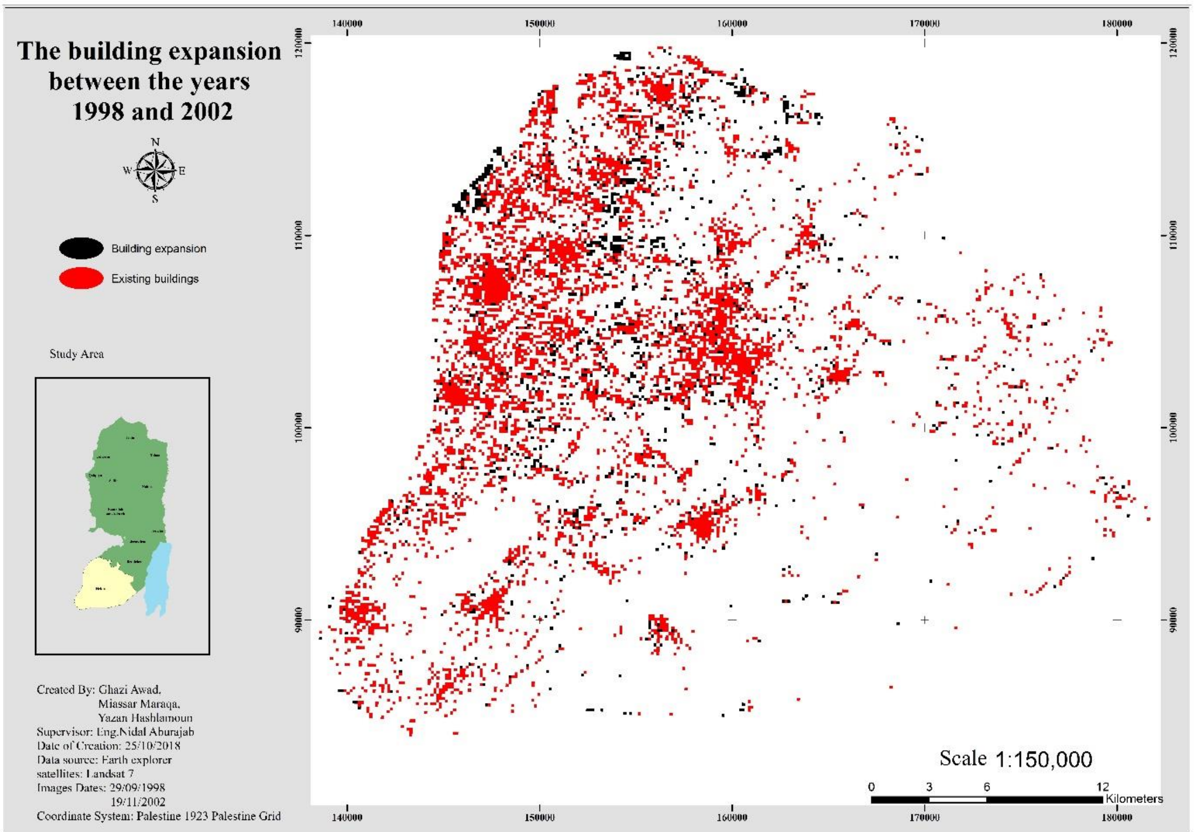


Figure 5-16 The building expansion between the years 1998and 2002

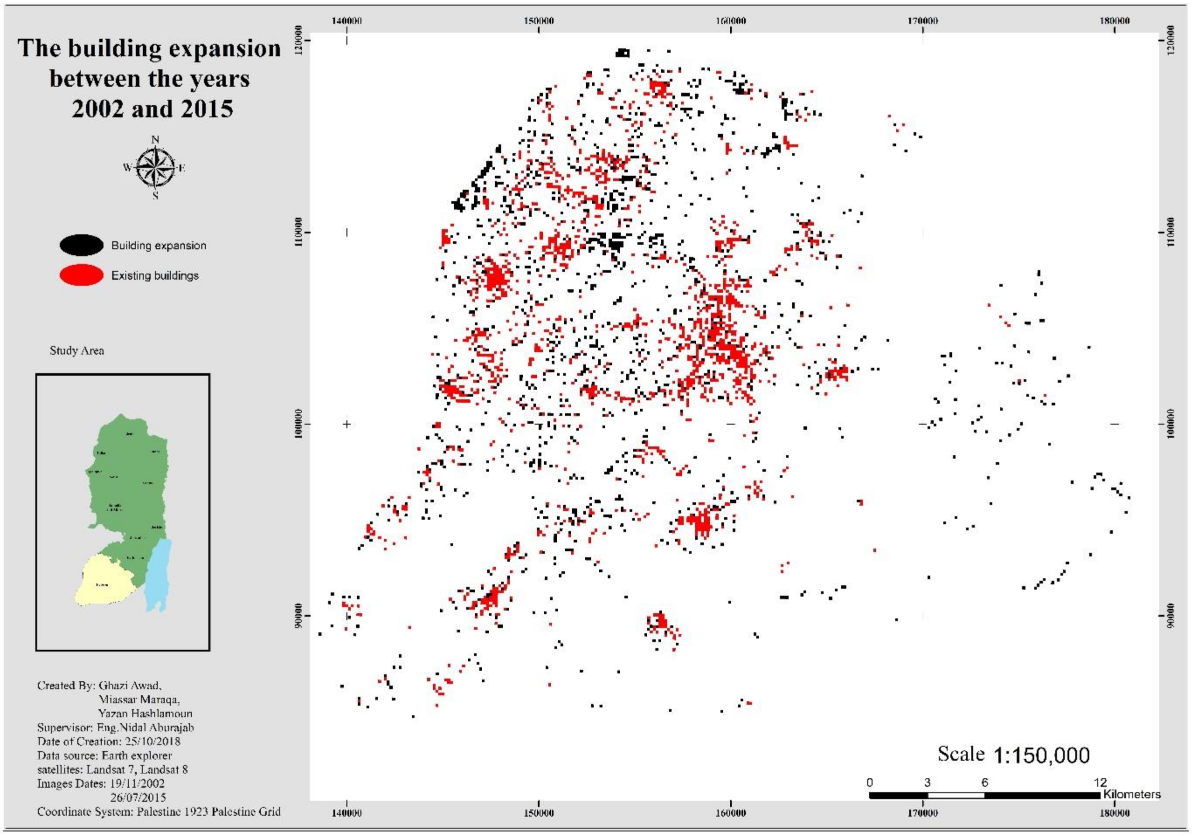


Figure 5-17 The building expansion between the years 2002 and 2015

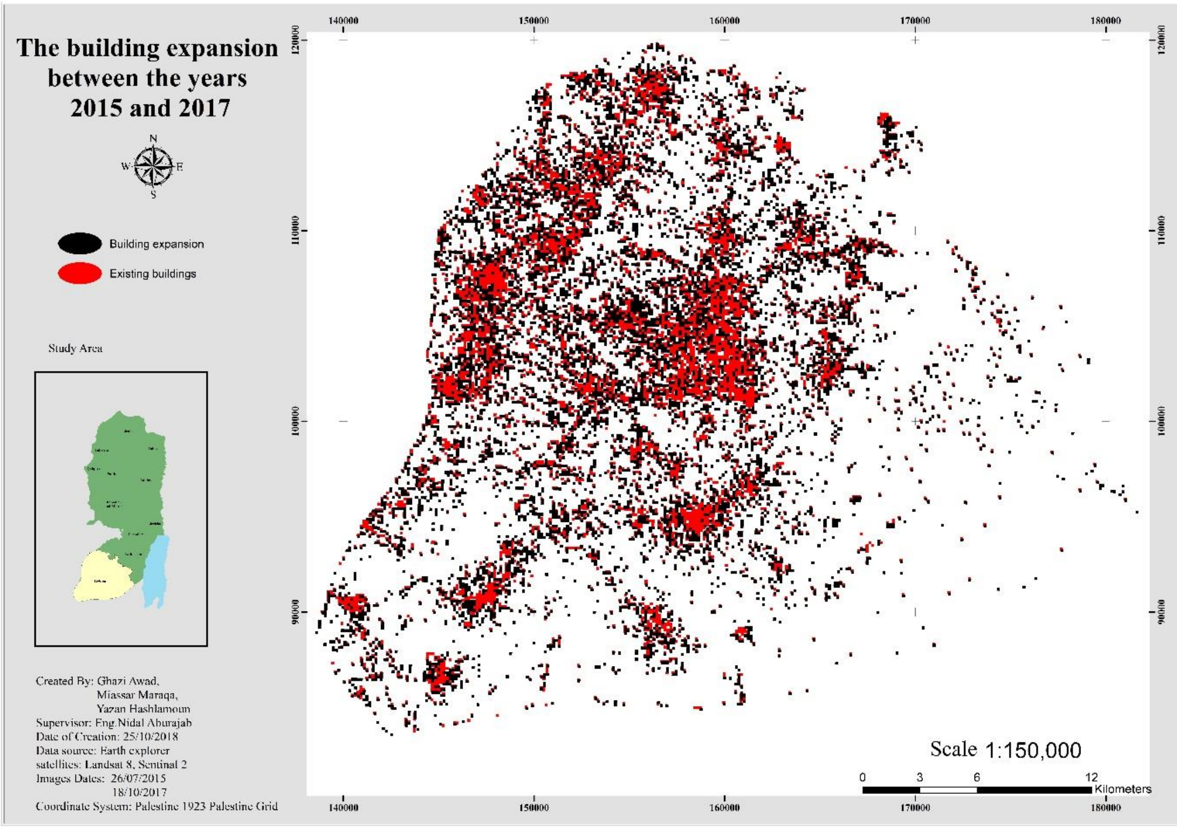


Figure 5-18 The building expansion between the years 2015 and 2017

Therefore, the increase in buildings from 1984 to 2017 was:

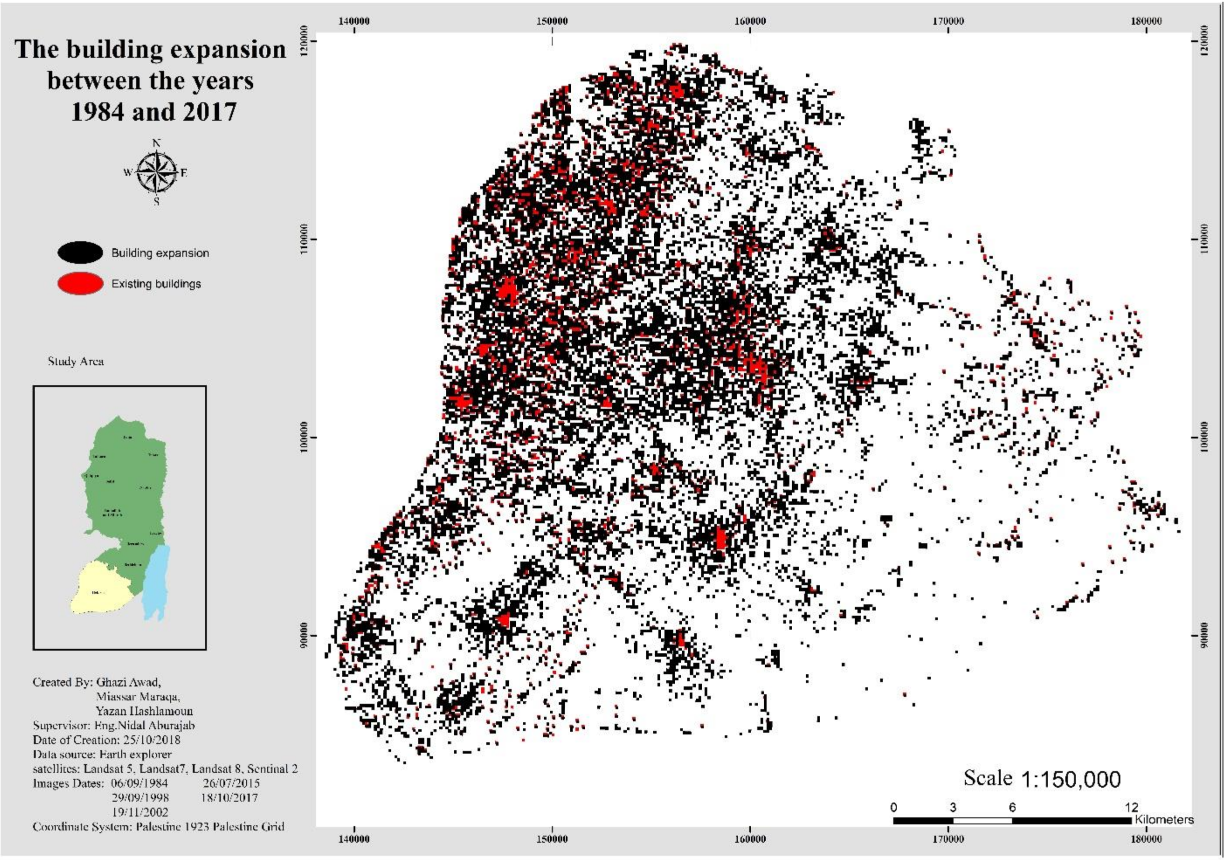
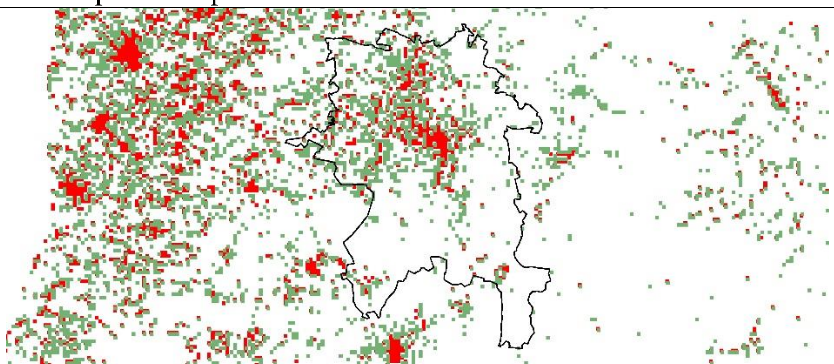
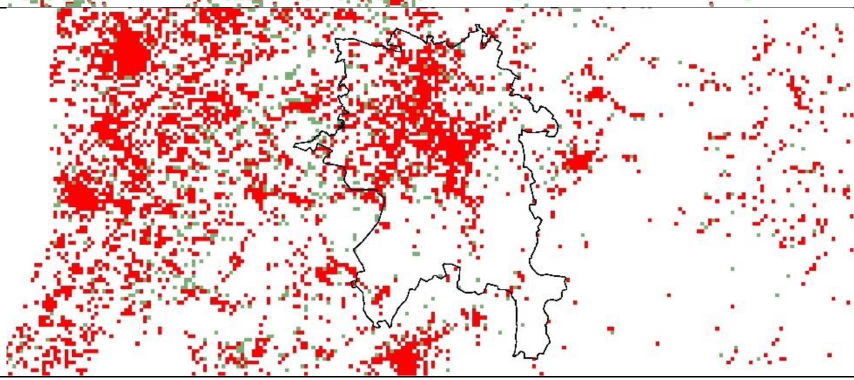


Figure 5-19 The building expansion between the years 1984 and 2017

For a more detailed example, this is the building expansion for Hebron city:

From year to year	Built up area expansion
From 1984 to 1998	
From 1998 to 2002	

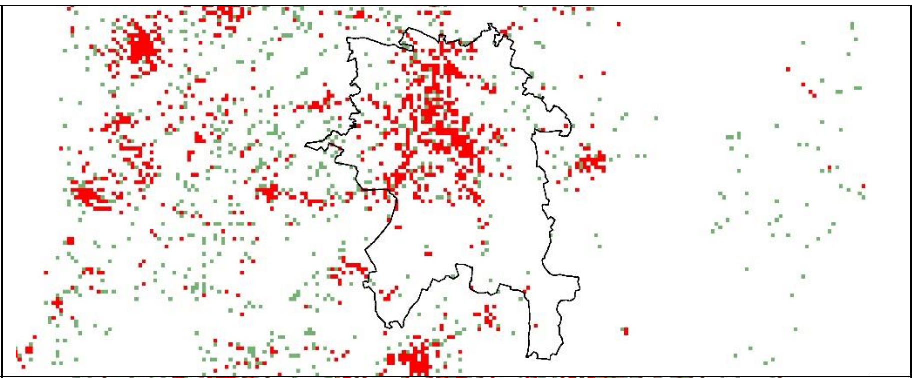
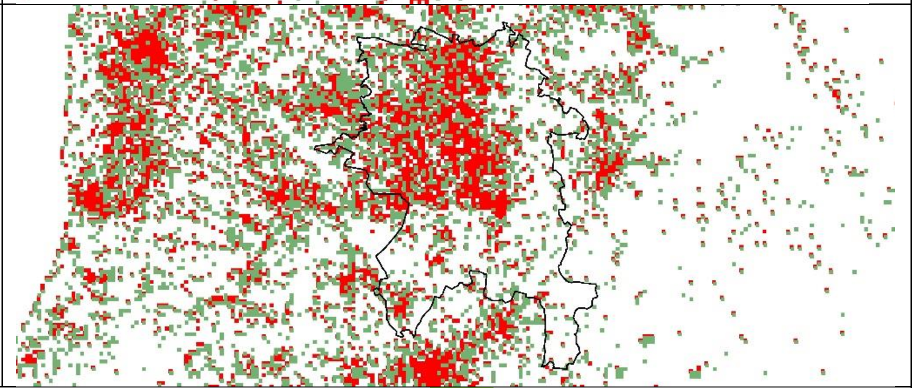
From 2002 to 2015	
From 2015 to 2017	
Existing Buildings	Built up area expantion

Table 5-13 The building expansion of Hebron city between 1984 and 2017

5.3 Land use

After acquiring the needed data, and digitizing the missing data, a land use map was acquired with these categories:

- Forests
- High value agricultural lands
- Medium value agricultural lands
- Low value agricultural lands
- Built up areas
- Roads
- Israeli settlements
- Natural reserves

The resultant map was:

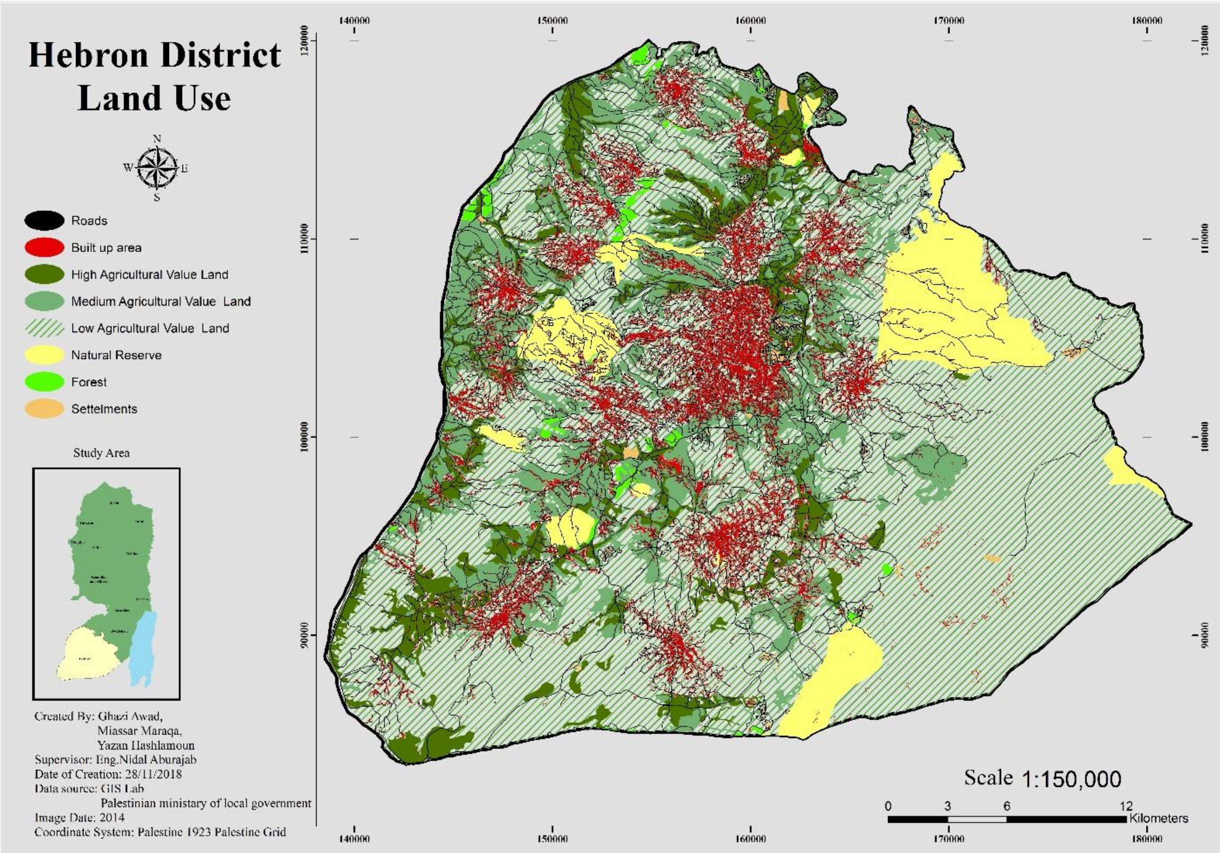
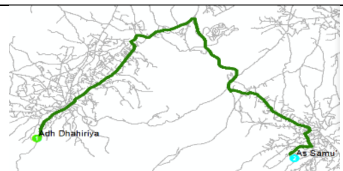


Figure 5-20 Hebron district land use

5.4 Network analysis

In order to test and improve the efficiency of the road network, the road center lines of Hebron district was digitized, then a road network was created, and to test the efficiency the center of the city and towns was created, then the best route between them was created, and the travel time and distance has been had. The existing road network suffers from the unnecessary turns that makes the distance longer, and the lack of highways, which makes the travel time longer. For example, the next table shows some of the results of the network analysis process:

First point	Second point	Total travel distance “meter”	Total time “minuets ”	Shortest path
Ad-Dahria	As-Samu’	17982.3	13	
As-Samu’	Yatta	13714.4	10	

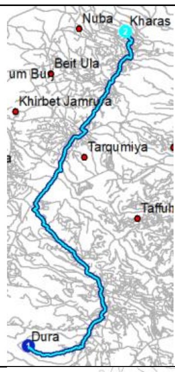
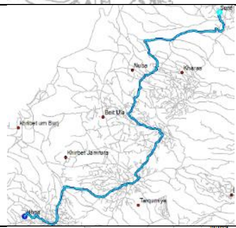
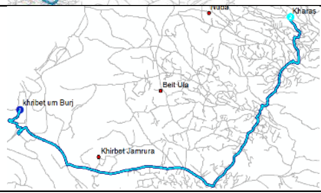
Dora	Kharas	23651.6	25	
Idhna	Surif	21718.3	18	
Khirbet Um Burj	Kharas	13838.3	11	

Table 5-14 Network analysis results of the existing road network

For complete results of the network analysis, go to the appendix chapter and look at Appendix A.3 part.

5.5 Facility study results

After digitizing the current facilities, the falsities current states were studied, and a service area was created for each of them, these facilities were schools, dumping sites, and hospitals.

As for schools the schools were divided into male and female schools, due to the Islamic nature and the habits in Hebron district, and each of them were studied separately. The male schools was found to serve 82.91 percent of the built up area, so 17.09 percent were not served, due to the bad distribution of the schools in Hebron district.

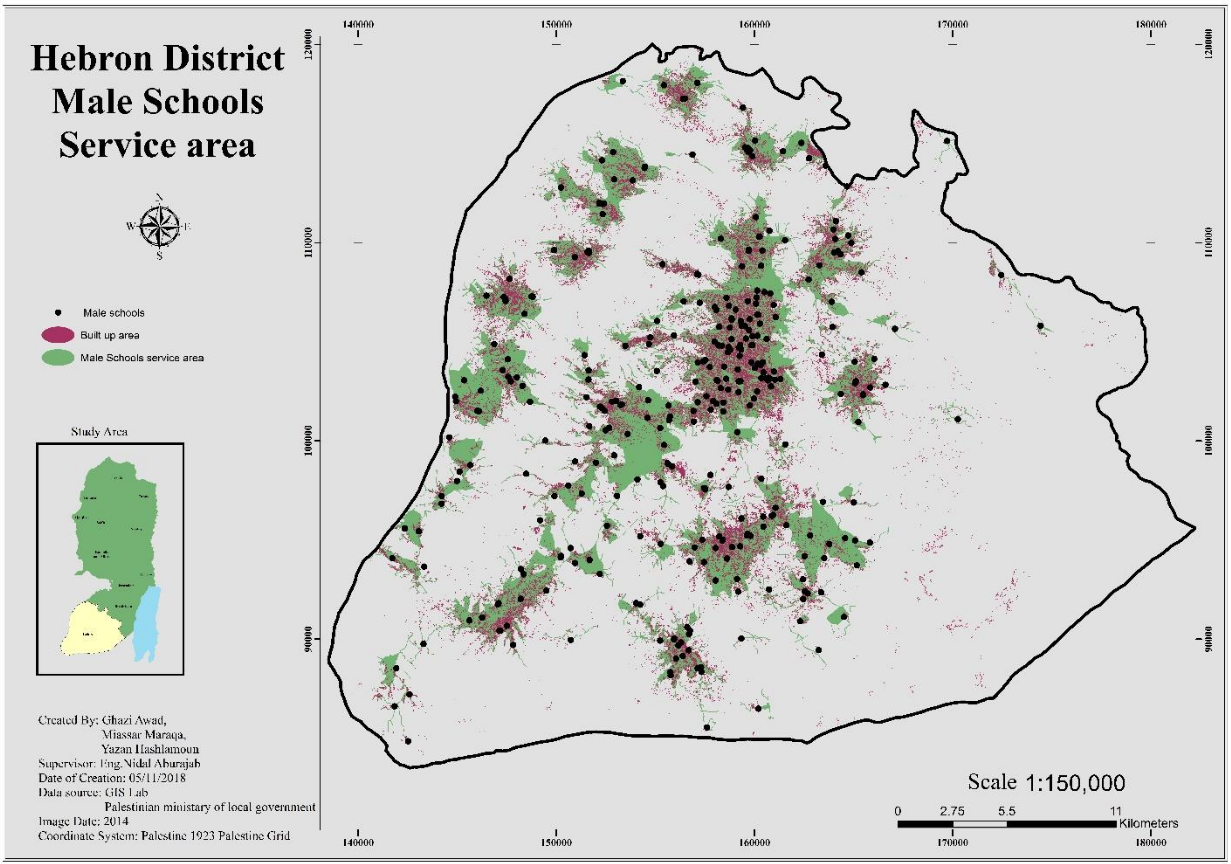


Figure 5-21 Hebron district male schools service area

The female schools was found to serve 81.92 percent of the built up area, so 18.08 percent were not served, due to the bad distribution of the schools in Hebron district.

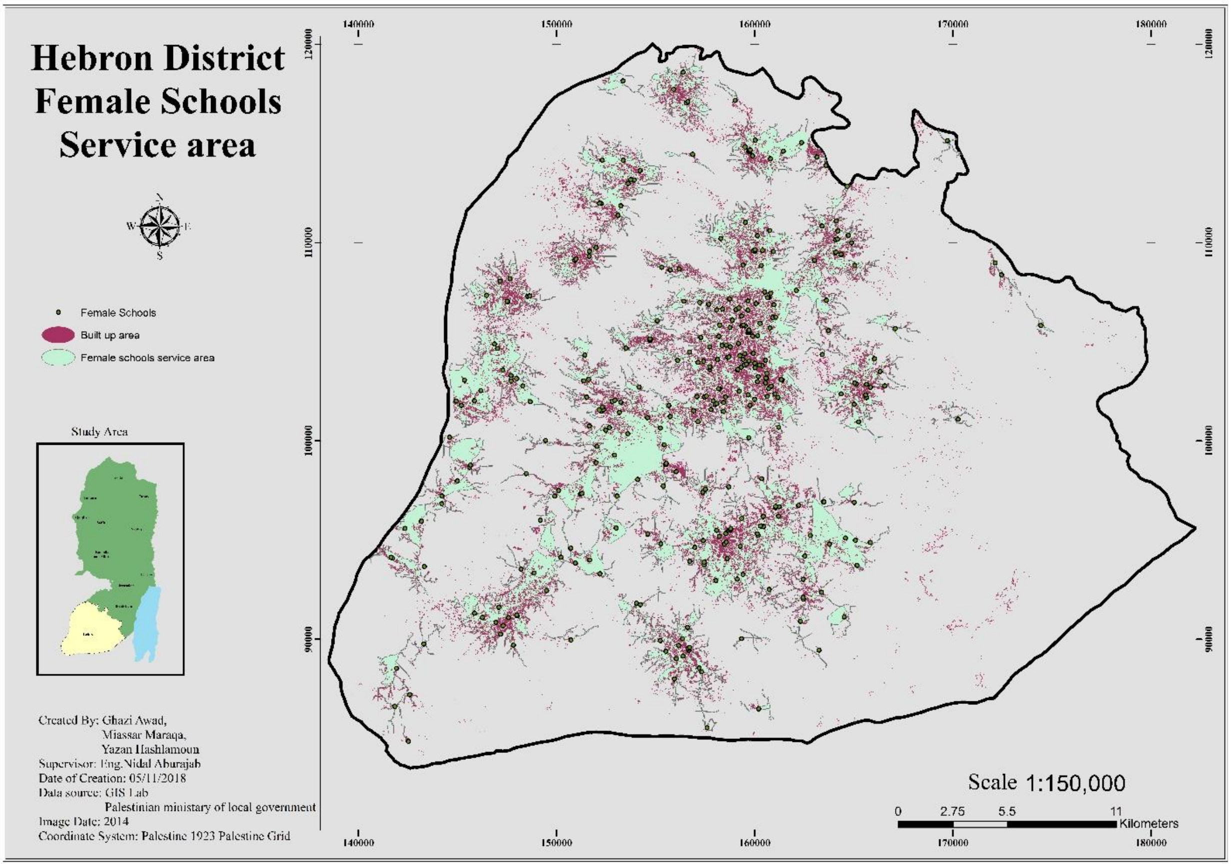


Figure 5-22 Hebron district female schools service area

The hospitals were found to serve 46.38 percent of the built up area, so 53.62 percent were not served, and that is due to the lake of hospitals in Hebron district, and the existing ones are concentrated in the city and certain places.

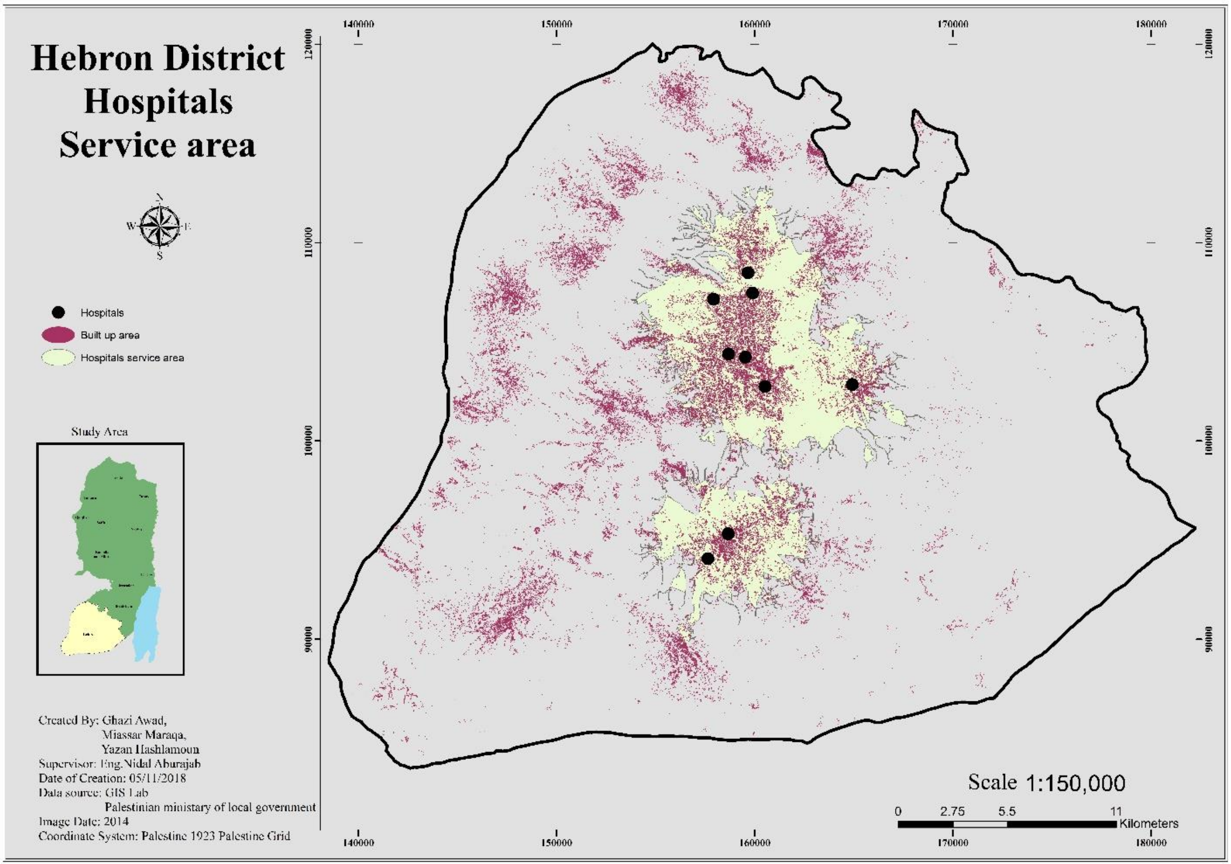


Figure 5-23 Hebron district hospitals service area

The Dumping sites were found to serve 46.47 percent of the built up area, so 53.53 percent were not served, and that is due to the lake of Dumping sites in Hebron district.

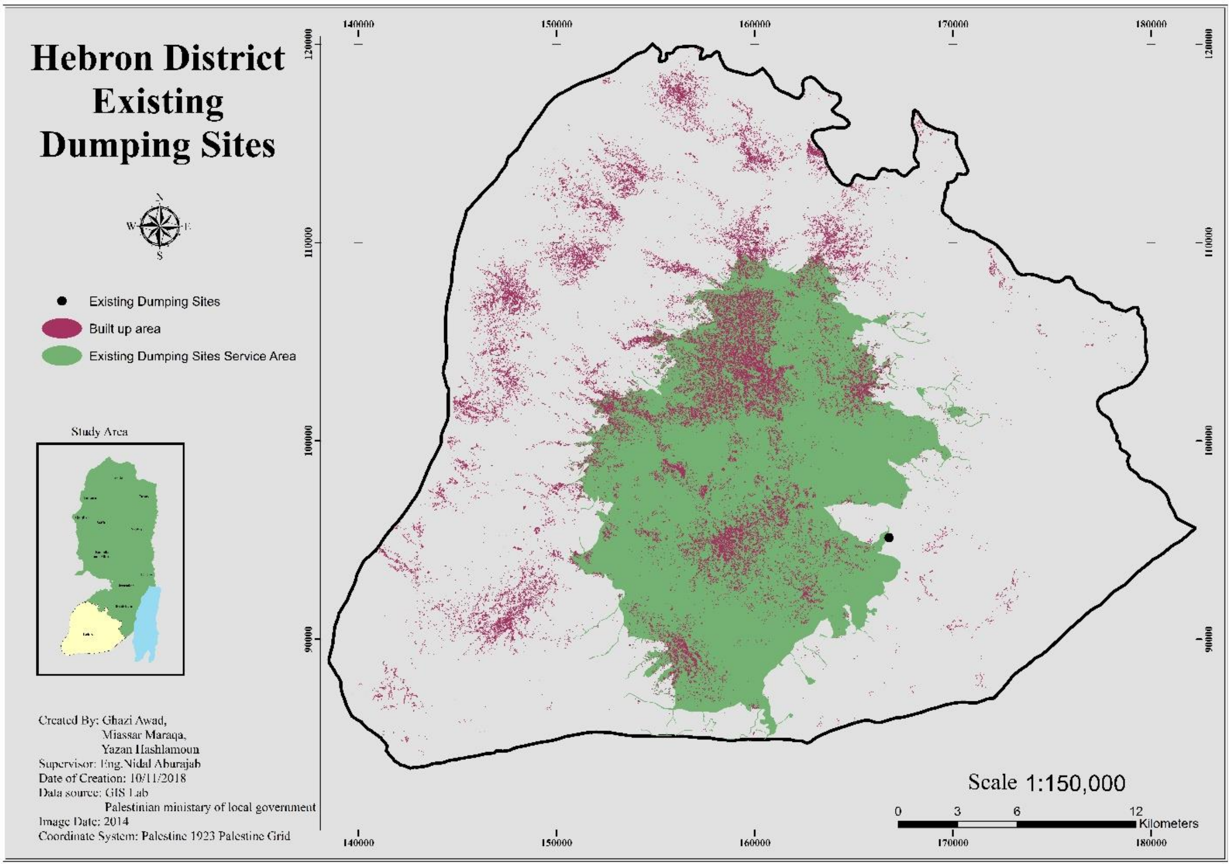


Figure 5-24 Hebron district Dumping sites service area

6. Suggested plans

6.1 introduction

6.2 Suggested road network

6.3 Suggested facilities

6.1 Introduction

After analyzing the existing roads and facilities, and in order to improve on the existing roads and facilities, future plans and suggestions were made according to the analysis results that was explained in the previous chapter. This chapter explains the suggested plans that were made in this project.

6.2 Suggested road network

Using the conditions that were explained in the sustainable planning using GIS and RS chapter in the roads part suggesting new centerline for roads, the land use map, and the contour map, new roads were suggested, and new road network were made, the next image shows the new road network.

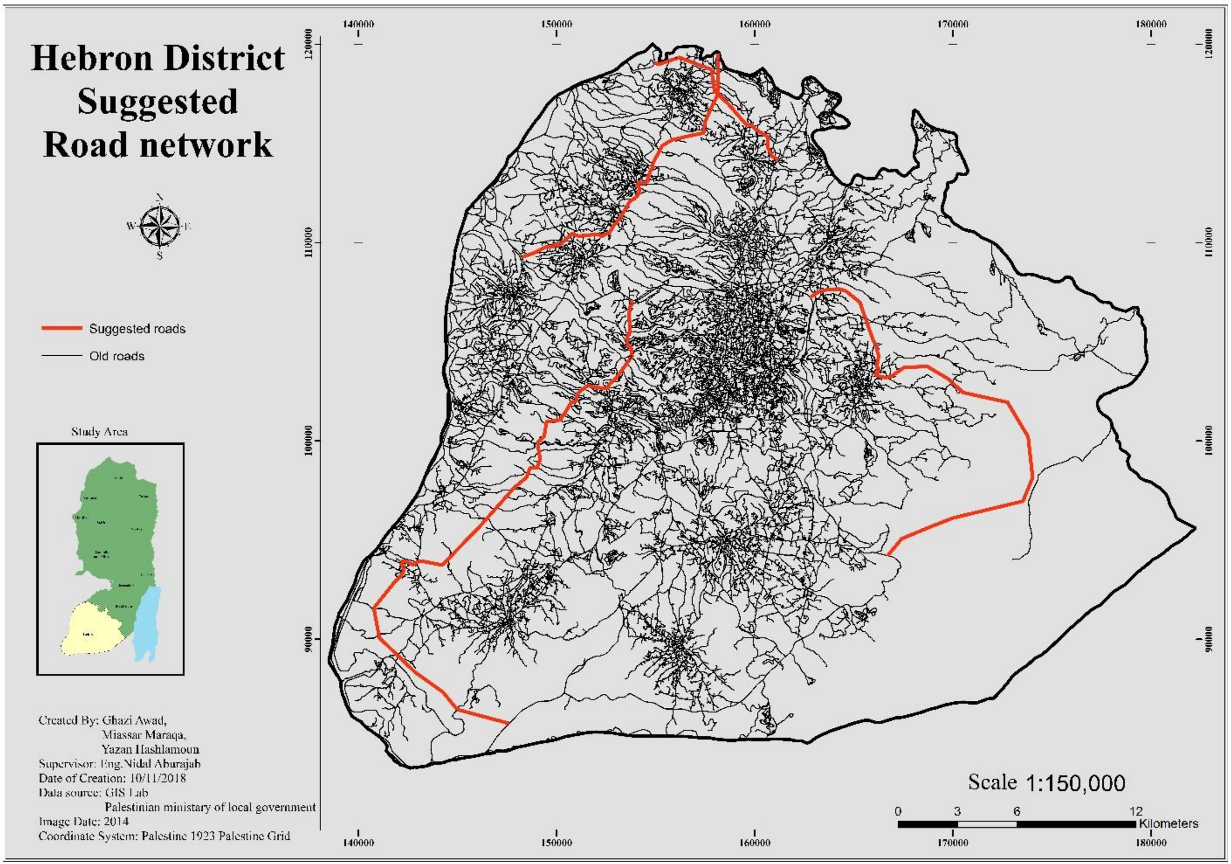


Figure 6-1 Suggested road network

6.2.1 Analysis of the new road network

In order to test the new road network efficiency, the network was analyzed and studied to see what land use it took, if it achieves the conditions of the new roads, and if it improves on the existing network.

For the achievement of conditions and land use taken, the roads were found out to achieve the road conditions, as the new roads stayed away from archeological sites, 0.03 percent from the new road area was built up area, 1.69 percent of the new road area was land of high agricultural value, 79.28 percent of the new road area was land of low agricultural value, 17.61 percent of the new road area was land of medium agricultural value, 1.38 percent of the new road area was intersections with existing roads, so the roads achieves the new road conditions.

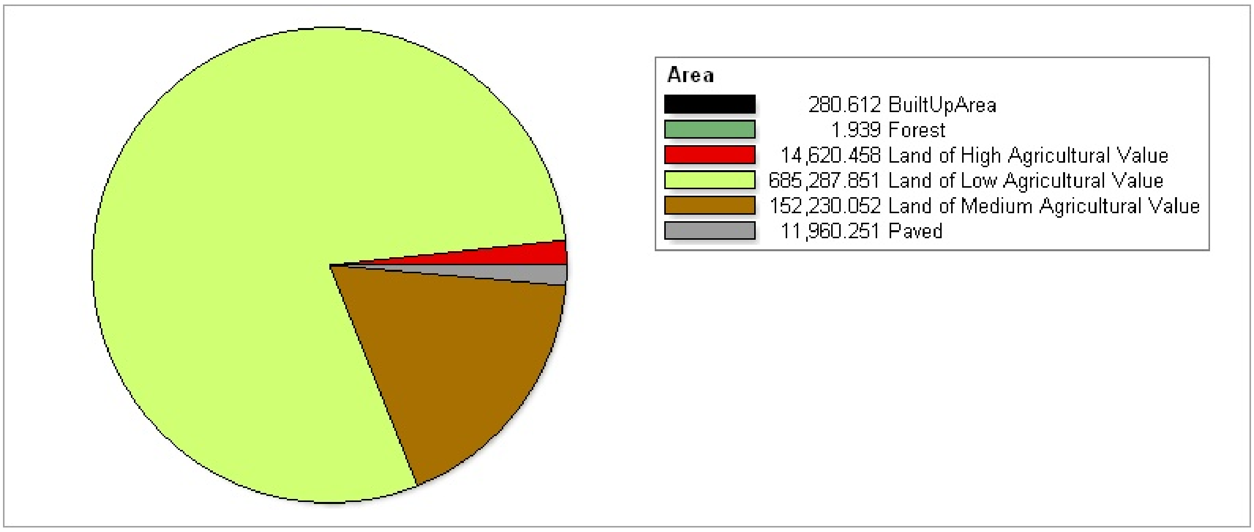
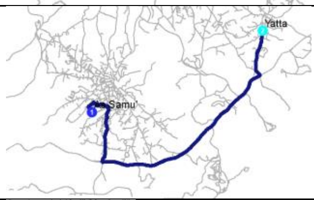
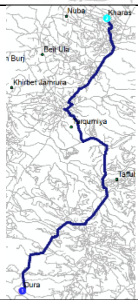
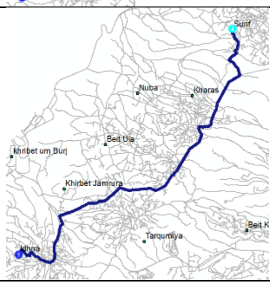


Figure 6-2 How much the new road takes from each part of the land use

As for the improvement on the old network, a new network analysis was made on the new road network, and the results were explained in the next table.

First point	Second point	Total travel distance “meter”	Total time “minuets ”	Shortest path
Ad-Dahria	As-Samu’	17860.3	12	
As-Samu’	Yatta	13668.3	10	
Dora	Kharas	22292	17	
Idhna	Surif	17574.7	14	

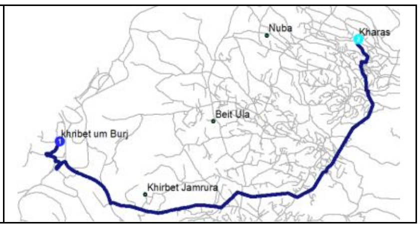
Khirbet Um Burj	Kharas	13257.5	10	

Figure 6-3 Network analysis results of the suggested road network

This shows that the new road network improves a lot on the existing, as most of the distances and time to reach the next point decreased a lot.

6.3 Suggested Facilities

This part of the chapter includes suggestions of new sites of the facilities that were studied earlier in this project, these facilities were schools that was divided into male schools, and female schools, hospitals, and dumping sites.

6.3.1 Male schools

Male schools were suggested according to the school conditions that were explained in the sustainable planning using GIS an RS chapter, facility study, conditions part. Following these conditions 86 new school sites were suggested.

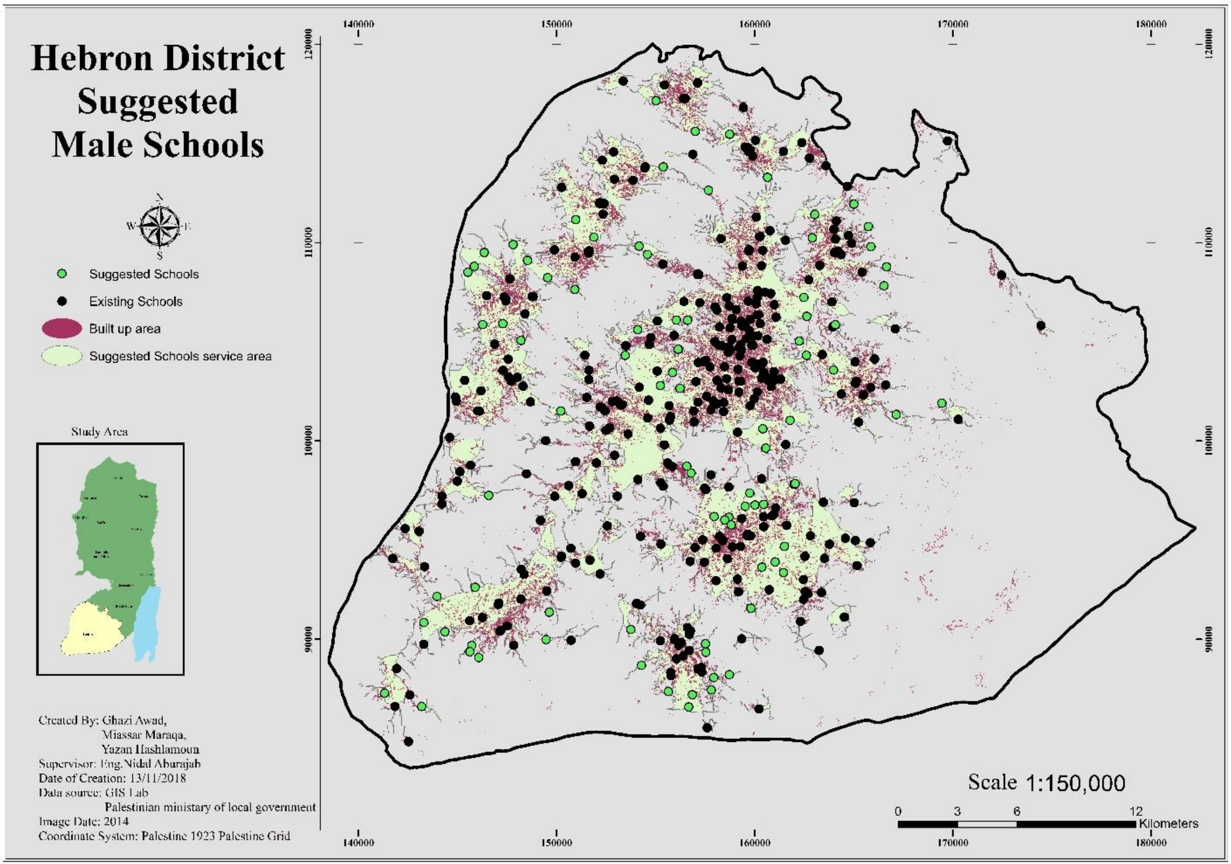


Figure 6-4 Hebron district Suggested male schools and their service area

After adding these 86 new schools, the school served 95.16 percent of the built up area, only 4.84 percent left unserved.

6.3.2 Female schools

Female schools were suggested according to the school conditions that were explained in the sustainable planning using GIS an RS chapter, facility study, conditions part. Following these conditions 63 new school sites were suggested.

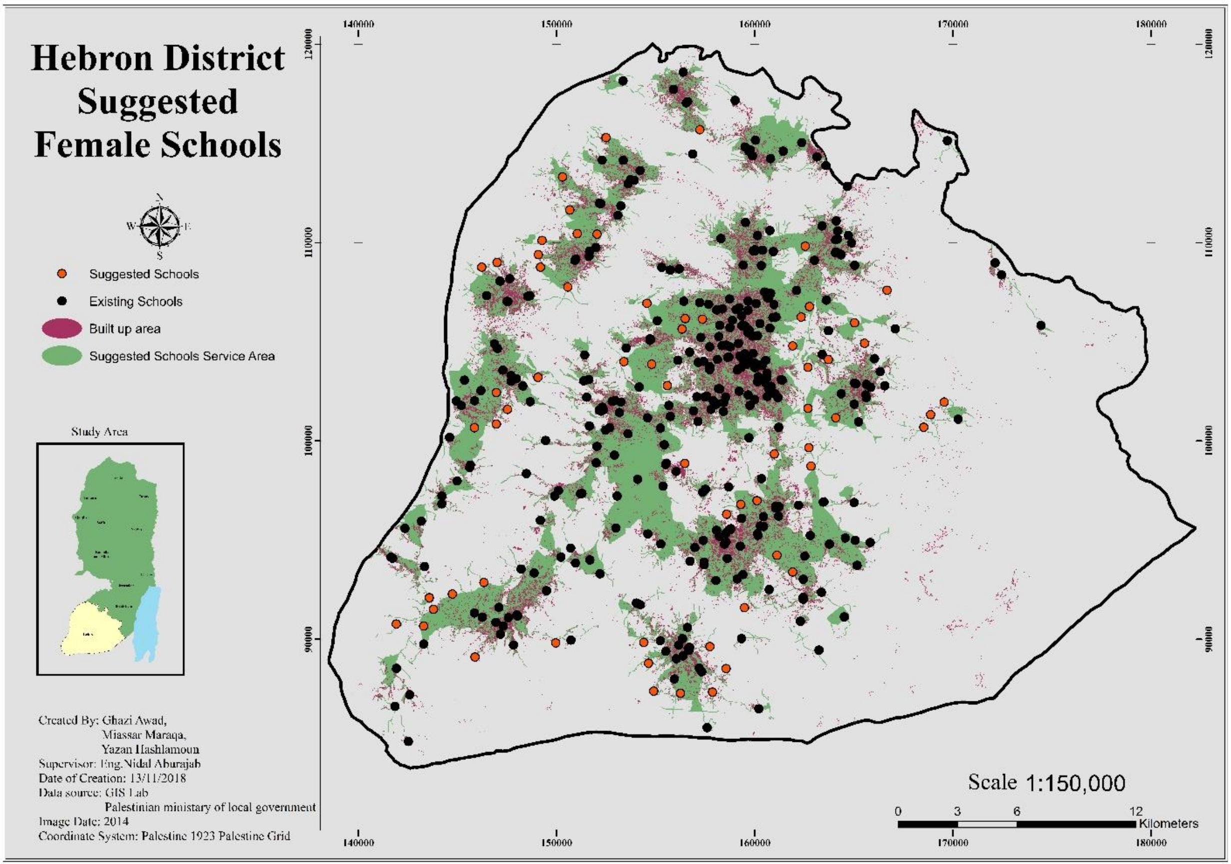


Figure 6-5 Hebron district Suggested female schools and their service area

After adding these 63 new schools, the school served 94.18 percent of the built up area, only 5.82 percent left unserved.

6.3.3 Hospitals

Hospitals were suggested according to the hospital conditions that were explained in the sustainable planning using GIS an RS chapter, facility study, conditions part. Following these conditions 14 new hospital sites were suggested.

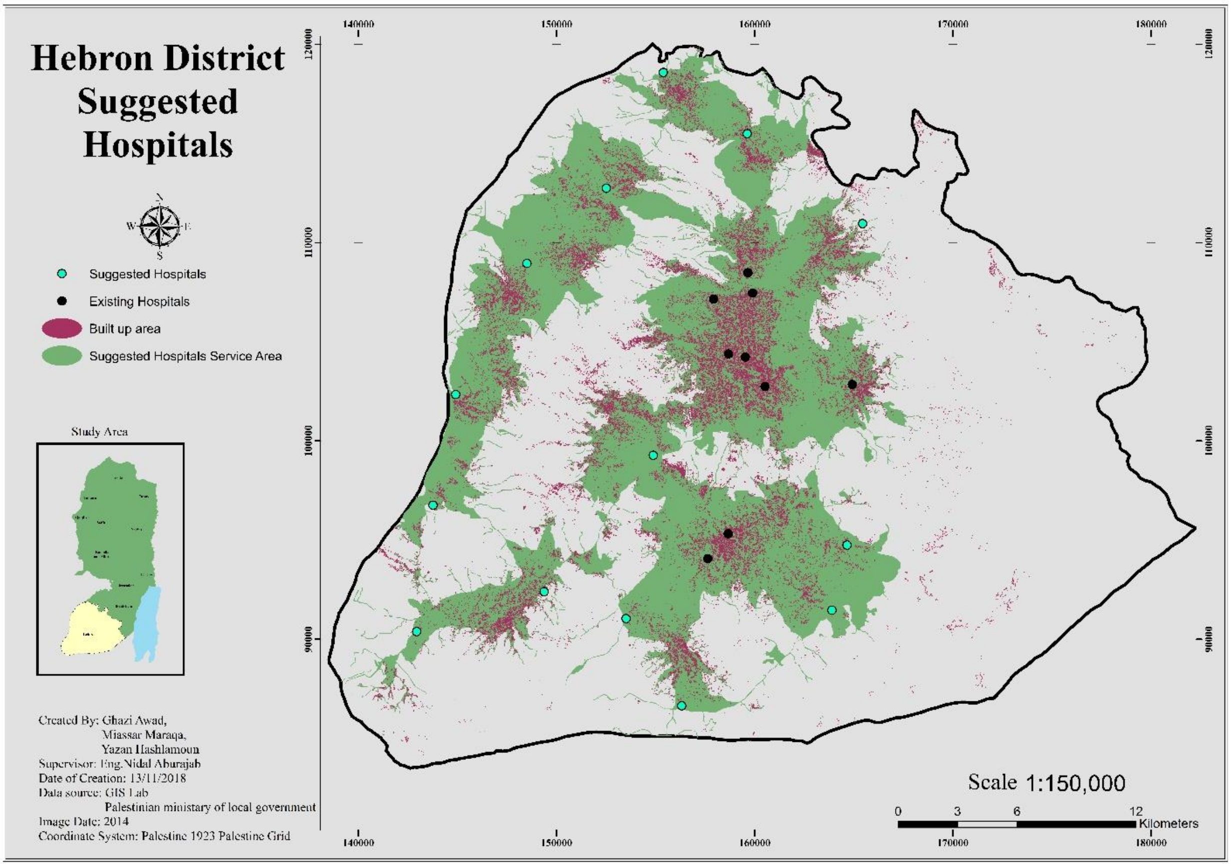


Figure 6-6 Hebron district Suggested hospitals and their service area

After adding these 14 new hospitals, the hospitals served 96.09 percent of the built up area, only 3.91 percent left unserved.

6.3.4 Dumping sites

Dumping sites were suggested according to the dumping sites conditions that were explained in the sustainable planning using GIS an RS chapter, facility study, conditions part. Following these conditions 3 new dumping sites were suggested.

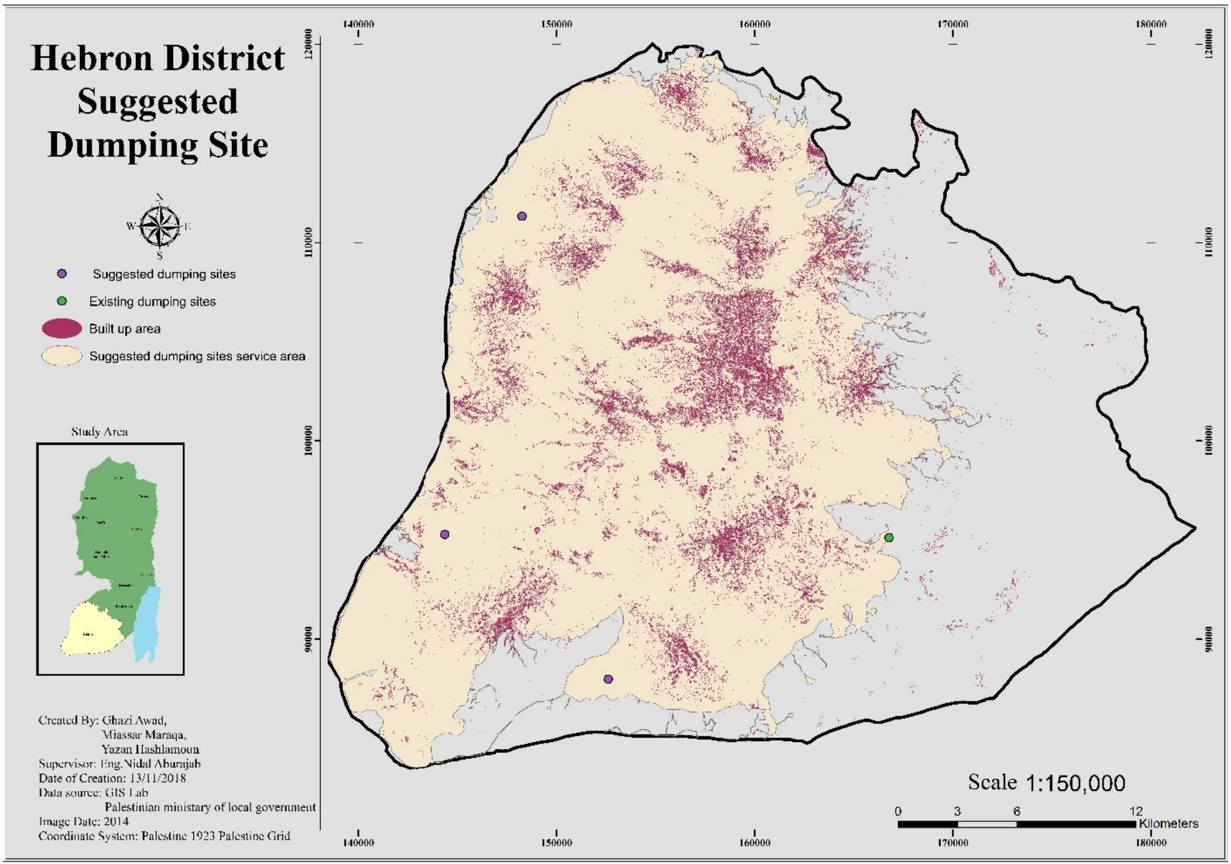


Figure 6-7 Hebron district Suggested dumping sites and their service area

After adding these 3 new dumping sites, the dumping sites served 97.96 percent of the built up area, only 2.04 percent left unserved.

7. Conclusions and Recommendation

7.1 Conclusions

7.2 Recommendations

7.1 Conclusions

From the results of this project, the following were concluded:

1. The built up area of Hebron district expands to the north-east direction, so any future urban planning should take that into consideration.
2. The road network of Hebron district is not well distributed, as the west side of the district lakes in main roads, so the movement on that side is hard, as well as the lake of highways in all the district.
3. The Israeli settlements are expanding rapidly, and taking a lot of the Palestinian lands with it as shown in the appendix chapter, Appendix A.3.1 The Israeli settlements.
4. The natural reserves are being badly violated as shown in the appendix chapter, Appendix A.3.2 Natural reserves.
5. The male and female schools of Hebron district are large in numbers, but very badly distributed, so they don't serve as much as they should.
6. The hospitals of Hebron district are focused in Hebron city, and Yatta town, and not very well distributed, so the rest of the towns needs to reach the city for medical care.
7. There is only one dumping site in Hebron district, which was found to serve 46 percent of the built up area, as mentioned in the analysis and results chapter, facility study results part of the chapter.

7.2 Recommendations

In the end of this project, the following were recommended:

1. It is important to take care of planning Hebron district appropriately and services must be adequate and responsive to the needs of the growing numbers of population.
2. The position of the services must be planned and distributed through the district and suitable for the population.
3. Government must take care of the natural reserves and organize building expansion
4. Preserve existing natural reserves and create new green spaces within cities and use modern means, such as green houses and green factories.
5. Find a political way out of the political crisis in the country.
6. Restrict and design infrastructure and highways.
7. Starts new projects of hospitals and schools to suit the needs of the population and distributed well according to the population density.
8. Establish modern dump sites that recycle waste and produce energy.

A. Appendix-A

Appendix-A.1 Introduction

Appendix-A.2 Image stacks and statistics

Appendix-A.3 Image classification results

Appendix-A.4 Network analysis results

Appendix-A.5 Suggested road network analysis results

Appendix-A.6 Primary maps and data

Appendix-A.1 Introduction

In the previous chapters, the basic knowledge and science behind the methods that were used in this project was explained, furthermore, the methodology and the results of the project were explained. This chapter will include the detailed results that could not be mentioned in the previous chapters.

Appendix-A.2 Image stacks and statistics

This part of this chapter includes all of the image stacks, and statistics that helps to further understanding of the images and bands that were used in this project, and the relationship between the bands.

For the 1984 image the image stake was:

Figure A-1 The 1984 image stack

Its statistics were:

Basic Stats	Min	Max	Mean	Stdev	Num	Eigenvalue
Band 1	31	213	95.367205	25.545754	1	1553.706896
Band 2	34	167	73.720825	17.736721	2	21.017764
Band 3	77	255	131.205934	24.666575	3	0.892053

Table A-1 The 1948 image basic statistics

Covariance	Band 1	Band 2	Band 3
Band 1	652.585526	449.562203	609.1526
Band 2	449.562203	314.591256	431.895158
Band 3	609.1526	431.895158	608.439931

Table A-2 The 1984 image covariance matrix

Correlation	Band 1	Band 2	Band 3
Band 1	1	0.992197	0.966715
Band 2	0.992197	1	0.98718
Band 3	0.966715	0.98718	1

Table A-3 The 1984 image correlation matrix

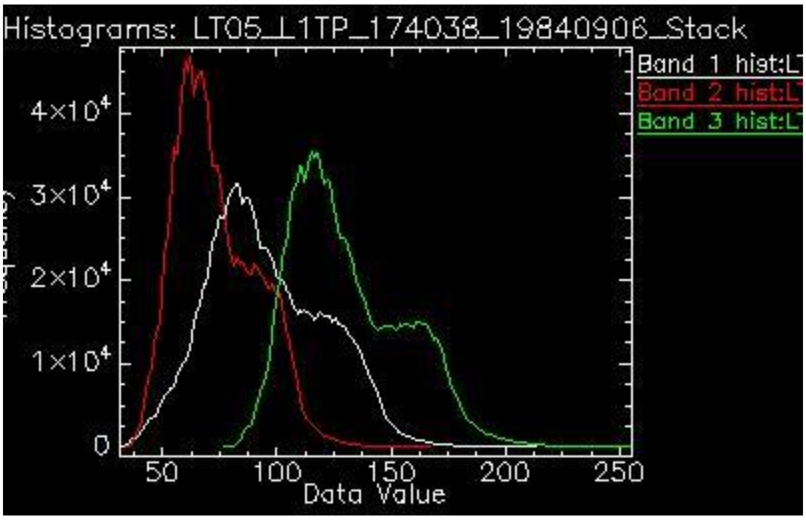


Figure A-2 The 1984 image histogram plot

As for the 1998 image, the image stack was:

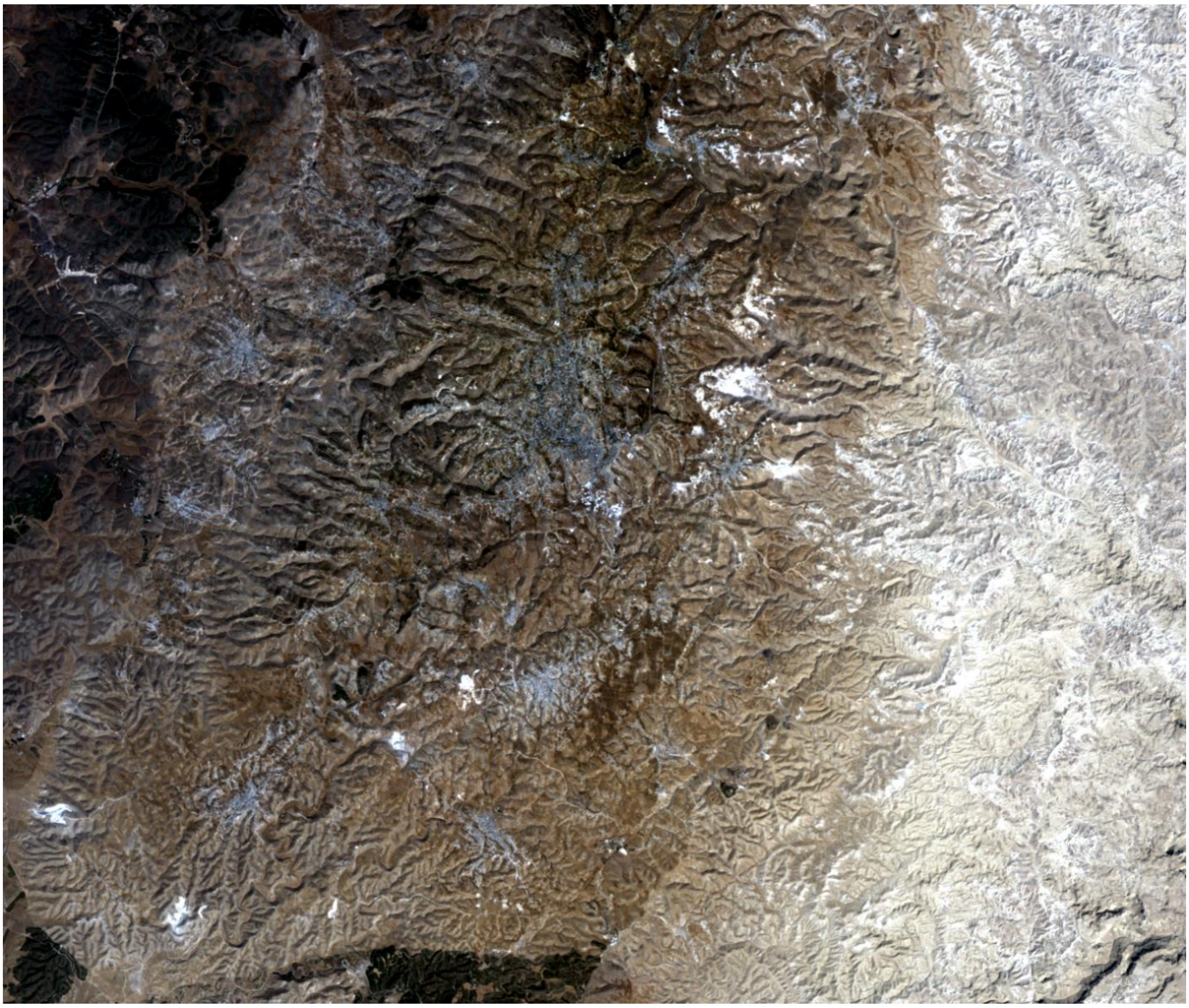


Figure A-3 The 1998 image stack

Its statistics were:

Basic Stats	Min	Max	Mean	Stdev	Num	Eigenvalue
Band 1	23	233	88.677153	27.607894	1	1626.725449
Band 2	26	178	63.49158	17.773189	2	19.706157
Band 3	60	255	110.691736	23.858734	3	0.889652

Table A-4 The 1998 image basic statistics

Covariance	Band 1	Band 2	Band 3
Band 1	762.195799	487.167369	638.766671
Band 2	487.167369	315.886261	419.019791
Band 3	638.766671	419.019791	569.239199

Table A-5 The 1998 image covariance matrix

Correlation	Band 1	Band 2	Band 3
Band 1	1	0.992841	0.969754
Band 2	0.992841	1	0.988147
Band 3	0.969754	0.988147	1

Table A-6 The 1998 image correlation matrix

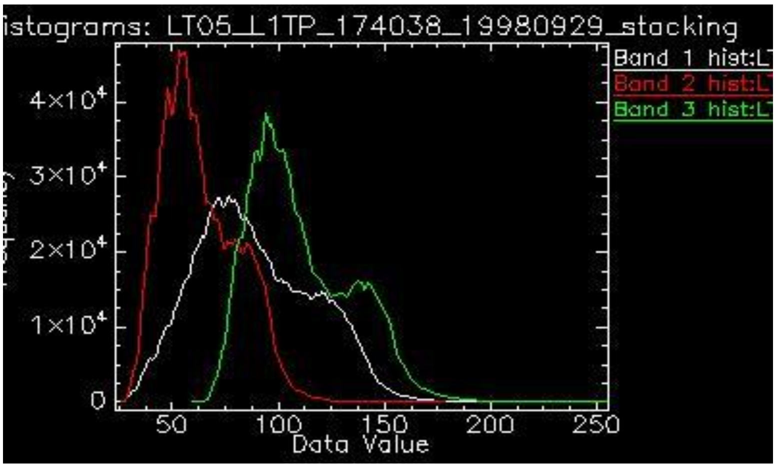


Figure A-4 The 1998 image histogram plot

As for the 2002 image, the image stack was:

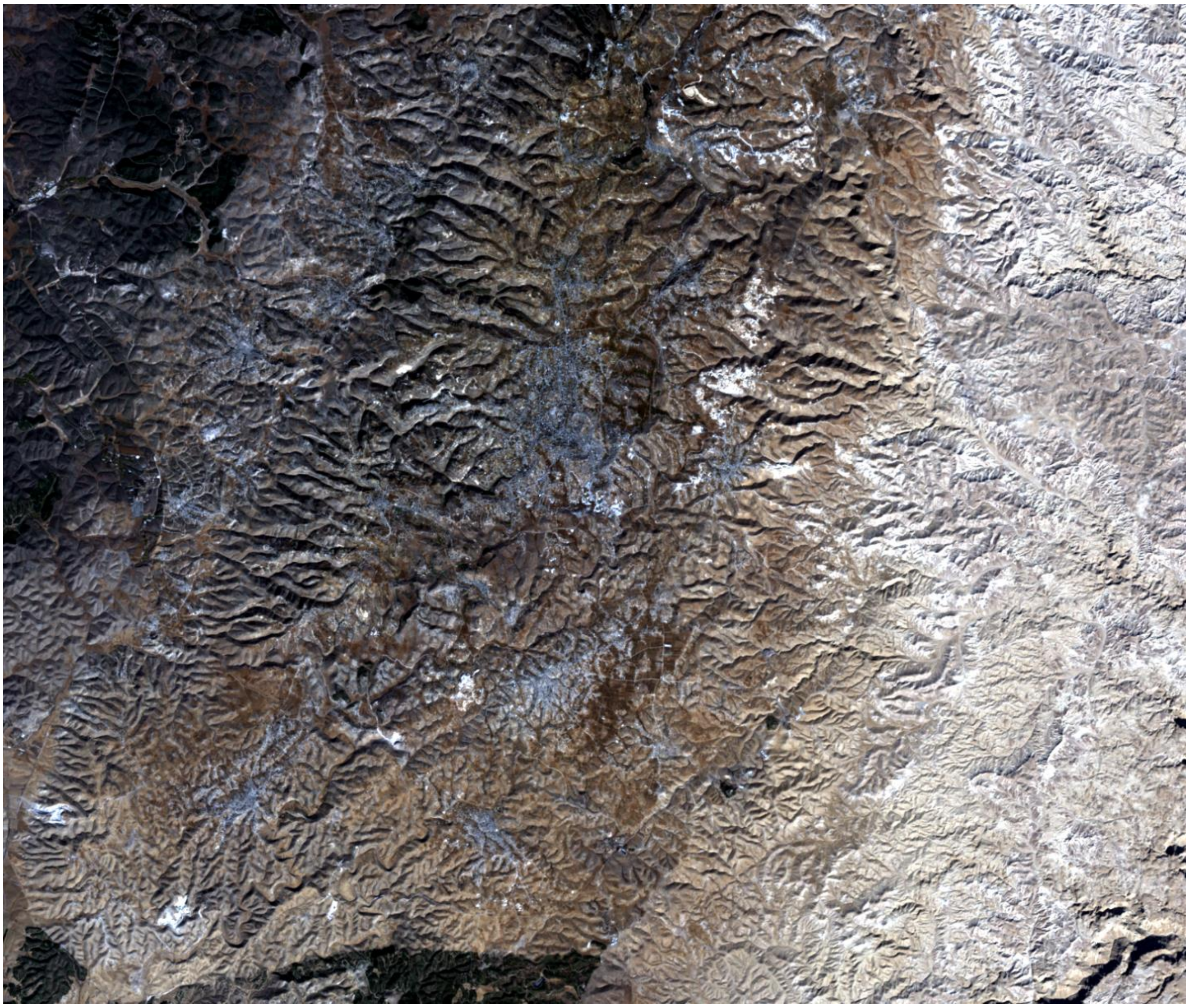


Figure A-5 The 2002 image stack

Its statistics were:

Basic Stats	Min	Max	Mean	Stdev	Num	Eigenvalue
Band 1	16	228	76.355915	27.867188	1	1251.421468
Band 2	20	183	59.106427	17.994611	2	10.538569
Band 3	32	172	59.423344	12.741355	3	0.768268

Table A-7 The 2002 image basic statistics

Covariance	Band 1	Band 2	Band 3
Band 1	776.580149	497.308033	342.687676
Band 2	497.308033	323.806039	226.257658
Band 3	342.687676	226.257658	162.342118

Table A-8 The 2002 image covariance matrix

Correlation	Band 1	Band 2	Band 3
Band 1	1	0.991722	0.965139
Band 2	0.991722	1	0.986837
Band 3	0.965139	0.986837	1

Table A-9 The 2002 image correlation matrix

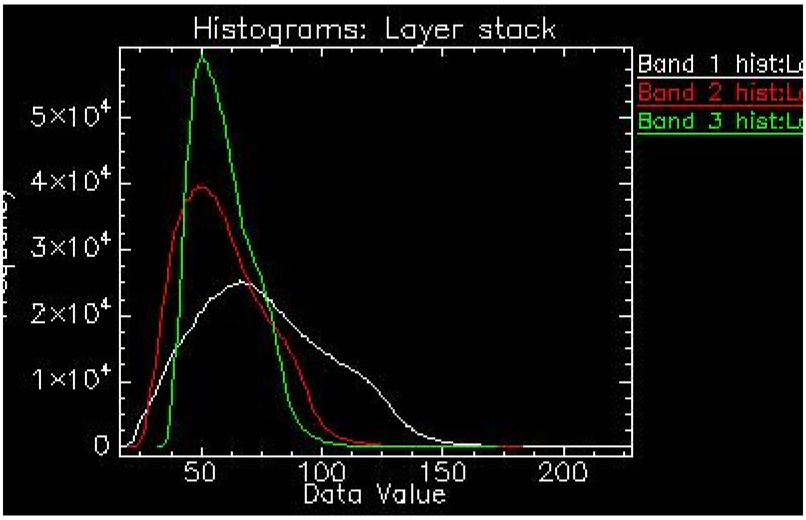


Figure A-6 The 2002 image histogram plot

As for the 2015 image, the image stack was:

Figure A-7 The 2015 Image stack

Its statistics were:

Basic Stats	Min	Max	Mean	Stdev	Num	Eigenvalue
Band 1	8222	36907	16966.7848	3673.2447	1	23258146.87
Band 2	8715	31687	14602.4085	2630.2593	2	194582.9611
Band 3	9801	27507	13392.2779	1747.177	3	10888.57122

Table A-10 The 2015 image basic statistics

Covariance	Band 1	Band 2	Band 3
Band 1	13492727	9574833.93	6205525.21
Band 2	9574833.93	6918264.11	4548230.91
Band 3	6205525.21	4548230.91	3052627.35

Table A-11 The 2015 image covariance matrix

Correlation	Band 1	Band 2	Band 3
Band 1	1	0.991021	0.966923
Band 2	0.991021	1	0.989708
Band 3	0.966923	0.989708	1

Table A-12 The 2015 image correlation matrix

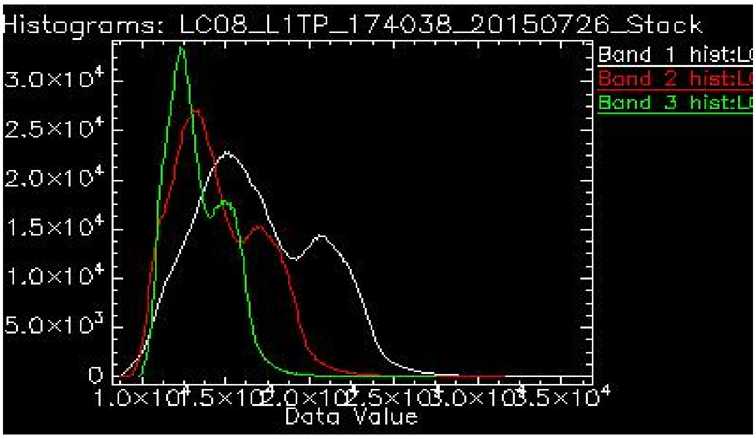


Figure A-8 The 2015 image histogram plot

Finally, the image stack for the 2017 image:

Figure A-9 The 2017 Image stack

Its statistics were:

Basic Stats	Min	Max	Mean	Stdev	Num	Eigenvalue
Band 1	565	22034	2435.02584	849.33208	1	1224704.951
Band 2	448	19739	1917.23213	585.90962	2	12125.0367
Band 3	169	20482	1743.69733	416.27328	3	1108.510458

Table A-13 The 2017 image basic statistics

Covariance	Band 1	Band 2	Band 3
Band 1	721364.977	491571.971	340761.718
Band 2	491571.971	343290.08	241127.249
Band 3	340761.718	241127.249	173283.441

Table A-14 The 2015 image covariance matrix

Correlation	Band 1	Band 2	Band 3
Band 1	1	0.987823	0.963817
Band 2	0.987823	1	0.988638
Band 3	0.963817	0.988638	1

Table A-15 The 2017 image correlation matrix

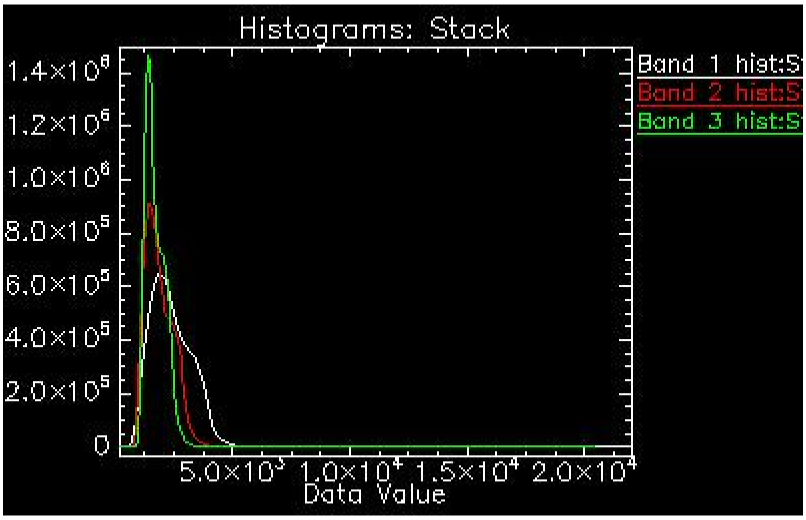


Figure A-10 The 2017 image histogram plot

Note that in the histogram for each image: band 1 is the red band, band 2 is the green band, and band 3 is the blue band.

Appendix A.3 Image classification results

The analysis and results chapter included the explanation of the results of the classification with mentioning an example of what these results were. In this part of the chapter, the detailed classification results of the settlements and the natural is included

Appendix A.3.1 Hebron district main cities

For Hebron City:

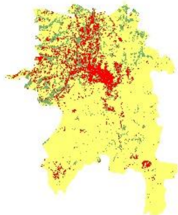
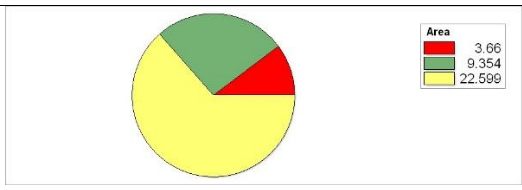
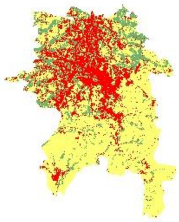
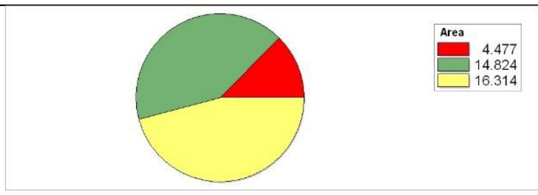
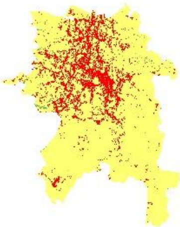
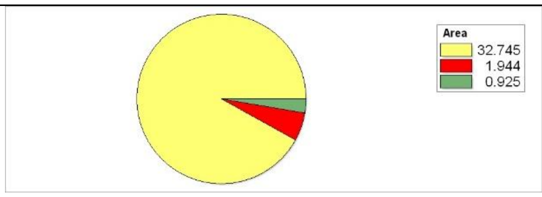
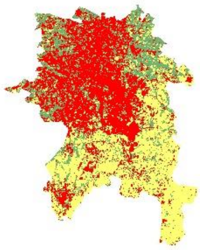
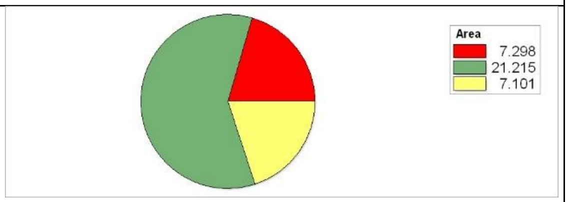
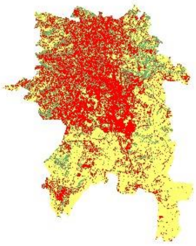
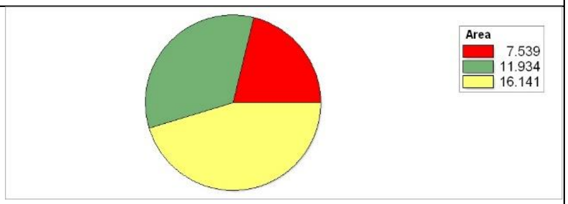
Year	Classification	Statistics “Areas are in kilometer square unit”
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-16 The development of Hebron city through time

For Halhul town:

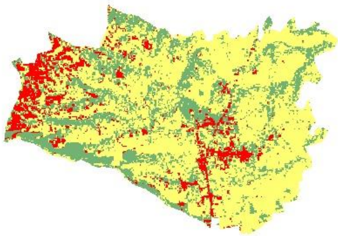
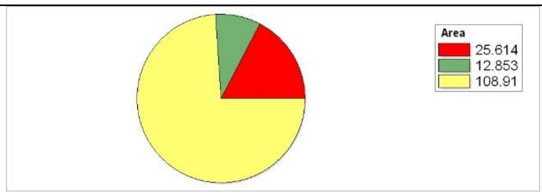
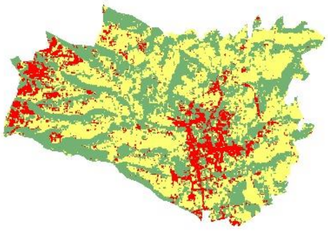
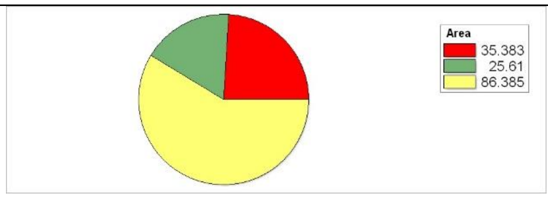
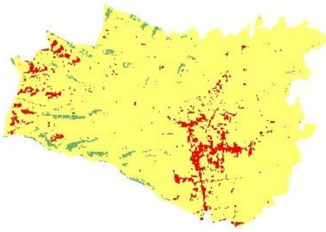
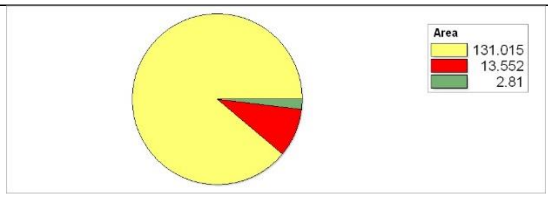
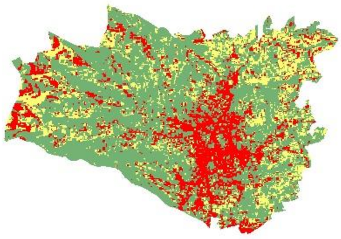
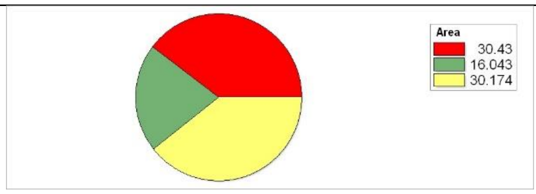
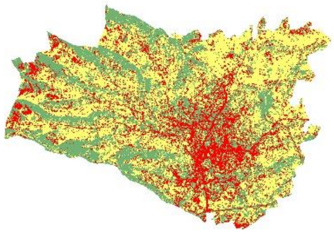
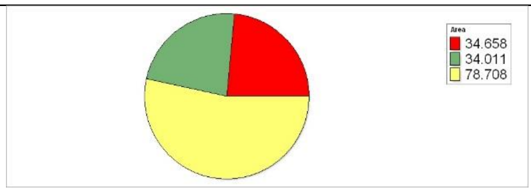
Year	Classification	Statistics “Areas are in kilometer square unit”
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-17 The development of Halhul town through time

For Yatta town:

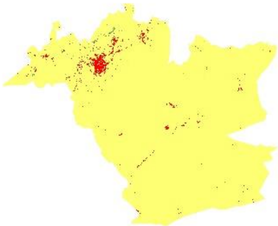
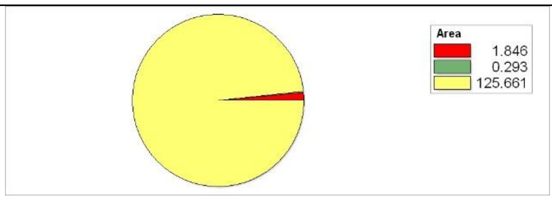
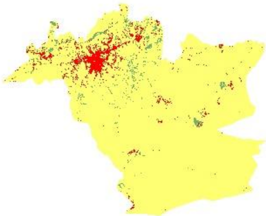
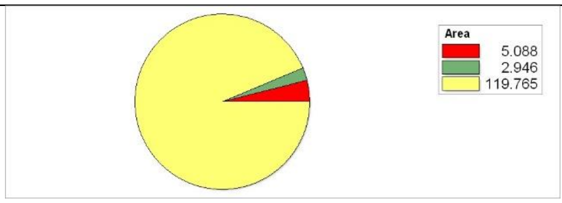
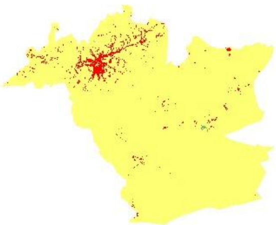
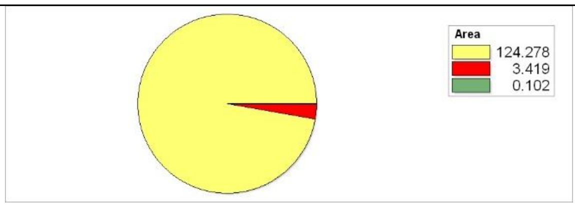
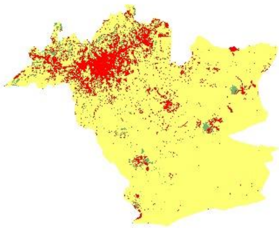
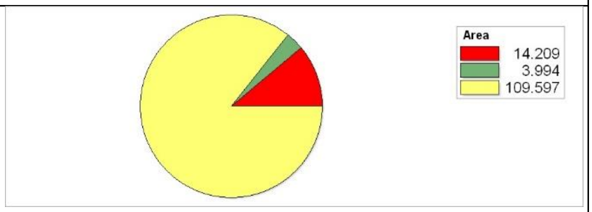
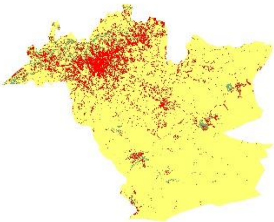
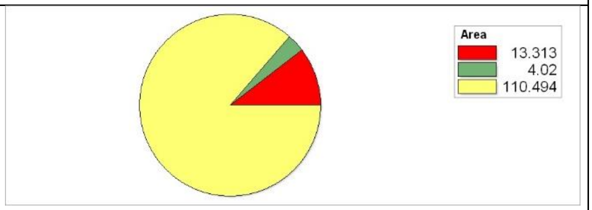
Year	Classification	Statistics “Areas are in kilometer square unit”
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-18 The development of Yatta town through time

For Dora town:

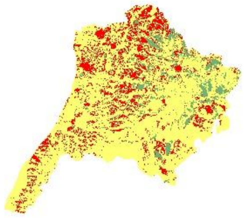
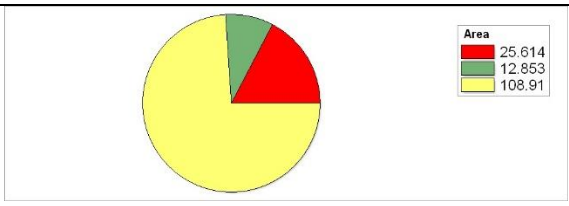
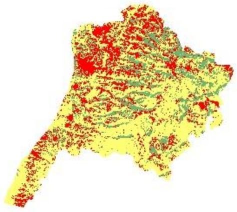
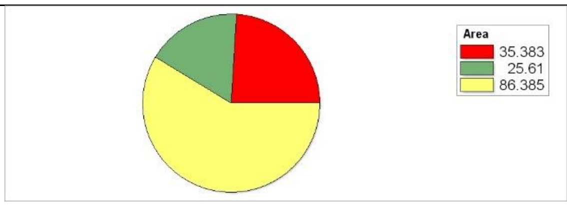
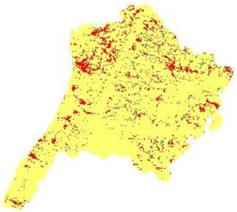
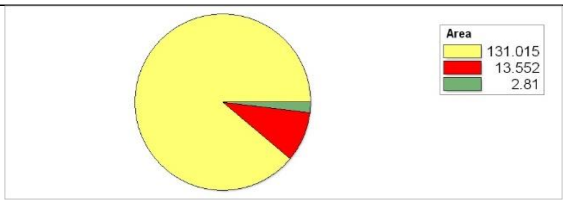
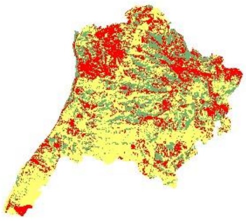
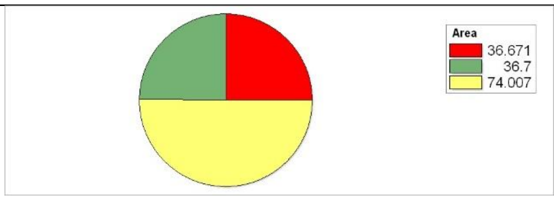
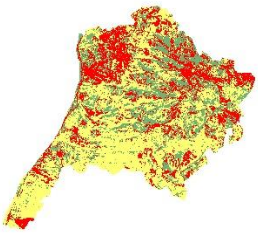
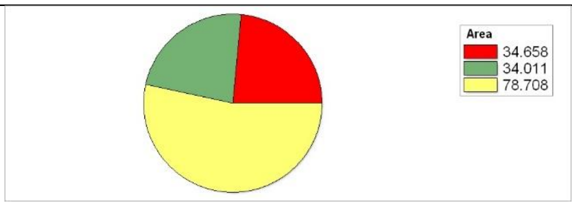
Year	Classification	Statistics “Areas are in kilometer square unit”
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-19 The development of Dora town through time

For Ad-Dahria town:

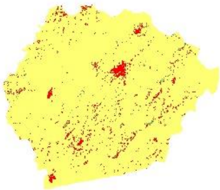
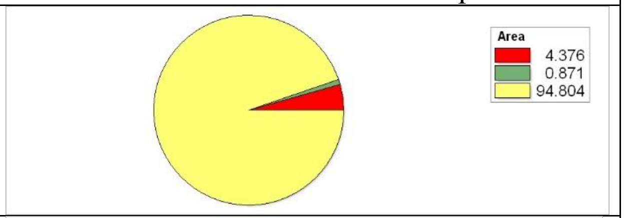
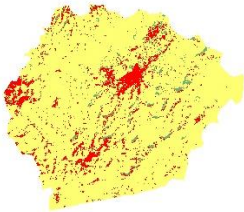
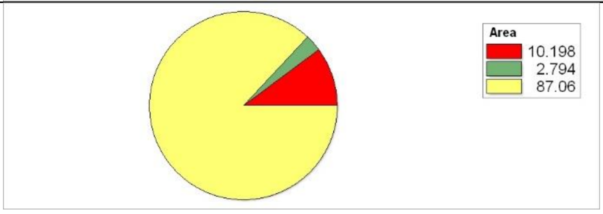
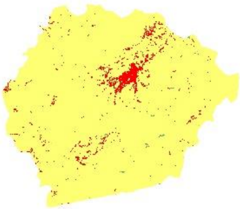
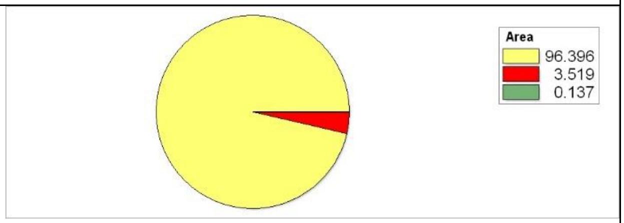
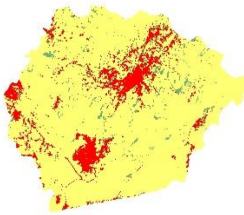
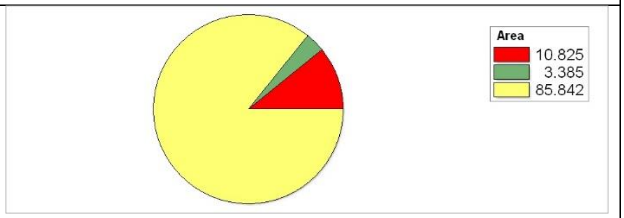
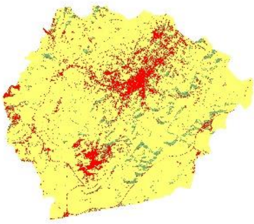
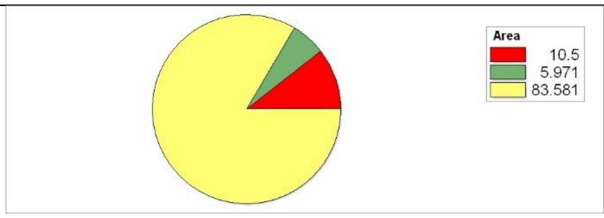
Year	Classification	Statistics “Areas are in kilometer square unit”
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-20 The development of Ad-Dahria town through time

Appendix A.3.1 The Israeli settlements

For Adora Settlement:

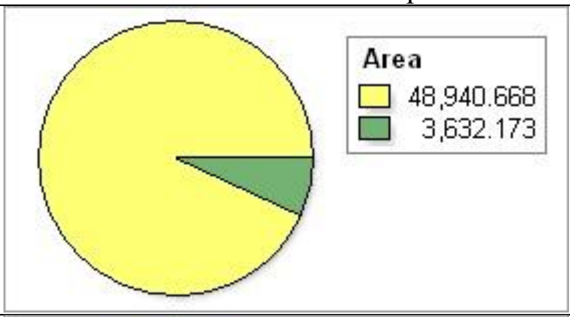
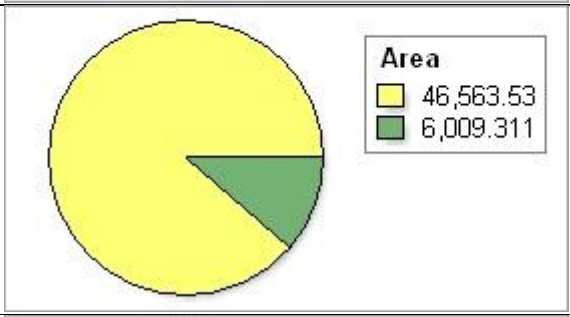
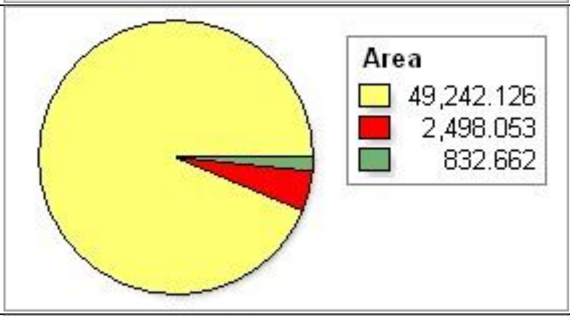
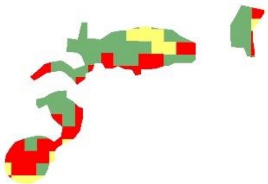
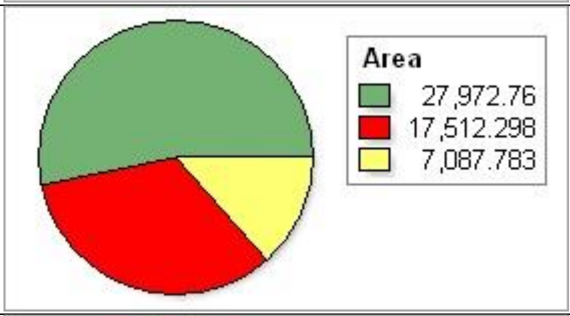
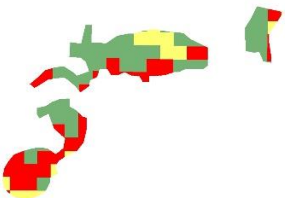
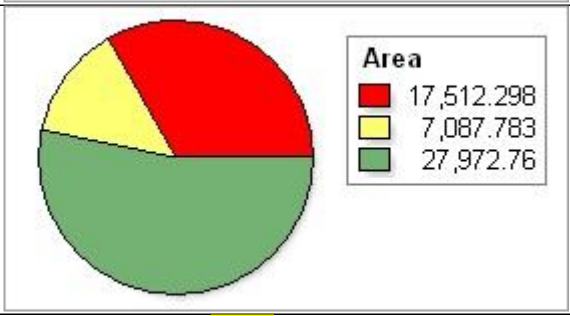
Year	Classification	Statistics “Areas are in meter square unit”
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-21 The development of the Adora settlement through time

For Ashkolit Settlement:

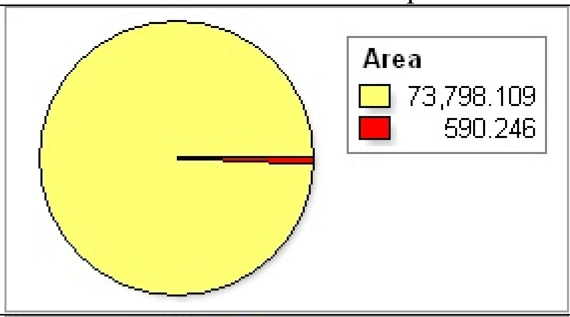
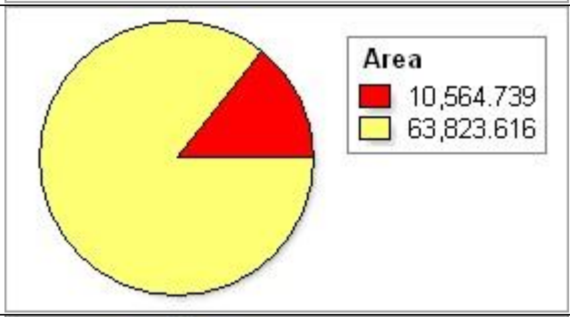
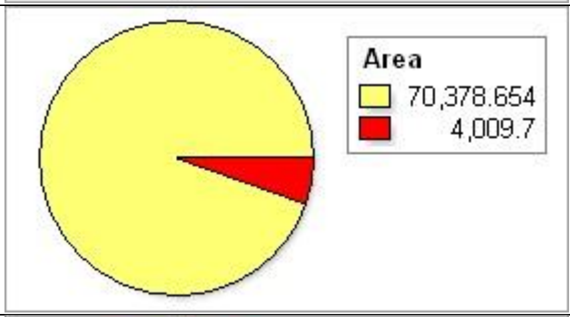
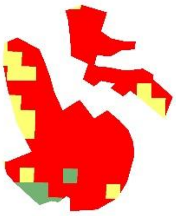
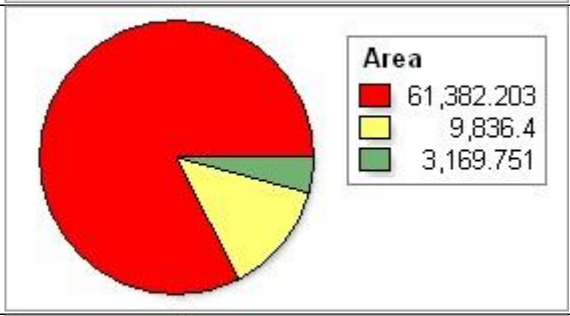
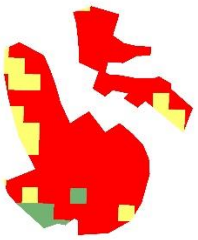
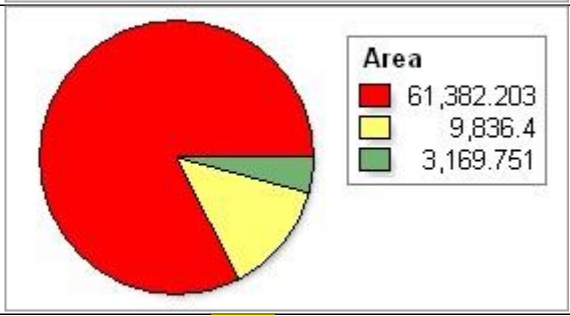
Year	Classification	Statistics “Areas are in meter square unit”
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-22 The development of the Ashkolit settlement through time

For Autnil Settlement:

<table>
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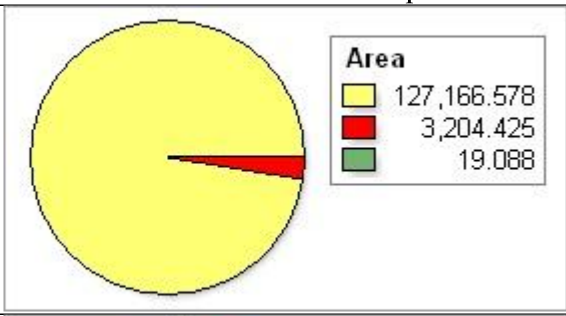
Landsat 5</td><td></td><td>
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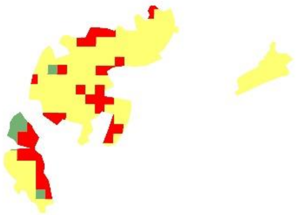
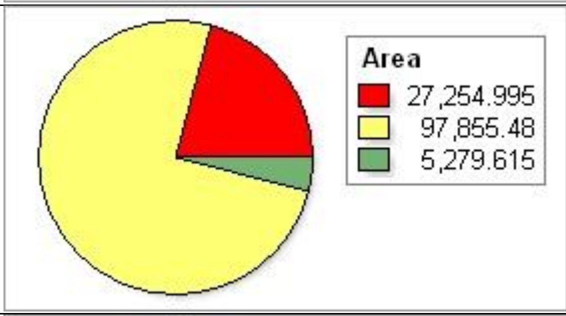
<tr><td>1998 Landsat 5</td><td></td><td>
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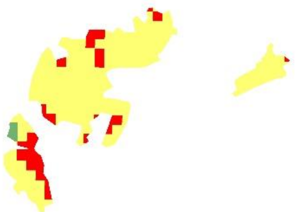
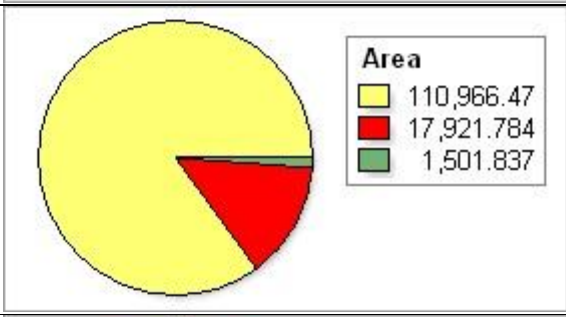
<tr><td>2002 Landsat 7</td><td></td><td>
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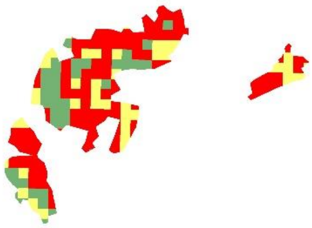
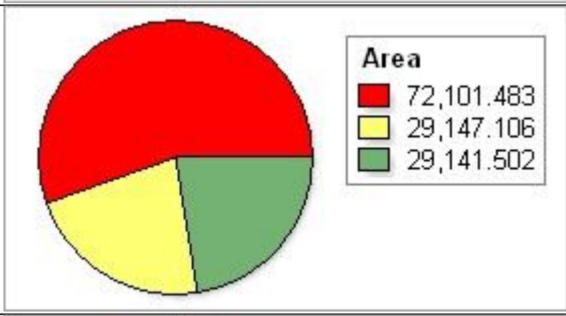
<tr><td>2015 Landsat 8</td><td></td><td>
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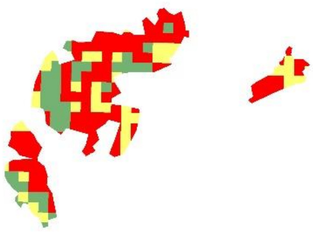
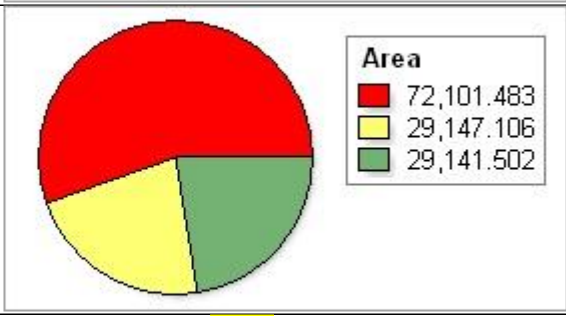
<tr><td>2017 Sentinel 2</td><td></td><td>
</td></tr>
<tr><td>Artificial surfaces</td><td>Agricultural areas</td><td>Forests and seminatural areas</td></tr>
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Table A-23 The development of the Autnil settlement through time

For Beit Ain Settlement:

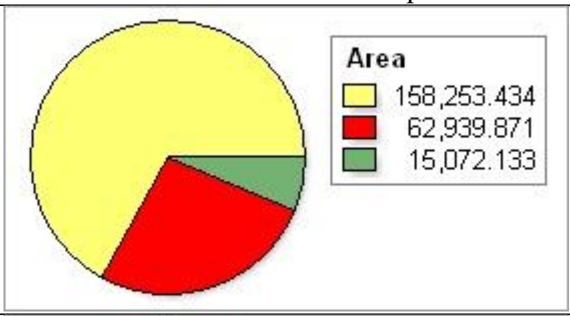
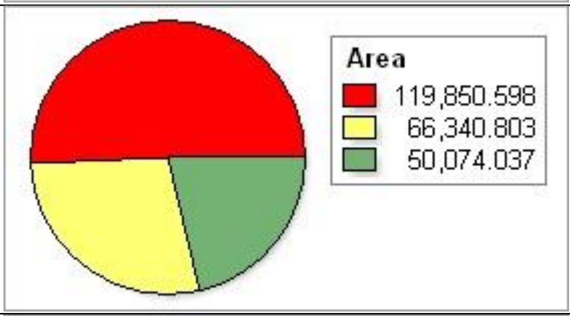
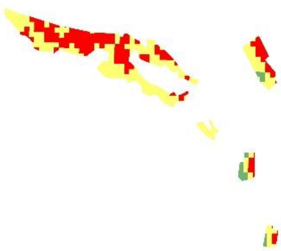
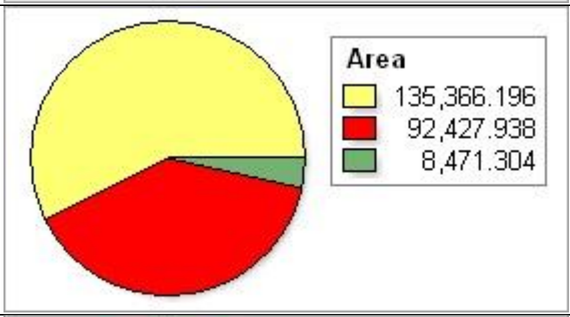
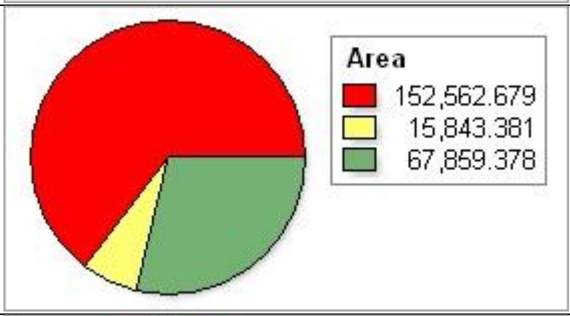
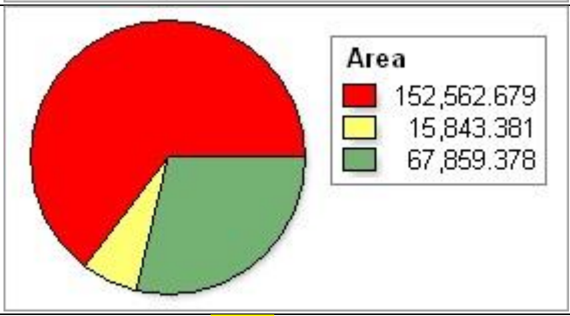
Year	Classification	Statistics "Areas are in meter square unit"
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-24 The development of the Beit Ain settlement through time

For Beit Hafer Settlement:

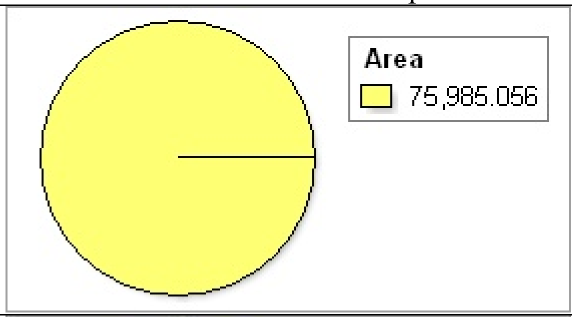
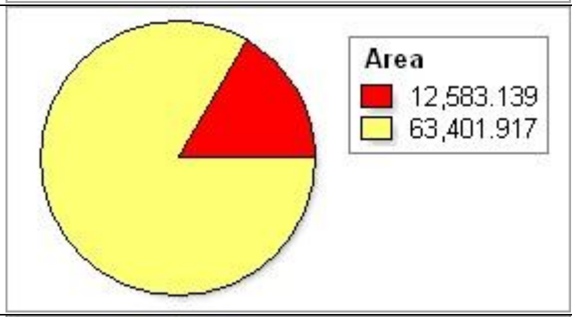
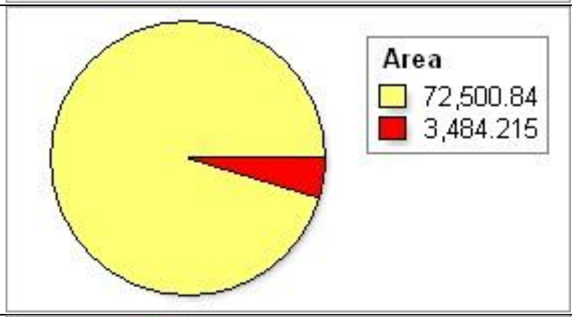
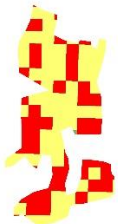
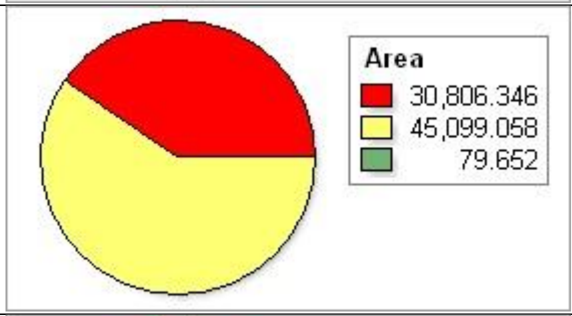
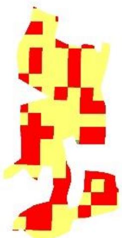
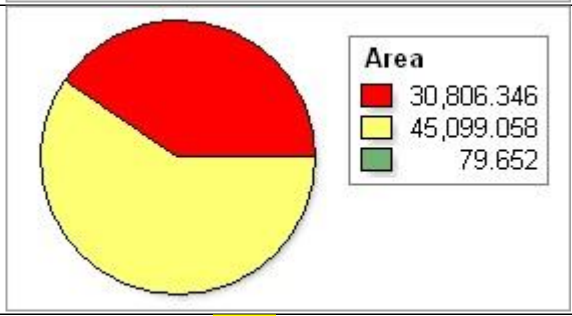
Year	Classification	Statistics “Areas are in meter square unit”
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-25 The development of the Beit Hafer settlement through time

For Hagai Settlement:

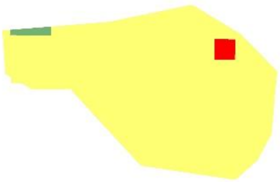
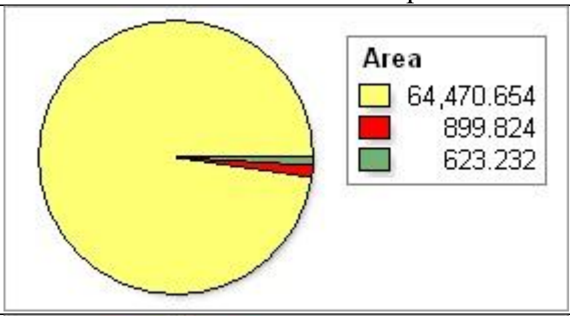
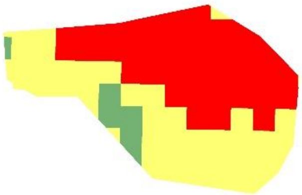
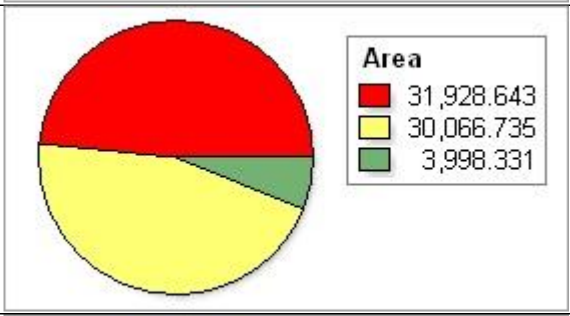
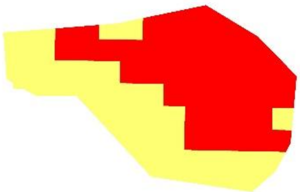
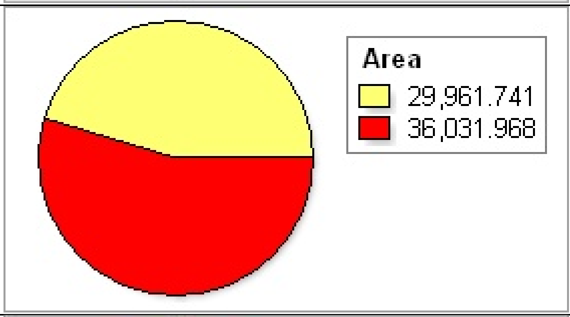
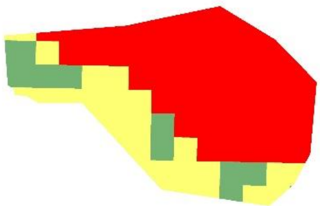
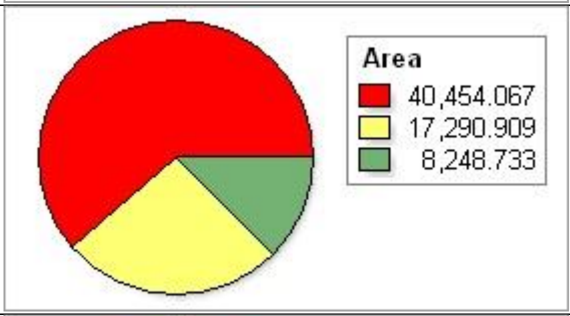
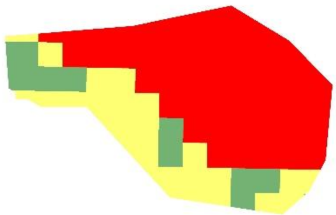
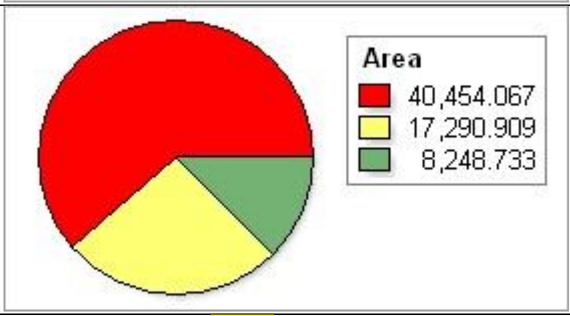
Year	Classification	Statistics “Areas are in meter square unit”
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-26 The development of the Hagai settlement through time

For Karmi Tzur Settlement:

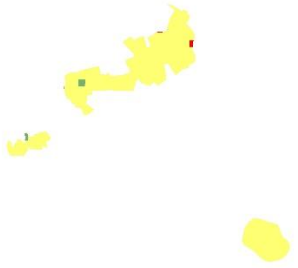
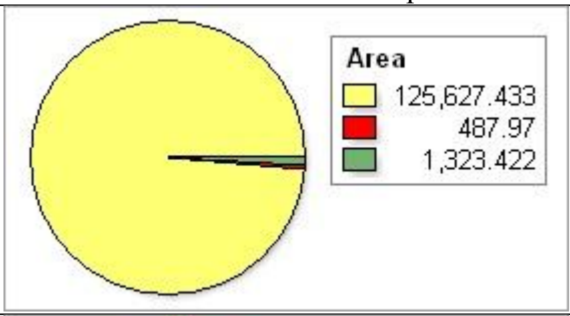
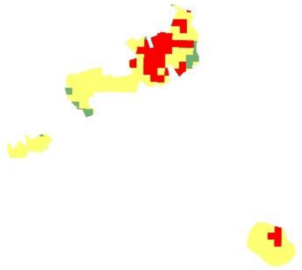
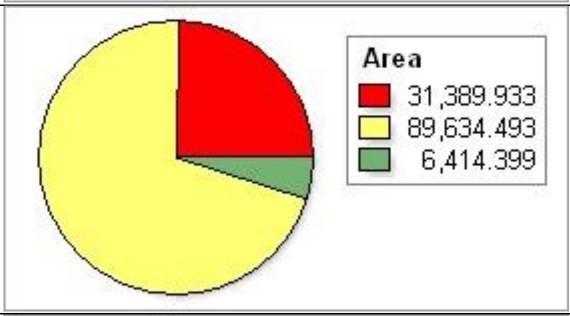
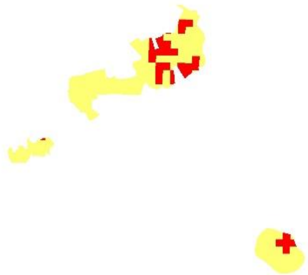
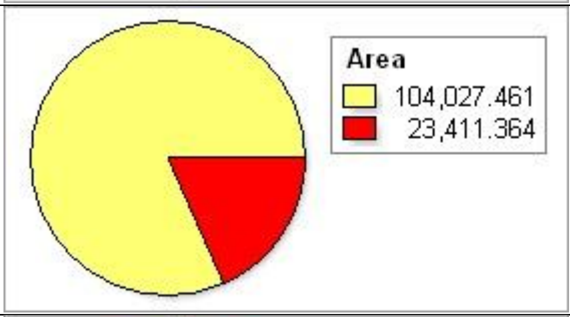
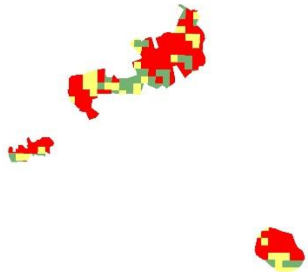
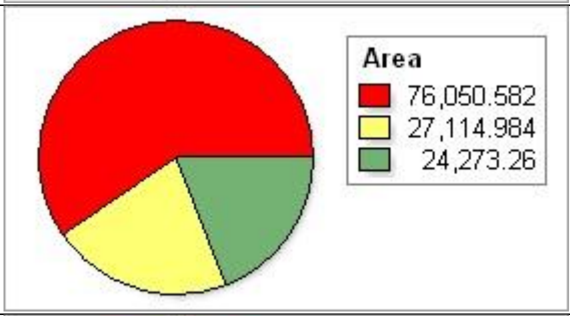
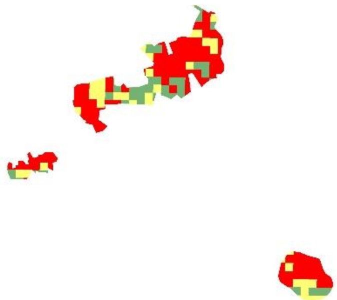
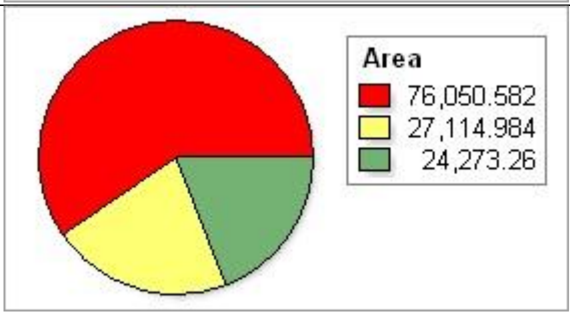
Year	Classification	Statistics “Areas are in meter square unit”
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-27 The development of the Karmi Tzur settlement through time

For Karmiel Settlement:

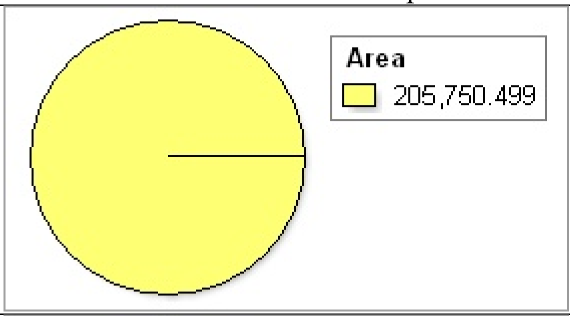
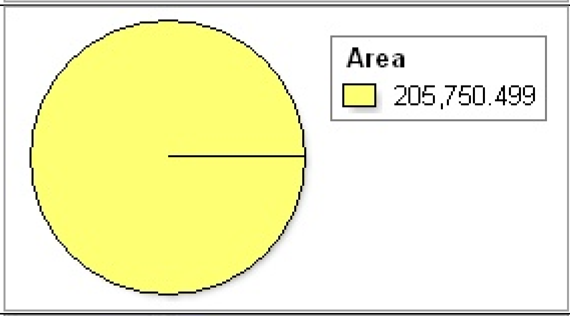
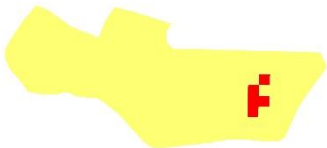
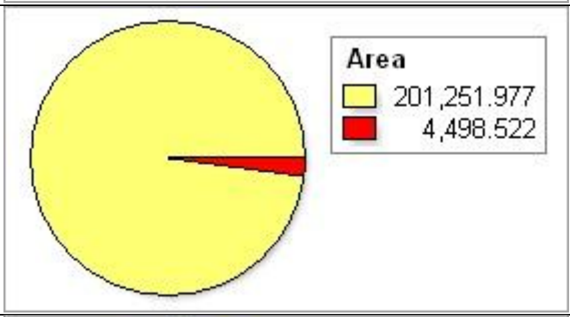
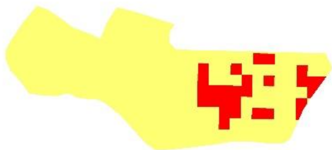
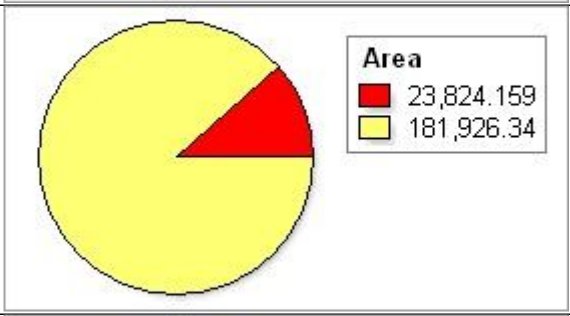
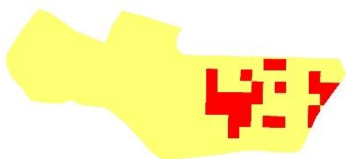
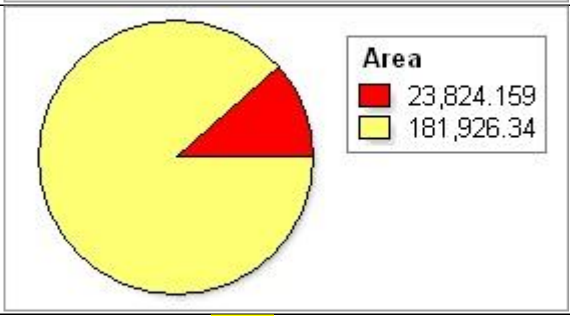
Year	Classification	Statistics “Areas are in meter square unit”
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-28 The development of the Karmiel settlement through time

For Kfar Etzion Settlement:

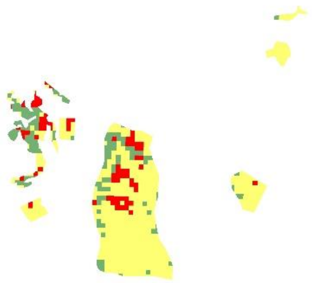
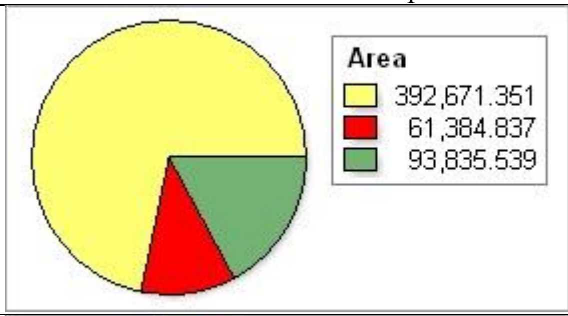
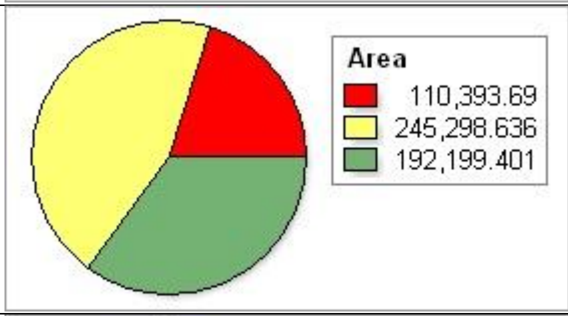
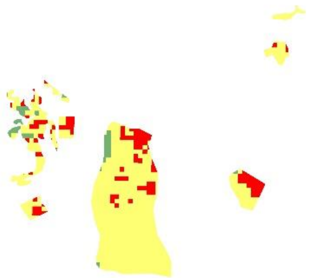
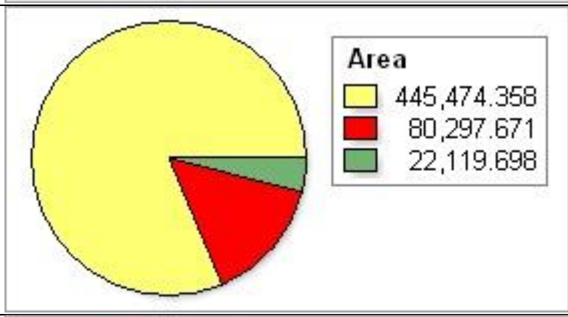
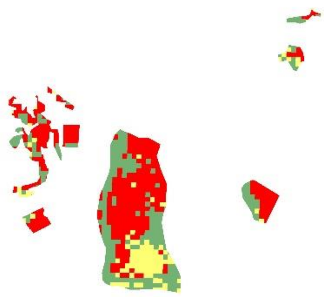
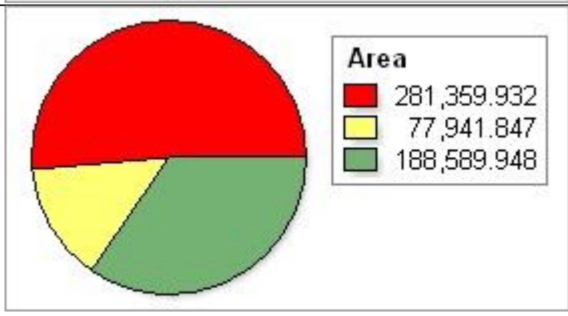
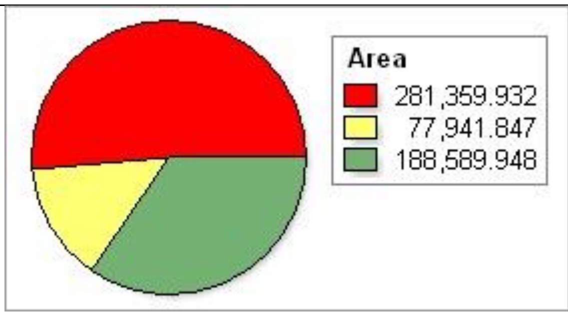
Year	Classification	Statistics “Areas are in meter square unit”
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-29 The development of the Kfar Etzion settlement through time

For Maon Settlement:

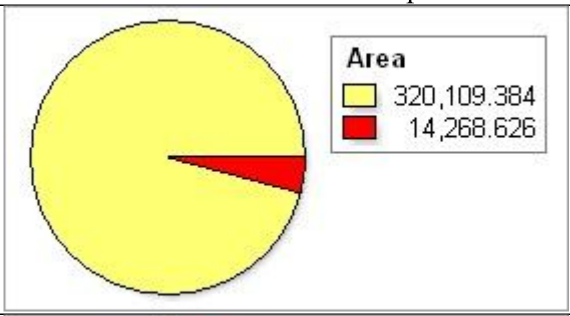
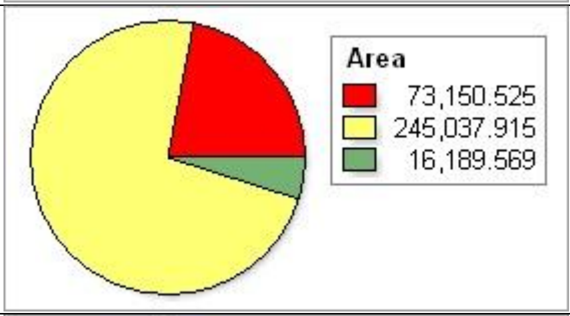
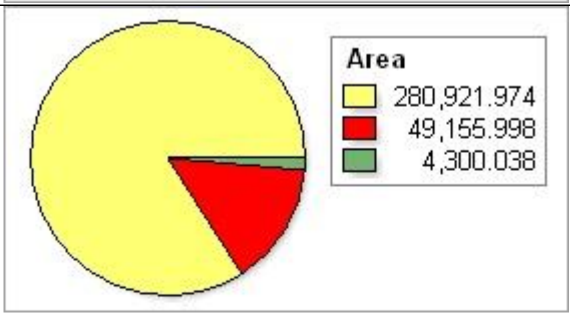
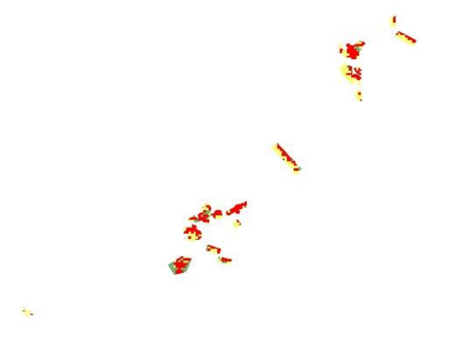
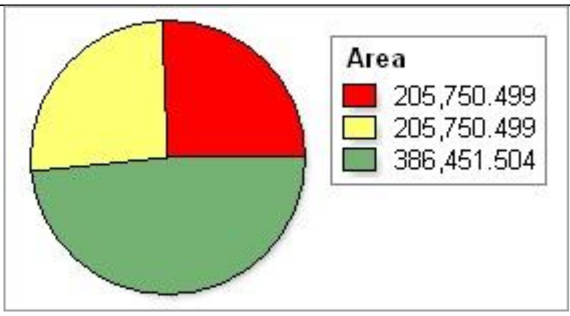
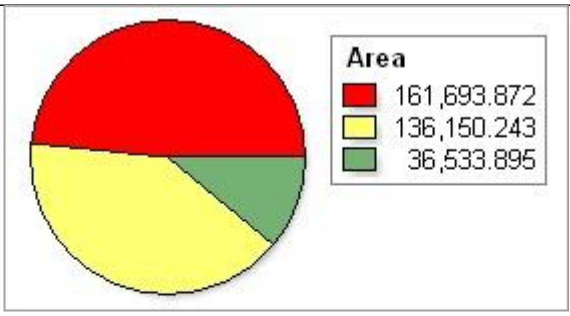
Year	Classification	Statistics “Areas are in meter square unit”
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-30 The development of the Maon settlement through time

For Matsodot Yahouda Settlement:

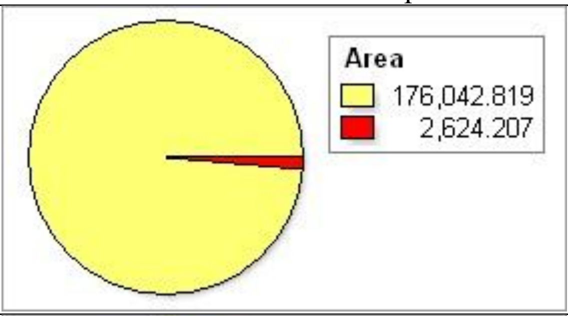
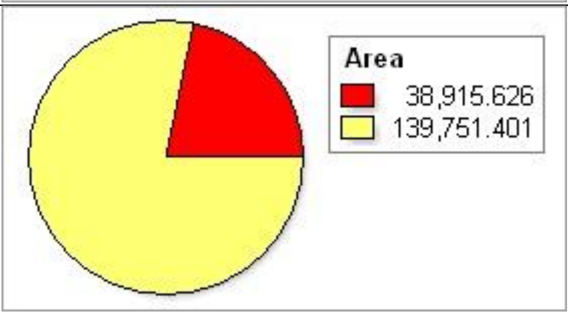
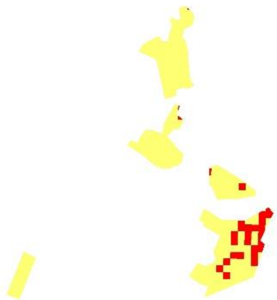
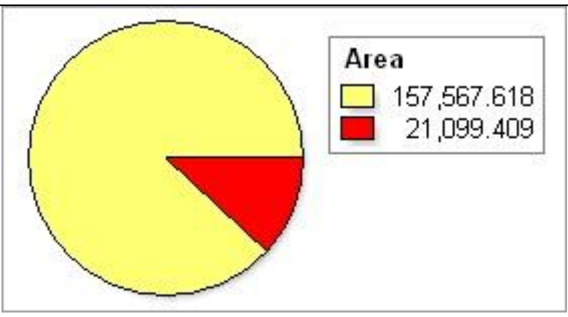
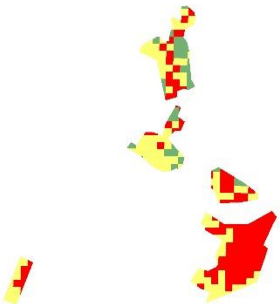
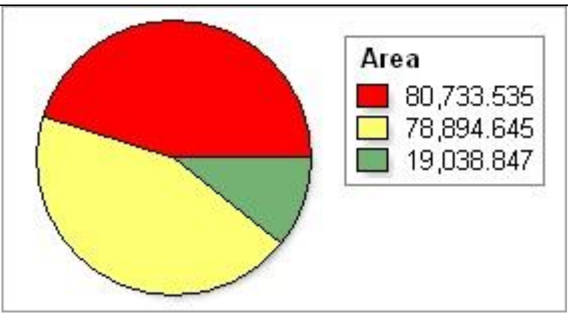
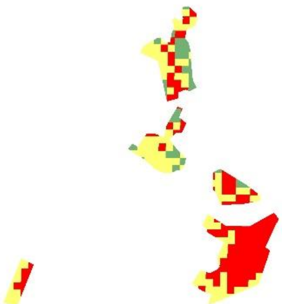
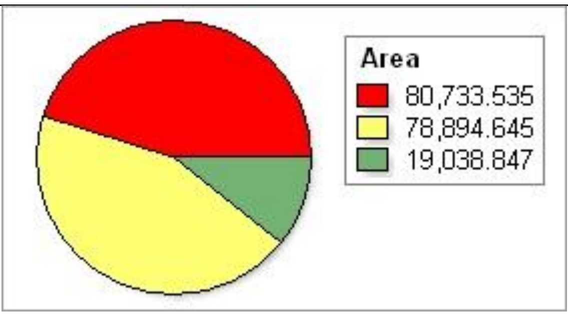
Year	Classification	Statistics "Areas are in meter square unit"
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-31 The development of the Matsodot Yahouda settlement through time

For Migdal Oz Settlement:

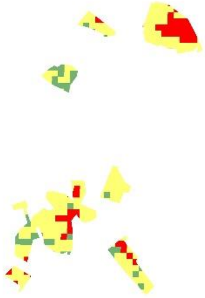
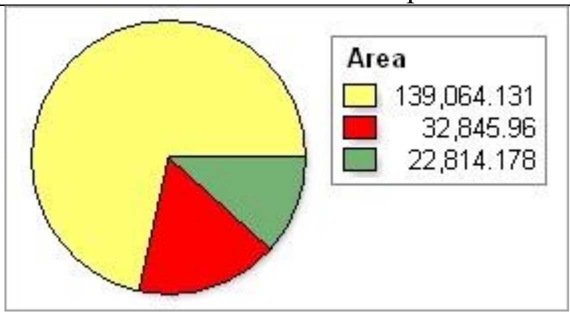
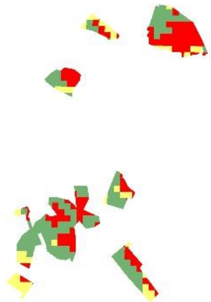
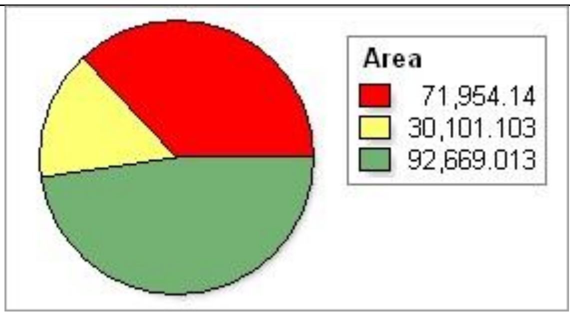
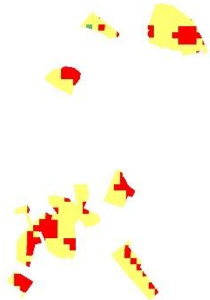
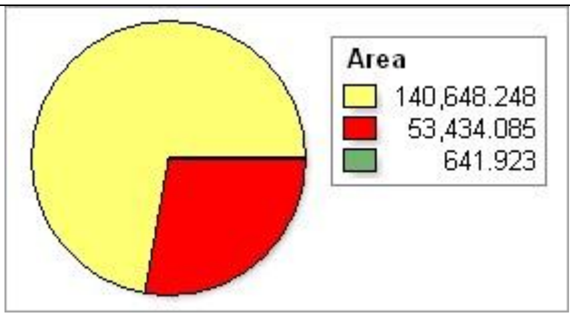
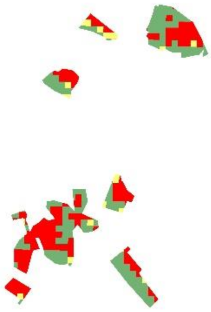
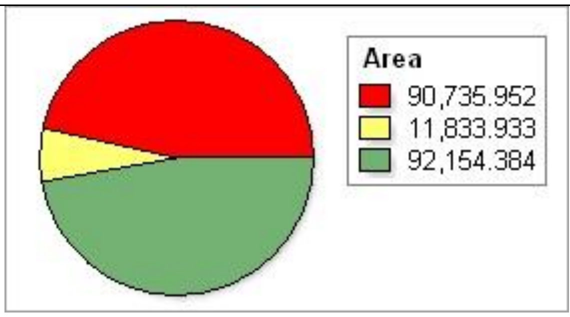
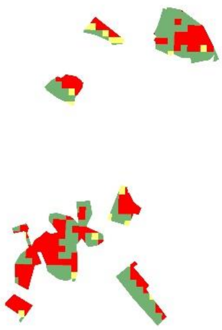
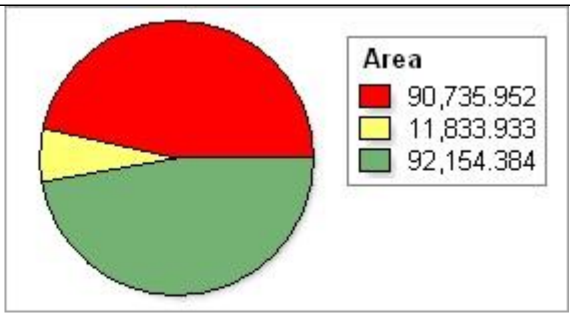
Year	Classification	Statistics “Areas are in meter square unit”
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-32 The development of the Migdal Oz settlement through time

For Mitzad Asfar Settlement:

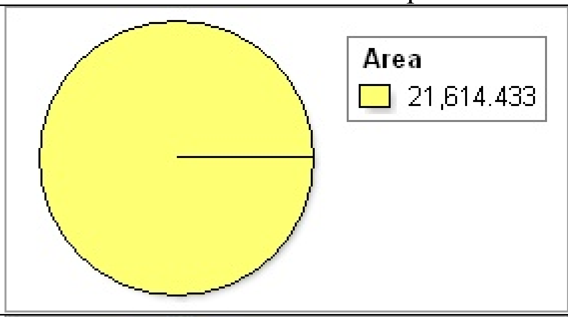
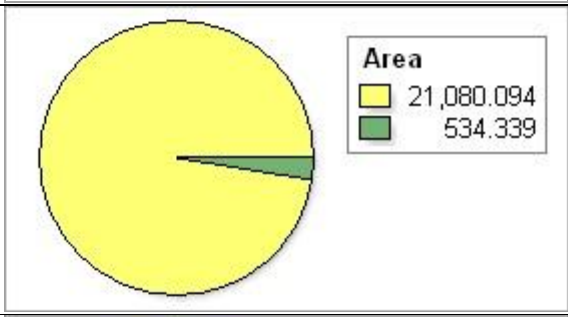
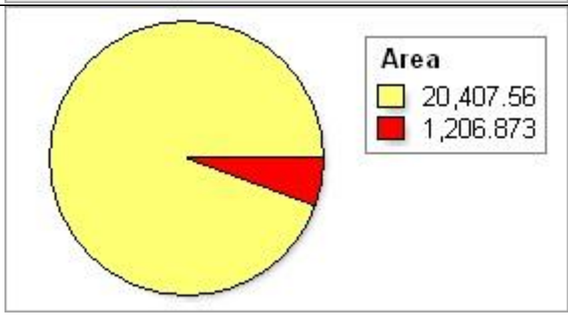
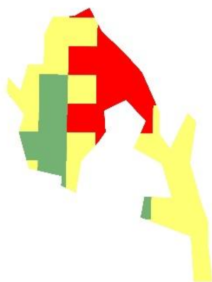
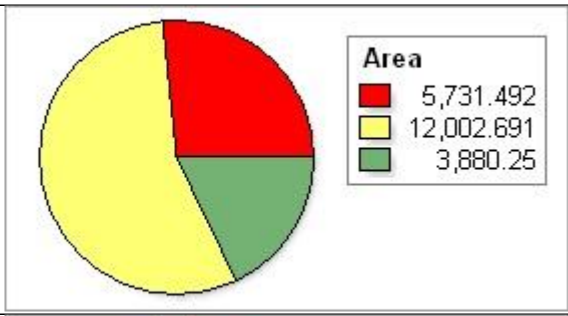
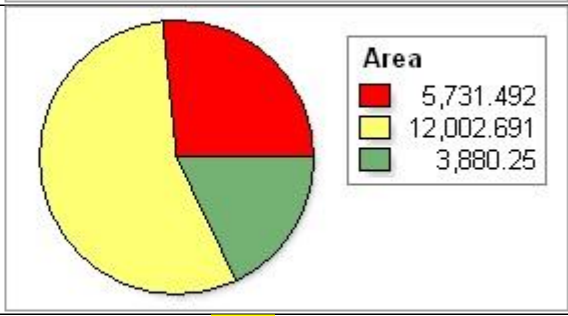
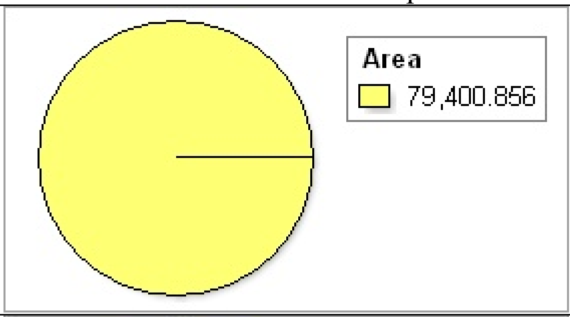
Year	Classification	Statistics "Areas are in meter square unit"
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-33 The development of the Mitzad Asfar settlement through time

For Mitzad Shimon Settlement:

<table>
<tr><th>Year</th><th>Classification</th><th>Statistics “Areas are in meter square unit”</th></tr>
<tr><td>1984
Landsat 5</td><td></td><td>
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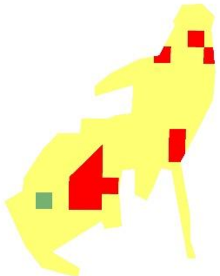
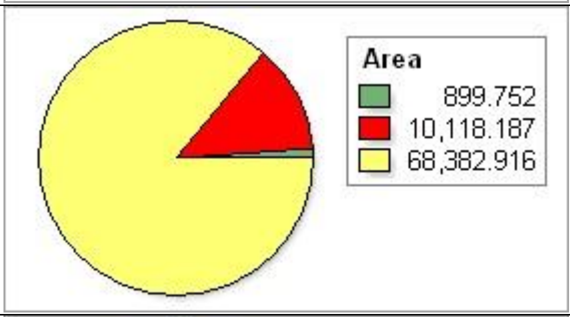
<tr><td>1998 Landsat 5</td><td></td><td>
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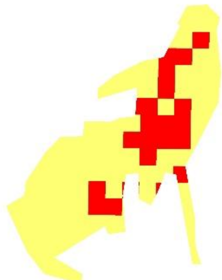
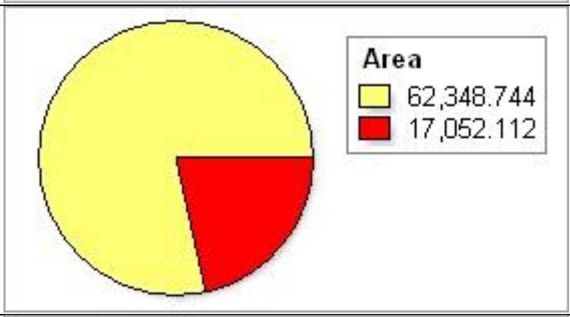
<tr><td>2002 Landsat 7</td><td></td><td>
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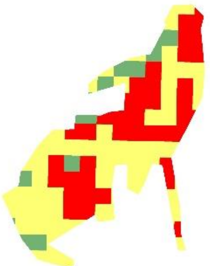
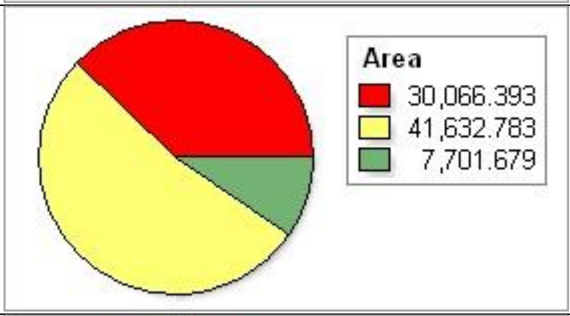
<tr><td>2015 Landsat 8</td><td></td><td>
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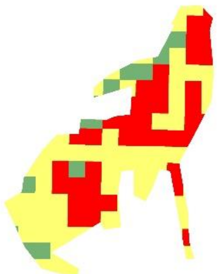
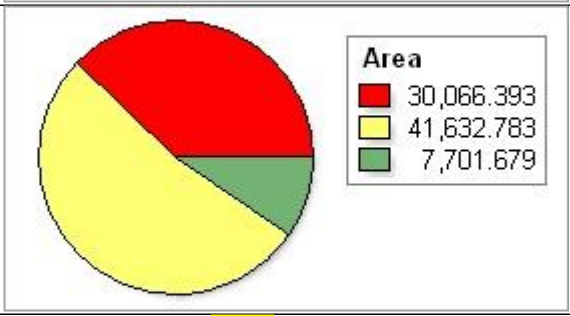
<tr><td>2017 Sentinel 2</td><td></td><td>
</td></tr>
<tr><td>Artificial surfaces</td><td>Agricultural areas</td><td>Forests and seminatural areas</td></tr>
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Table A-34 The development of the Mitzad Shimon settlement through time

For Nahal Adurim Settlement:

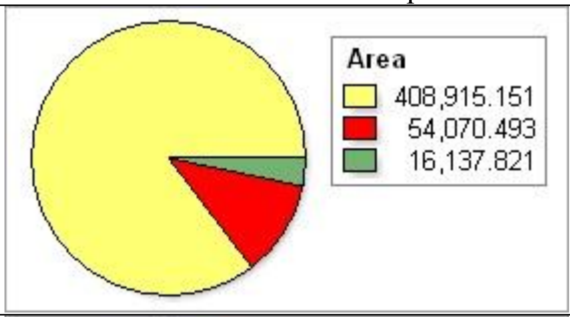
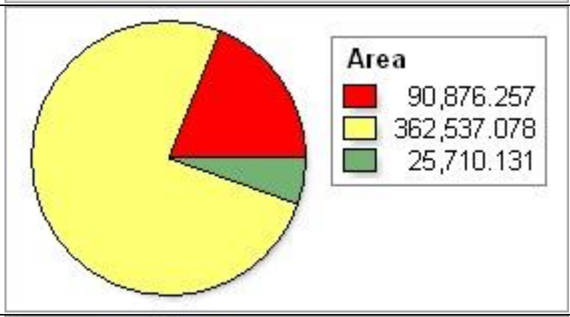
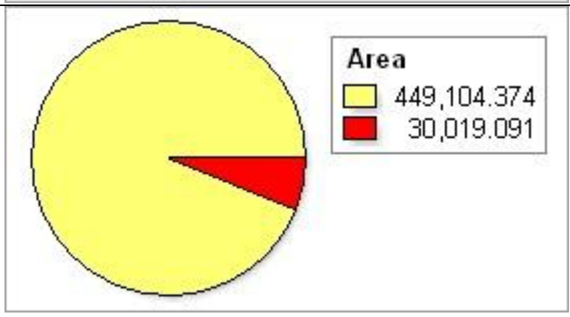
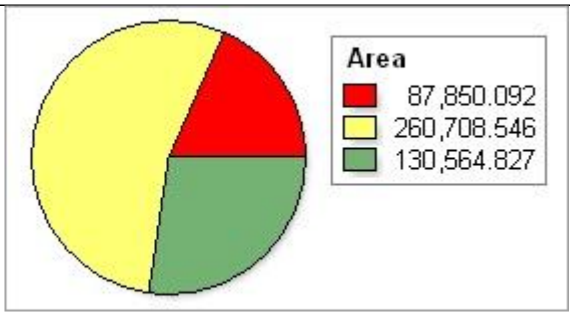
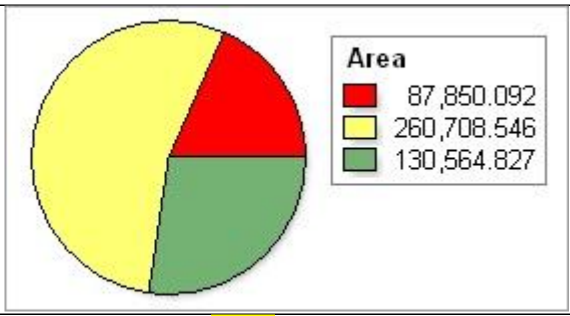
Year	Classification	Statistics “Areas are in meter square unit”
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-35 The development of the Nahal Adurim settlement through time

For Nahal Manuh Settlement:

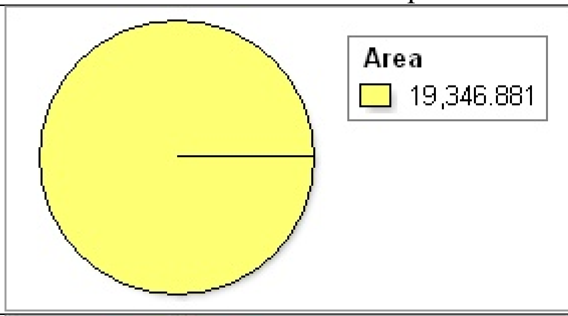
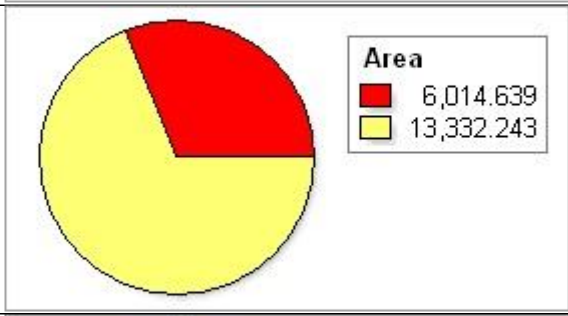
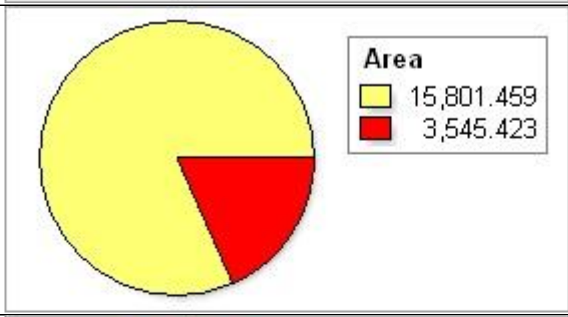
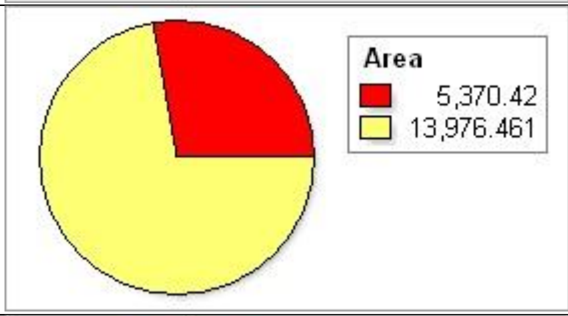
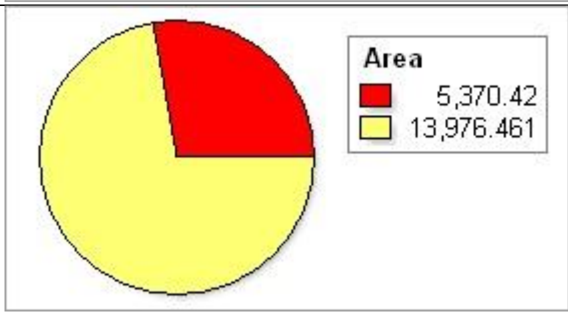
Year	Classification	Statistics “Areas are in meter square unit”
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-36 The development of the Nahal Manuh settlement through time

For Nahal Naguho Settlement:

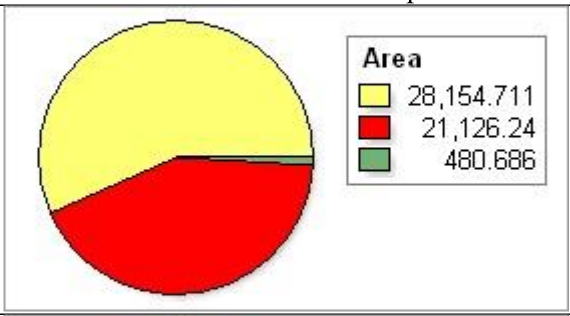
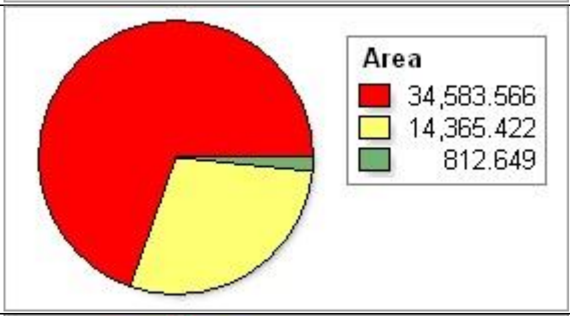
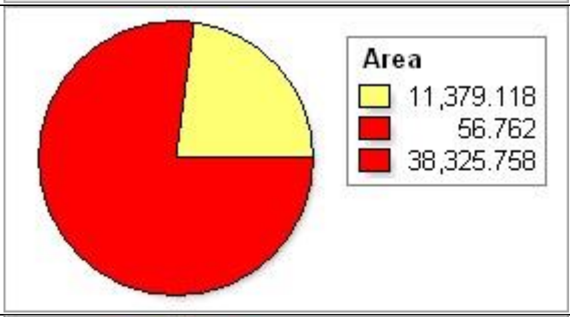
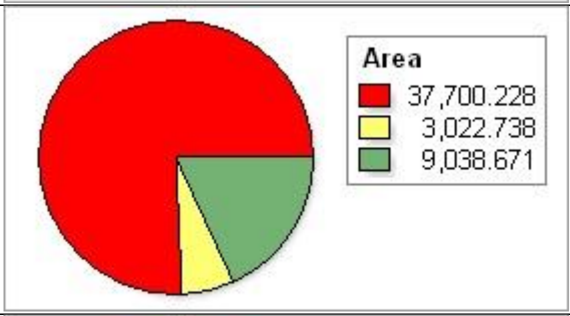
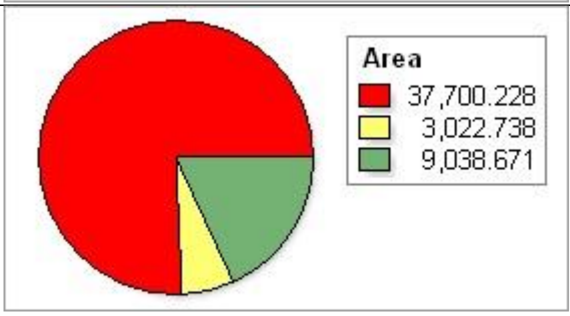
Year	Classification	Statistics “Areas are in meter square unit”
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-37 The development of the Nahal Naguho settlement through time

For Qriat Arbaa Settlement:

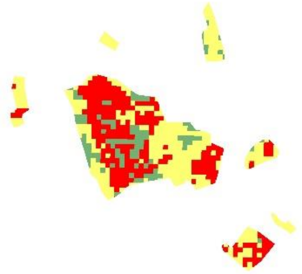
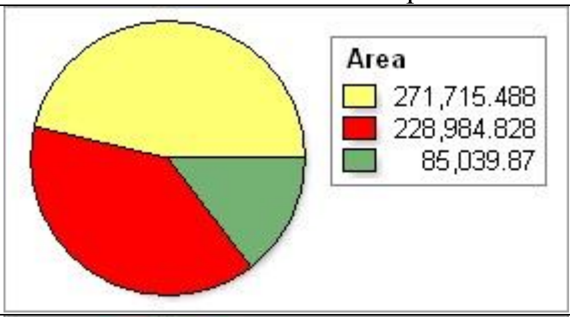
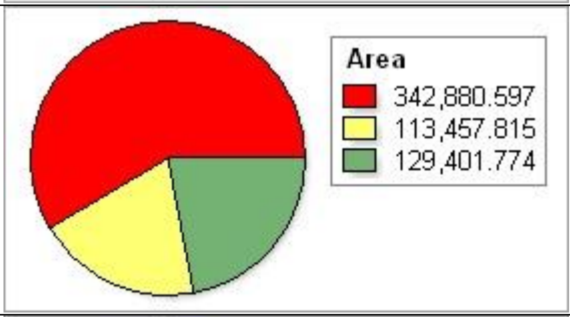
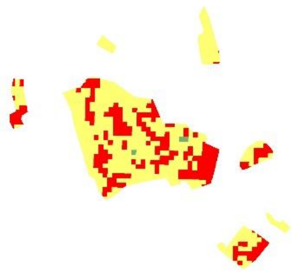
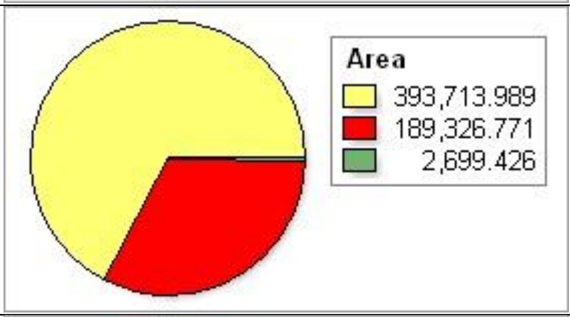
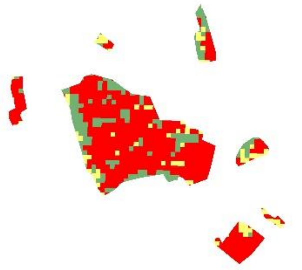
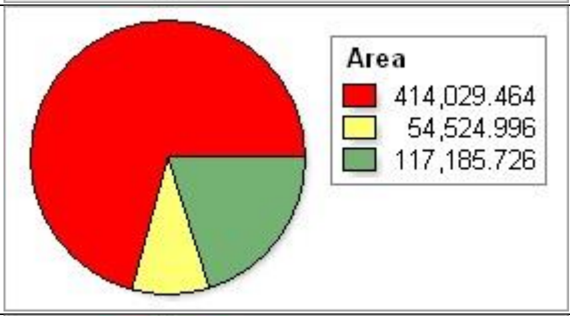
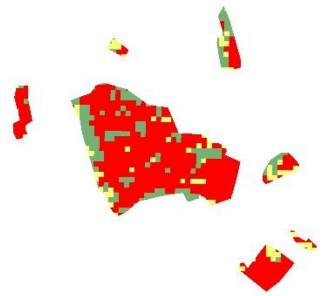
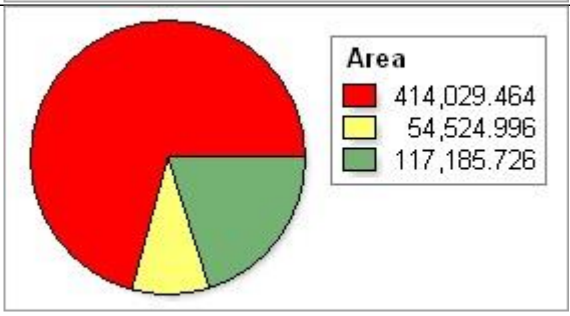
Year	Classification	Statistics “Areas are in meter square unit”
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-38 The development of the Qriat Arbaa settlement through time

For Ramat Mamre Settlement:

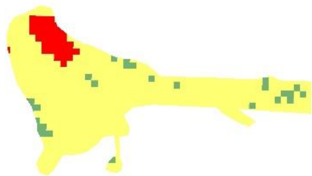
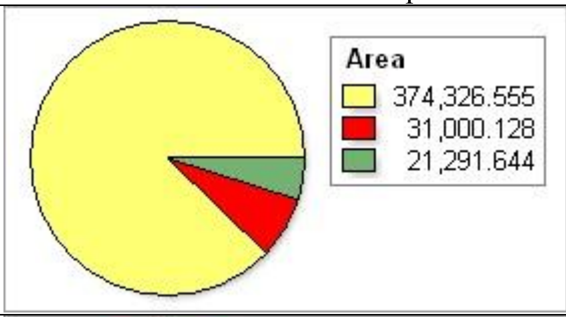
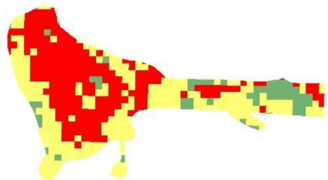
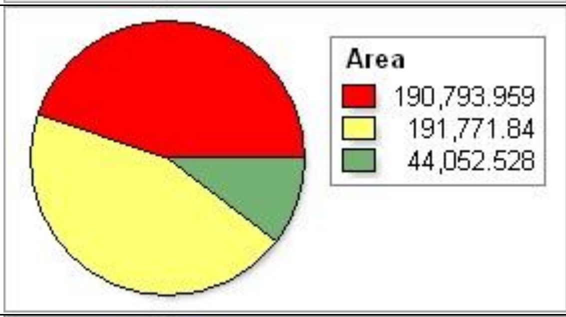
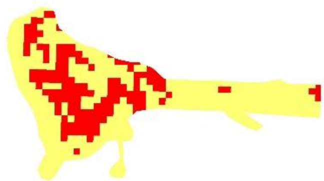
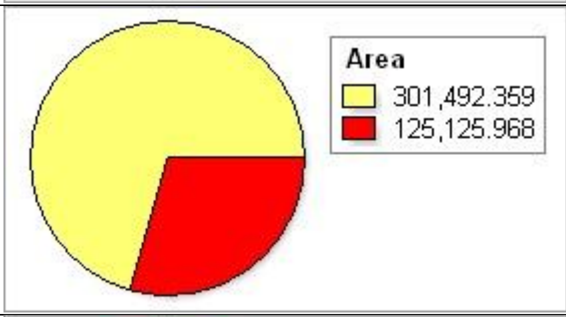
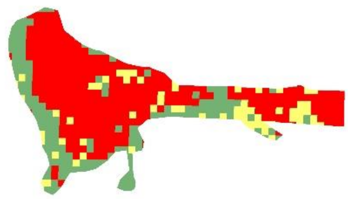
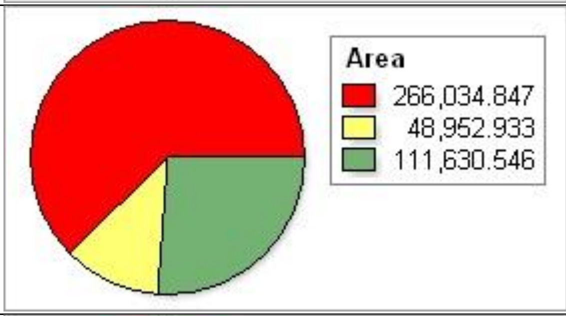
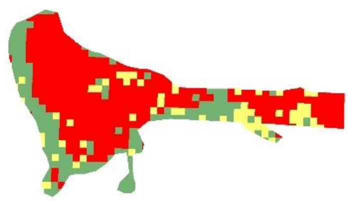
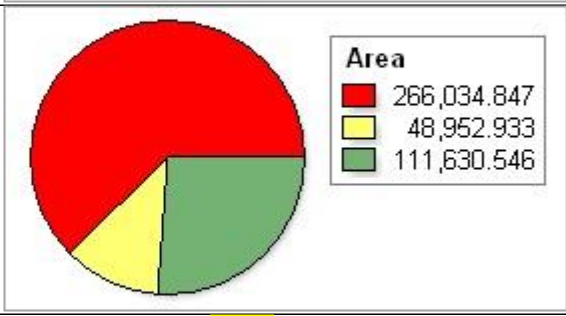
Year	Classification	Statistics “Areas are in meter square unit”
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-39 The development of the Mamre settlement through time

For Sansana Settlement:

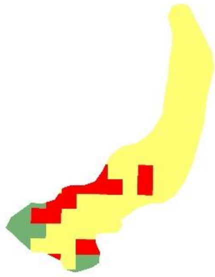
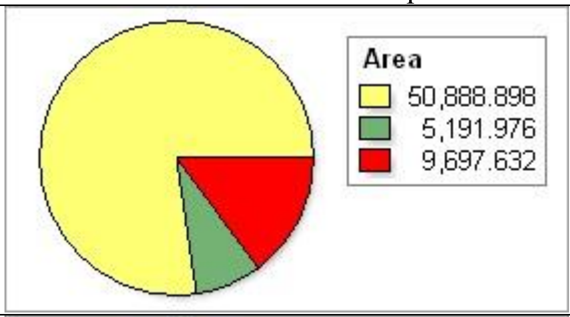
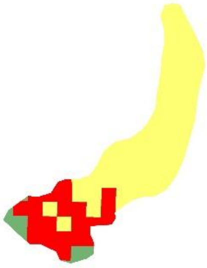
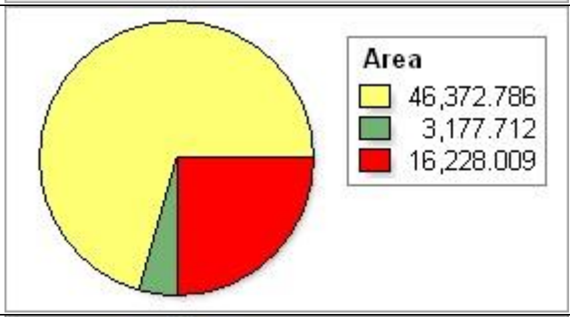
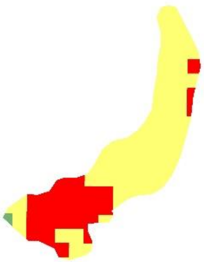
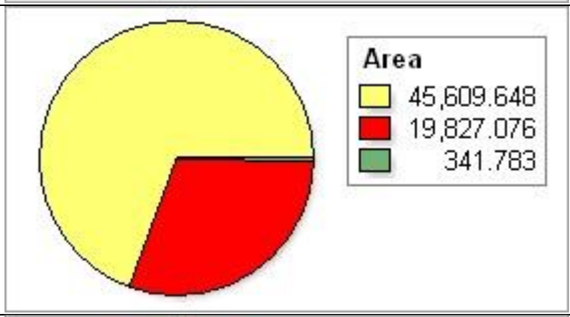
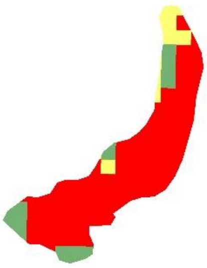
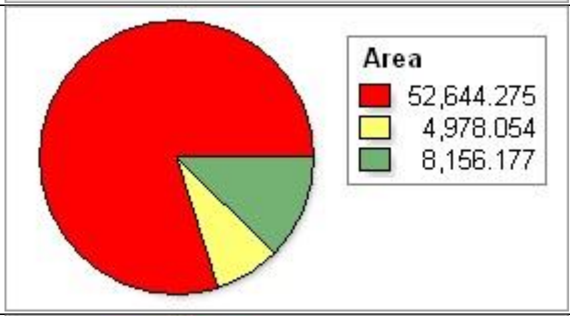
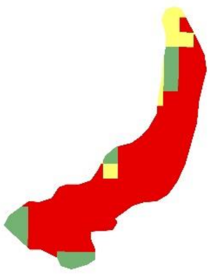
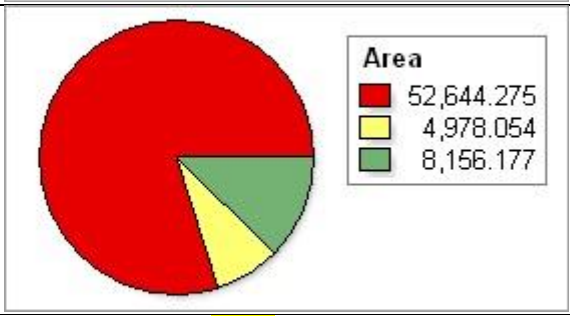
Year	Classification	Statistics “Areas are in meter square unit”
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-40 The development of the Sansana settlement through time

For Shimaa Settlement:

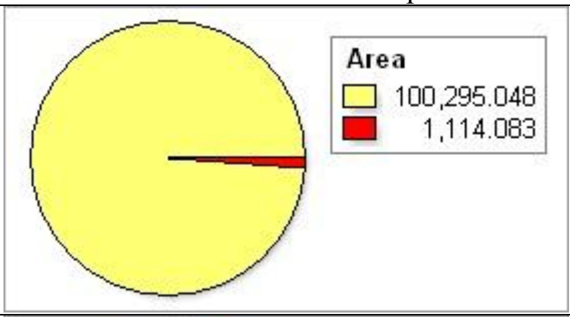
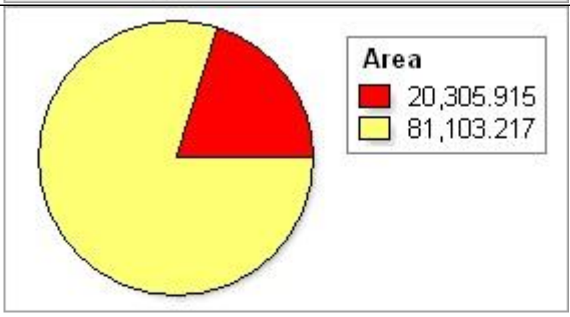
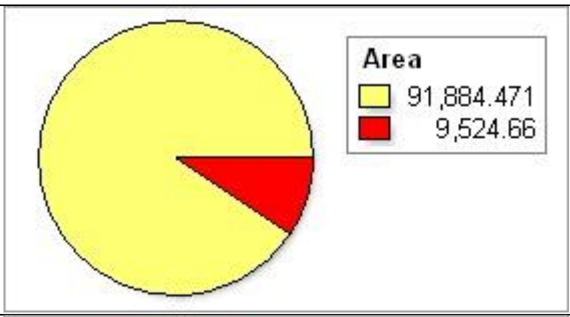
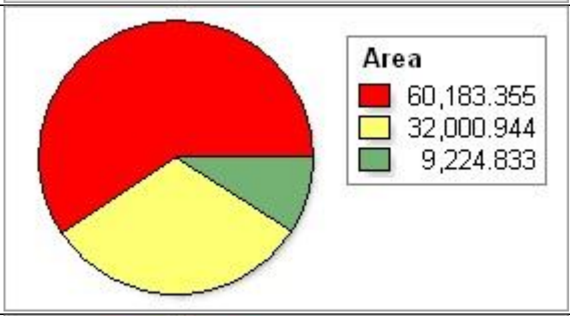
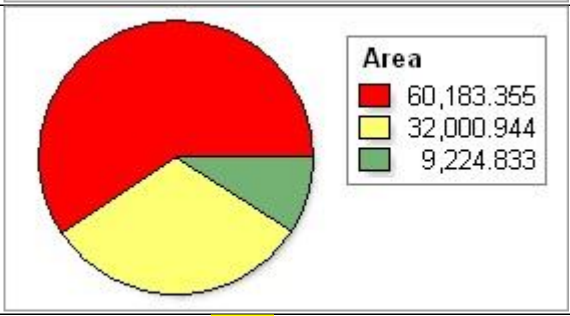
Year	Classification	Statistics "Areas are in meter square unit"
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-41 The development of the Shimaa settlement through time

For Susia Settlement:

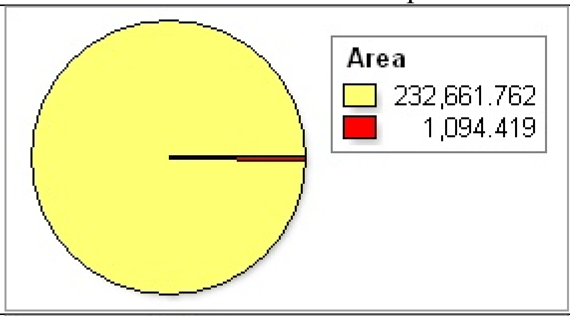
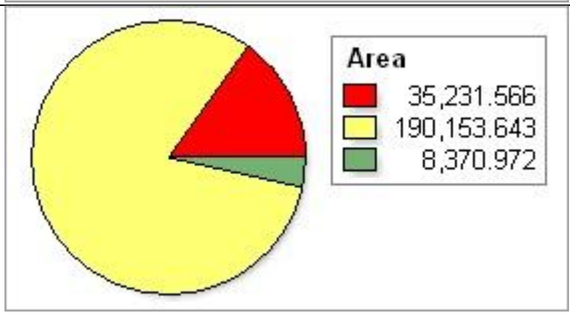
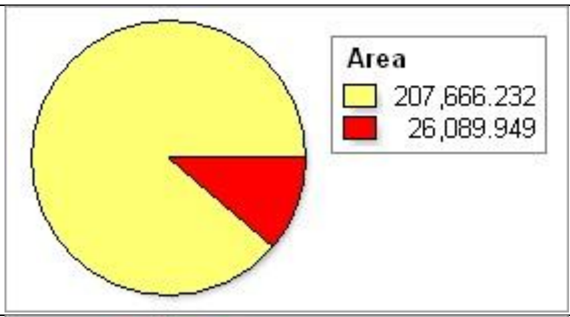
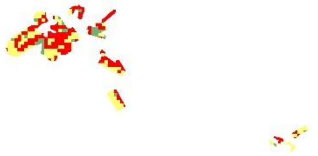
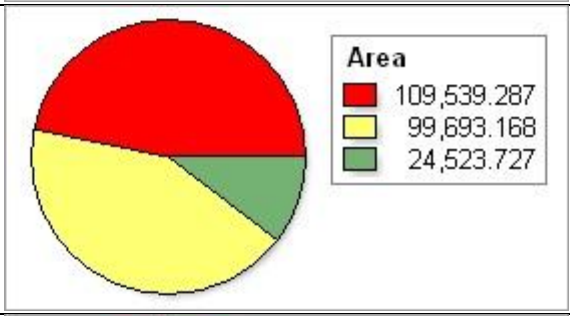
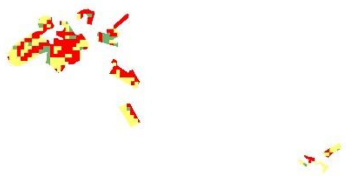
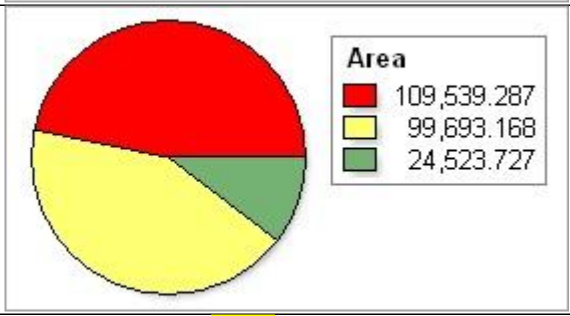
Year	Classification	Statistics “Areas are in meter square unit”
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-42 The development of the Susia settlement through time

For Tana Amarim Settlement:

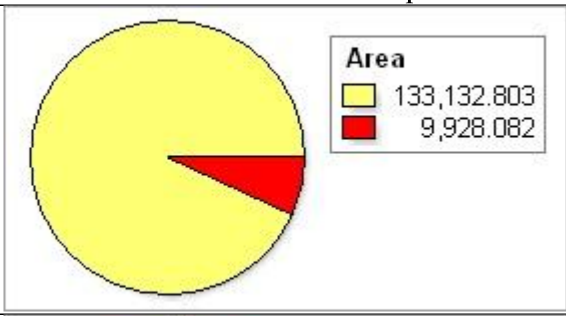
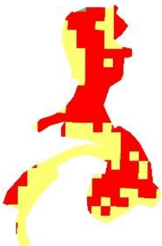
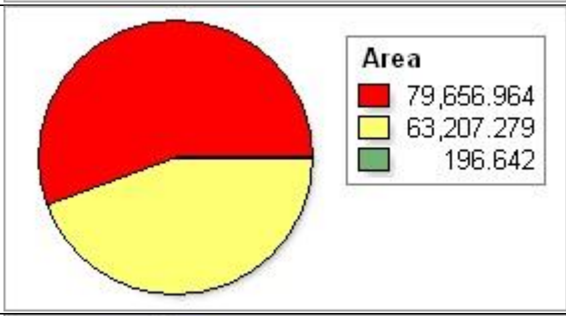
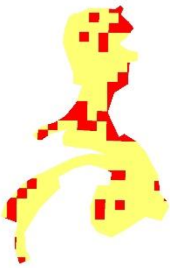
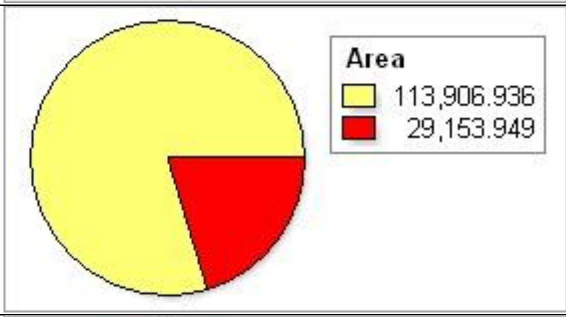
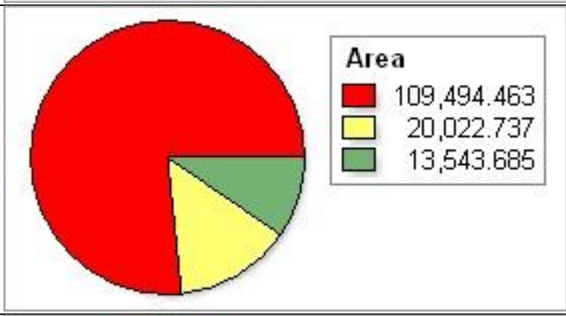
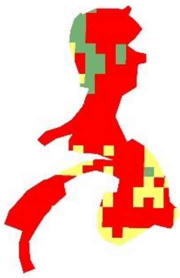
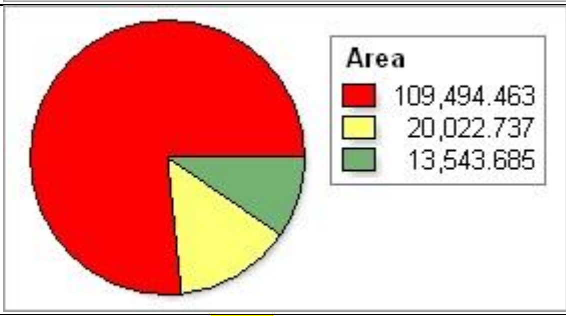
Year	Classification	Statistics “Areas are in meter square unit”
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-43 The development of the Tana Amarim settlement through time

For Telem Settlement:

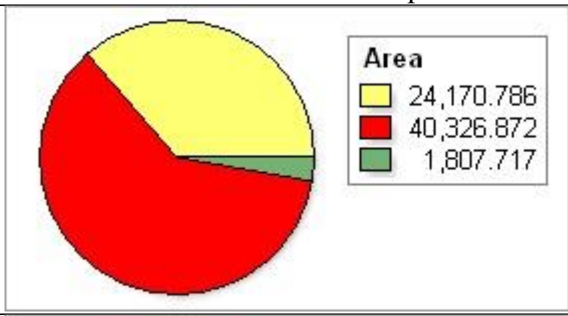
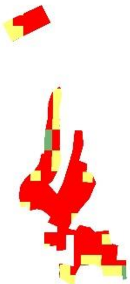
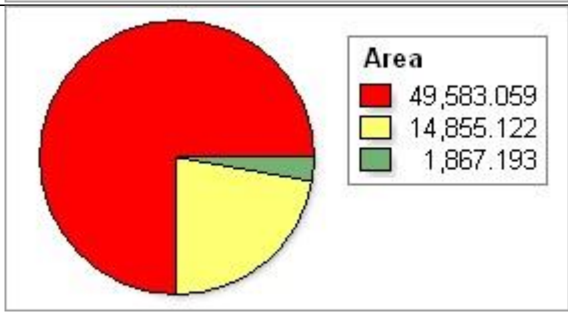
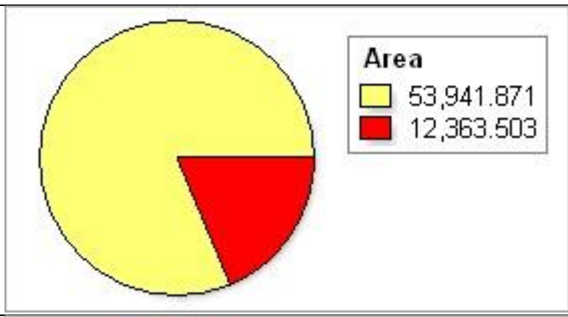
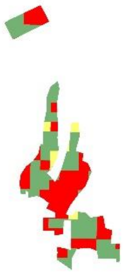
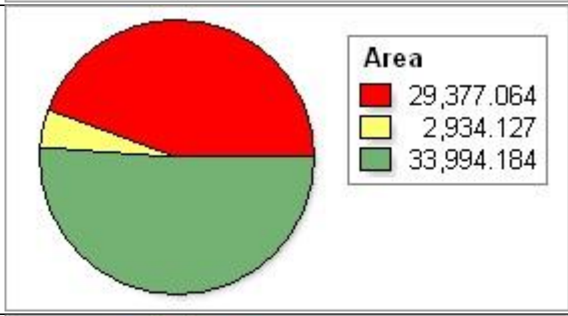
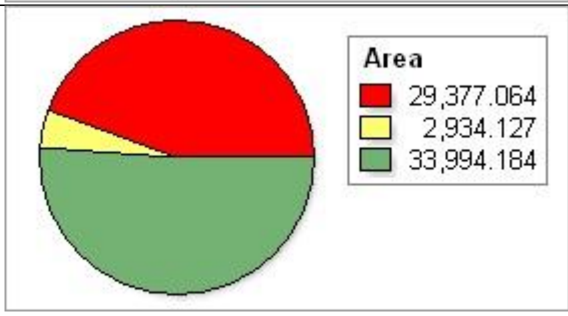
Year	Classification	Statistics “Areas are in meter square unit”
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-44 The development of the Telem settlement through time

Appendix A.3.2 Natural reserves

For first natural reserve:

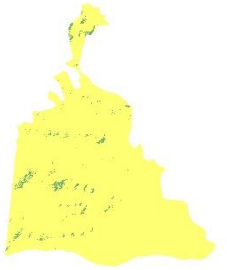
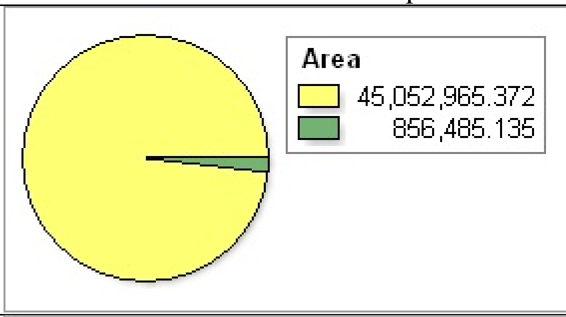
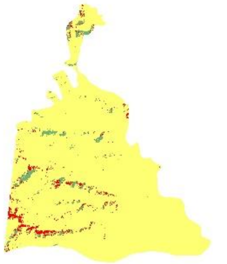
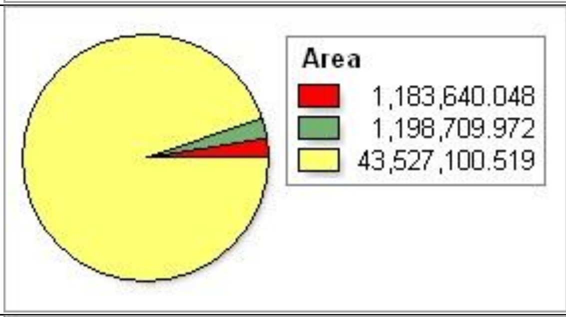
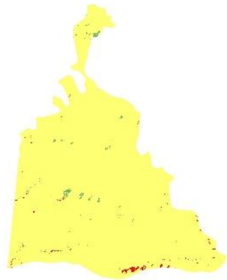
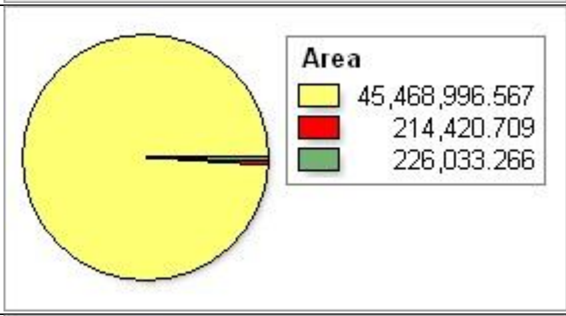
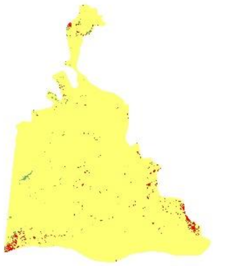
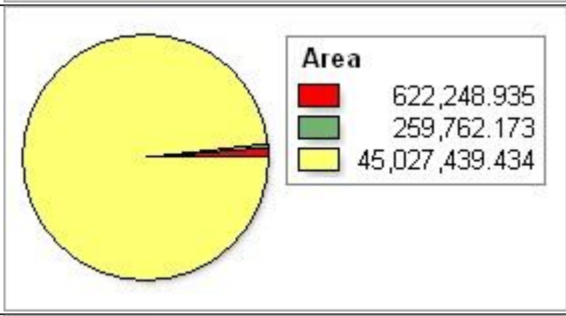
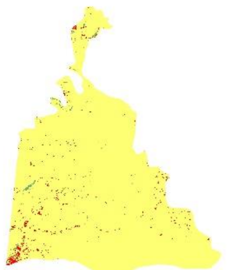
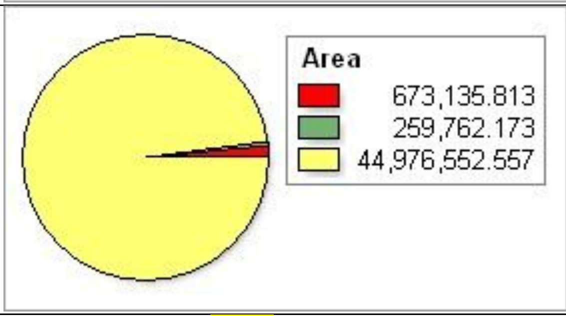
Year	Classification	Statistics "Areas are in meter square unit"
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-45 The development of the first natural reserve through time

For second natural reserve:

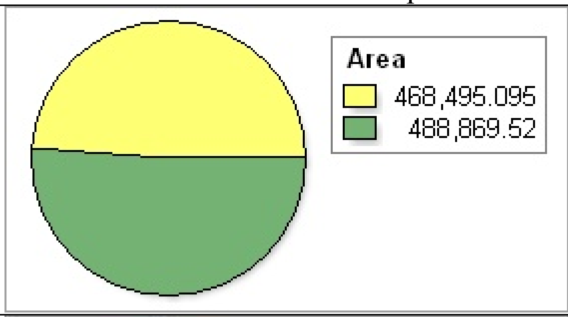
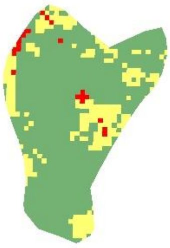
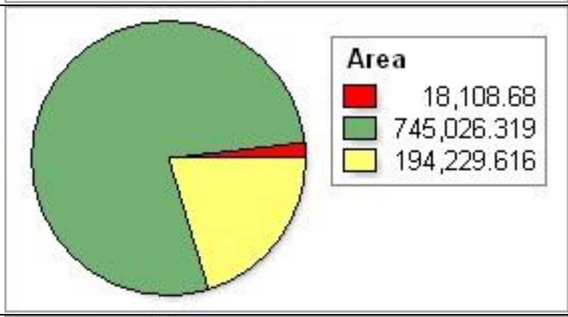
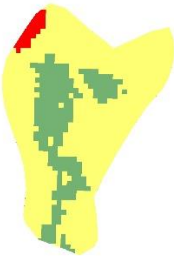
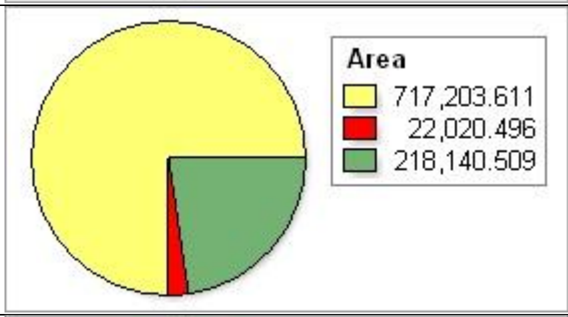
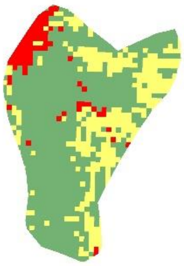
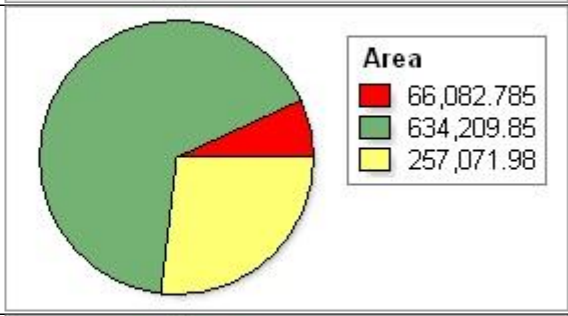
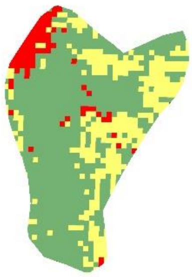
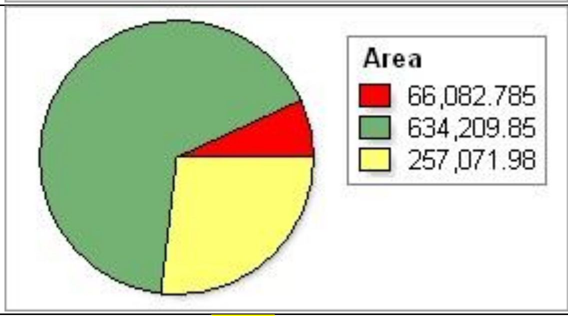
Year	Classification	Statistics “Areas are in meter square unit”
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-46 The development of the second natural reserve through time

For third natural reserve:

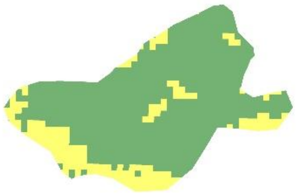
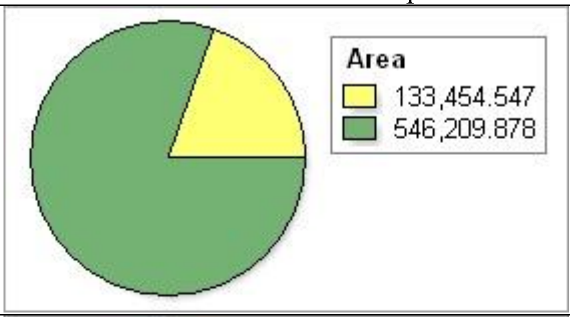
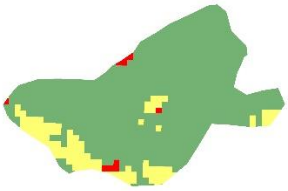
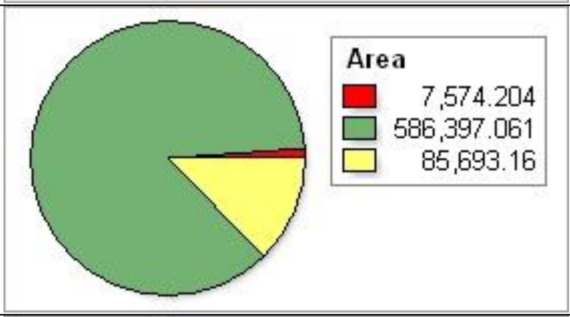
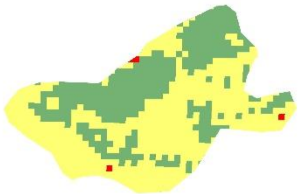
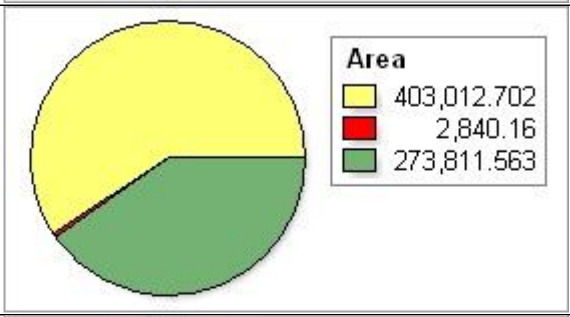
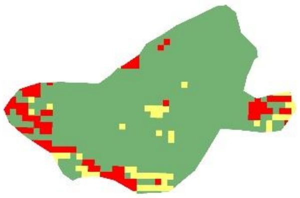
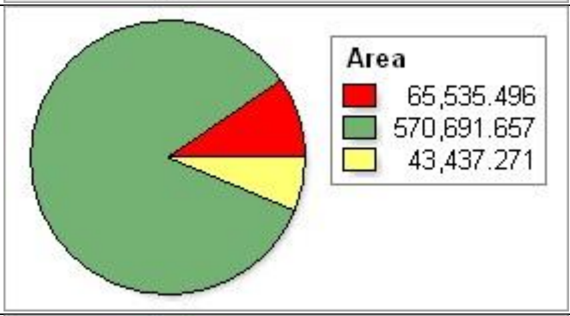
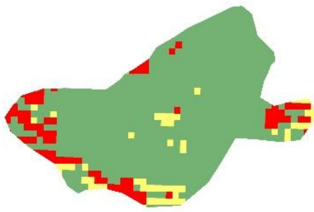
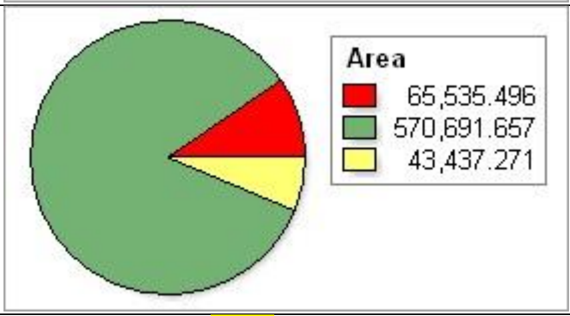
Year	Classification	Statistics “Areas are in meter square unit”
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-47 The development of the third natural reserve through time

For fourth natural reserve:

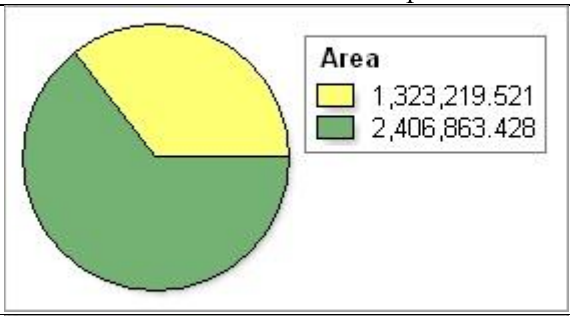
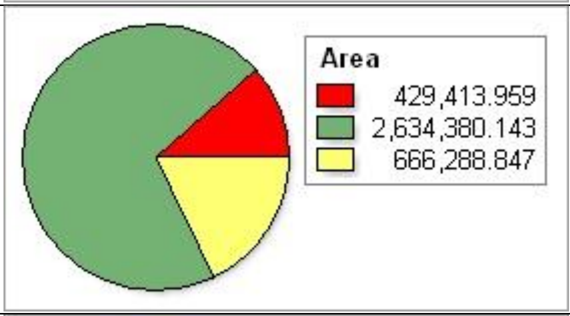
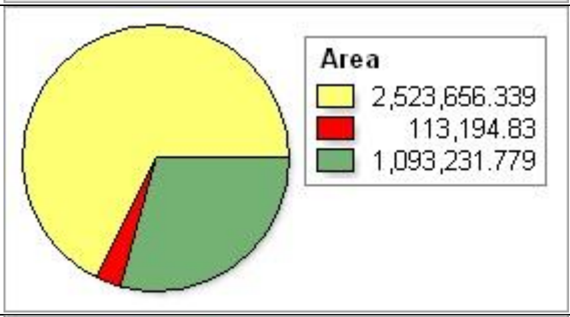
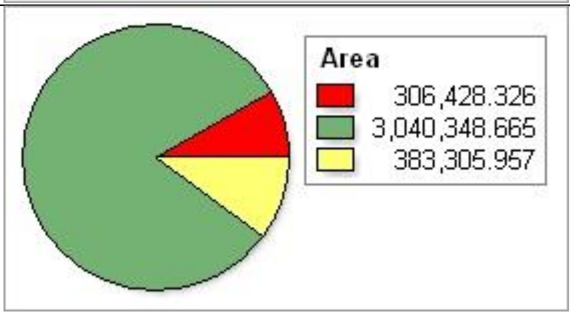
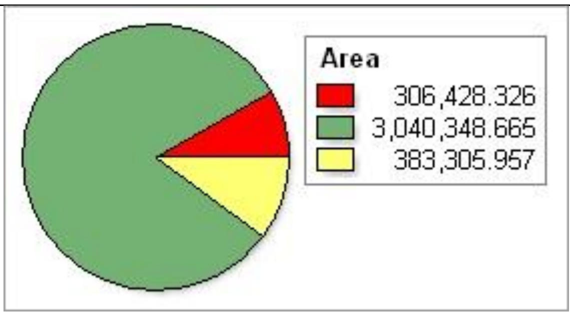
Year	Classification	Statistics “Areas are in meter square unit”
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-48 The development of the fourth natural reserve through time

For fifth natural reserve:

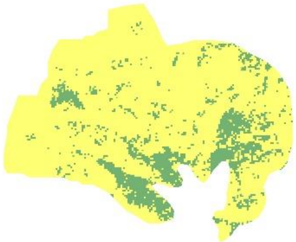
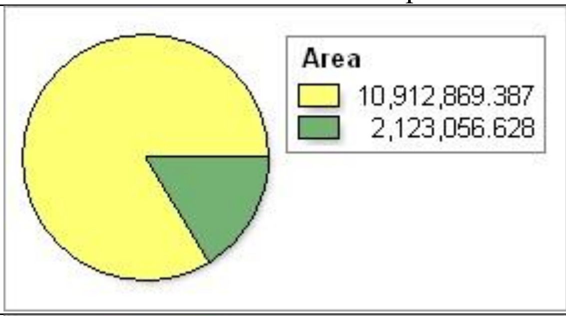
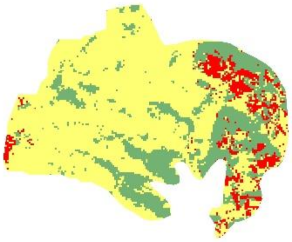
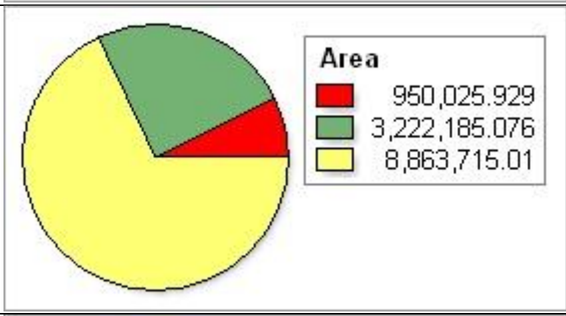
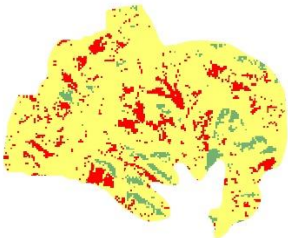
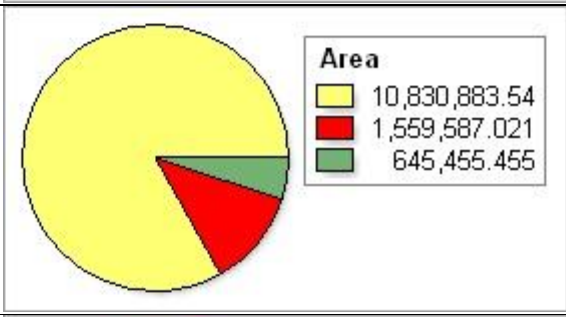
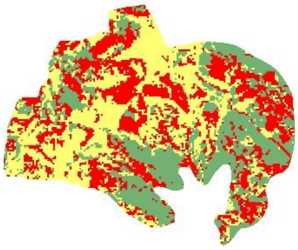
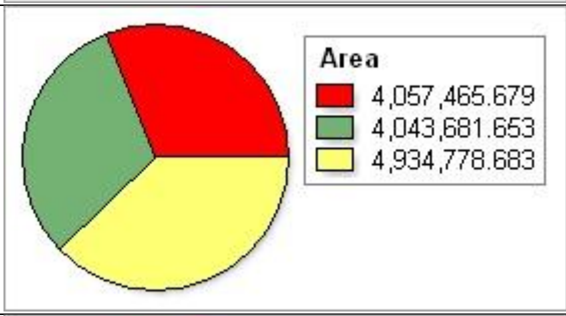
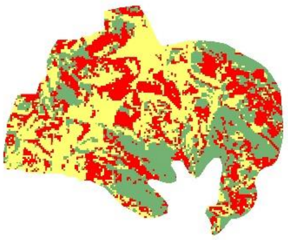
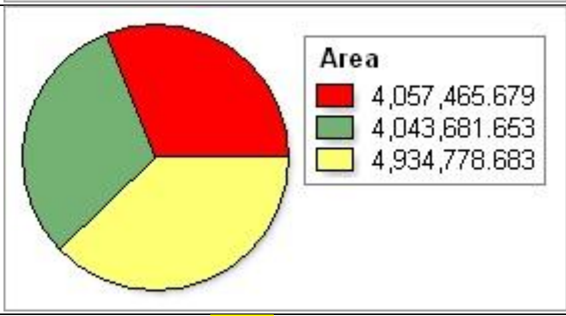
Year	Classification	Statistics “Areas are in meter square unit”
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-49 The development of the fifth natural reserve through time

For sixth natural reserve:

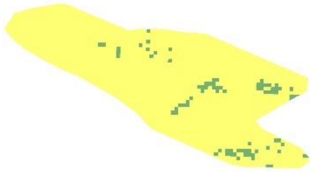
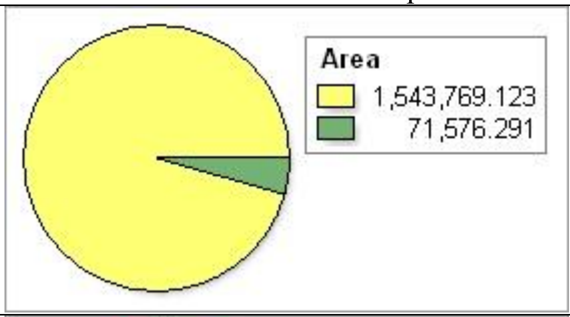
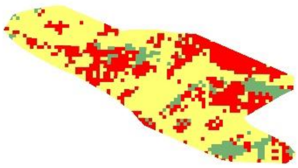
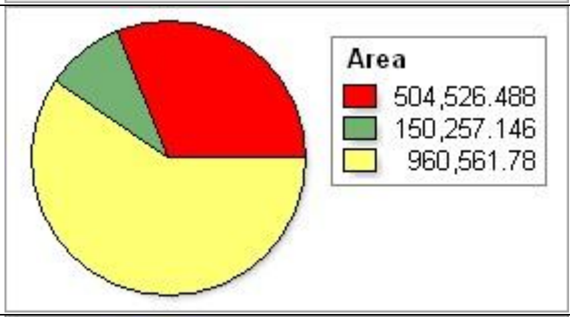
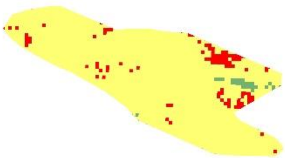
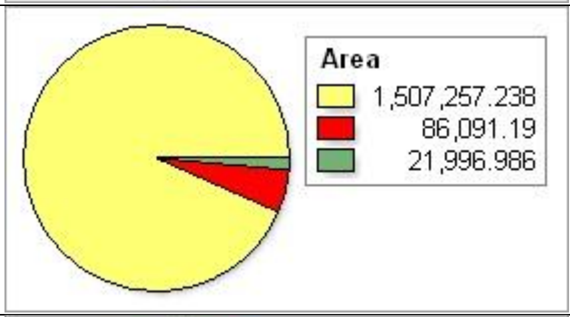
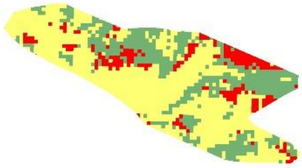
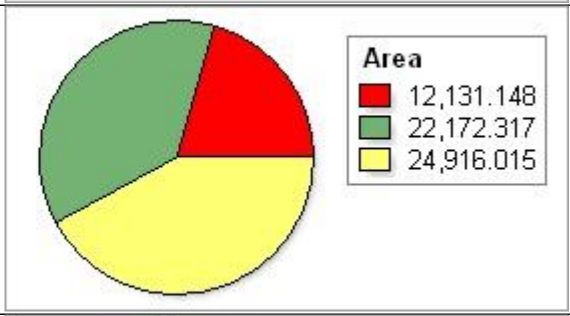
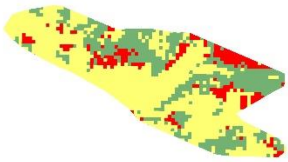
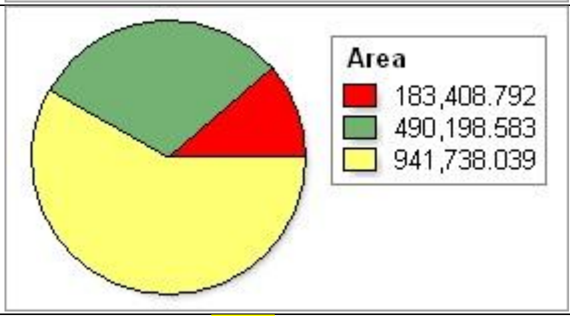
Year	Classification	Statistics “Areas are in meter square unit”
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-50 The development of the sixth natural reserve through time

For seventh natural reserve:

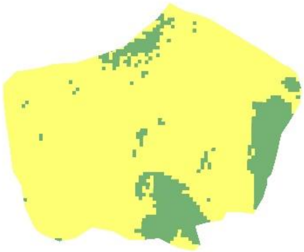
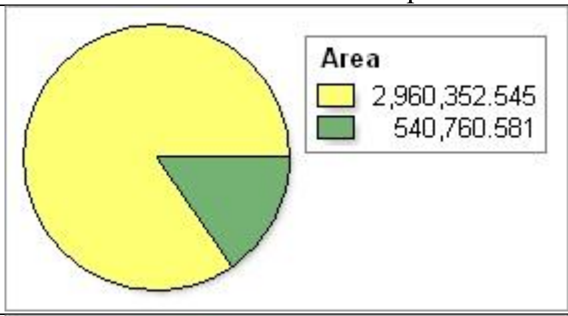
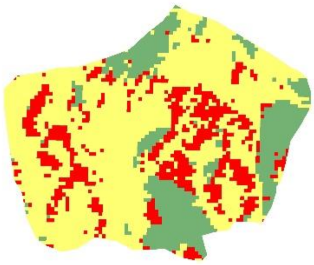
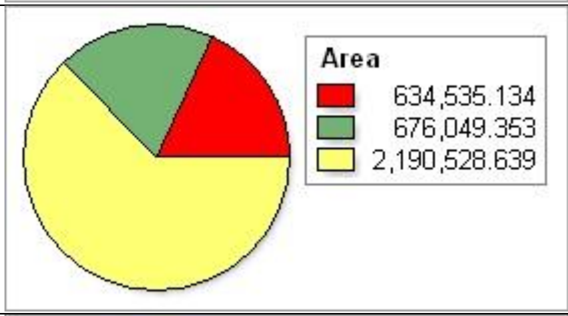
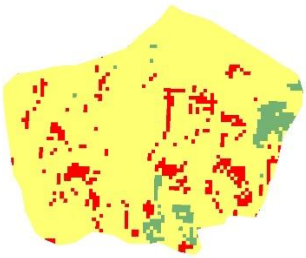
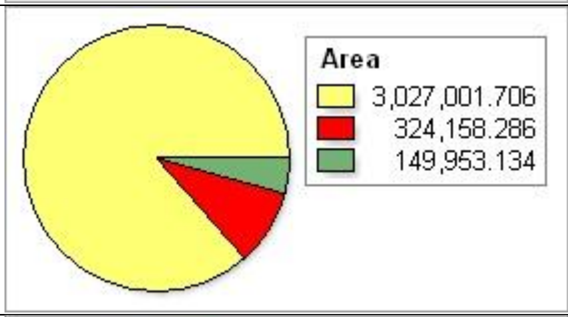
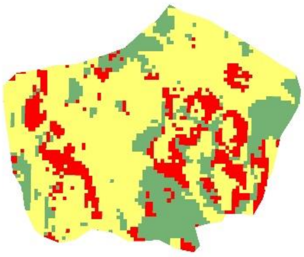
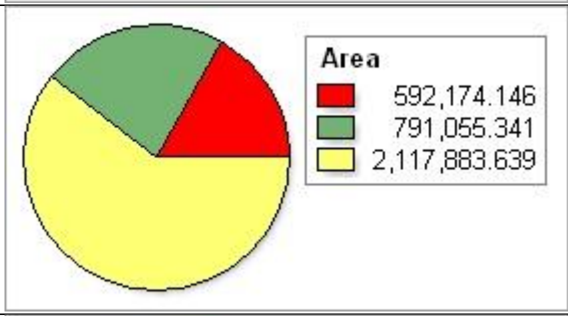
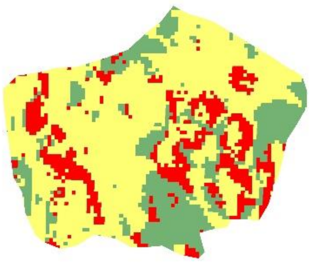
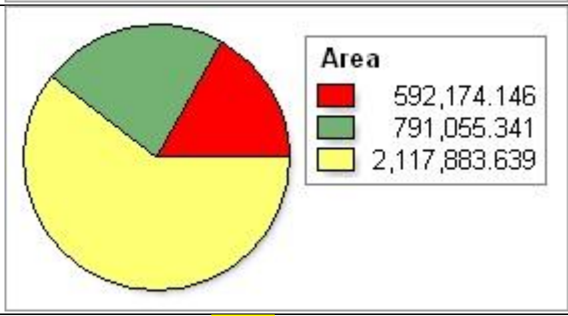
<table>
<tr><th>Year</th><th>Classification</th><th>Statistics “Areas are in meter square unit”</th></tr>
<tr><td>1984
Landsat 5</td><td></td><td>
</td></tr>
<tr><td>1998 Landsat 5</td><td></td><td>
</td></tr>
<tr><td>2002 Landsat 7</td><td></td><td>
</td></tr>
<tr><td>2015 Landsat 8</td><td></td><td>
</td></tr>
<tr><td>2017 Sentinel 2</td><td></td><td>
</td></tr>
<tr><td>Artificial surfaces</td><td>Agricultural areas</td><td>Forests and seminatural areas</td></tr>
</table>

Table A-51 The development of the seventh natural reserve through time

For eighth natural reserve:

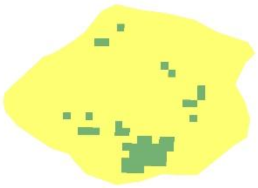
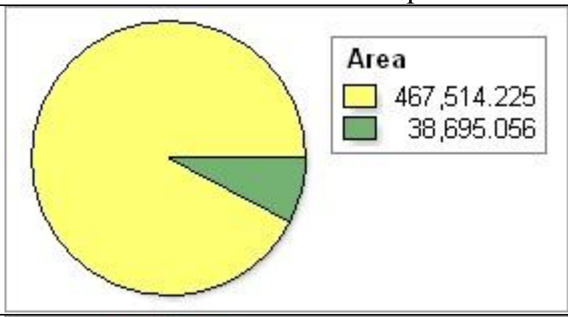
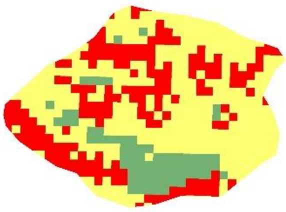
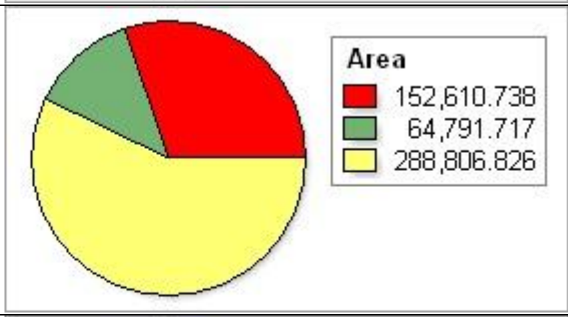
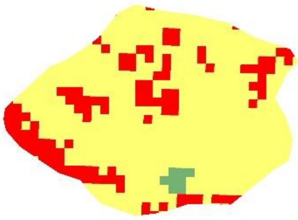
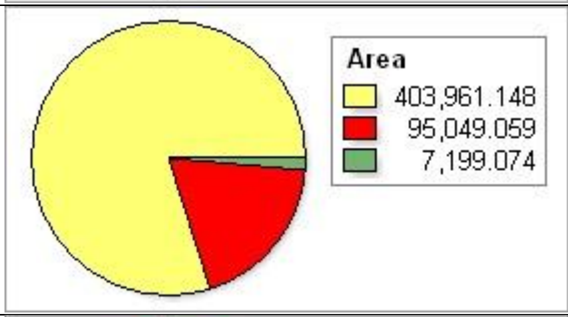
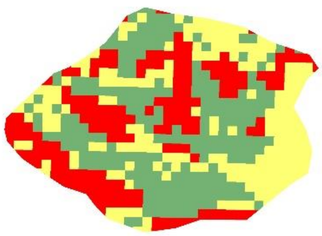
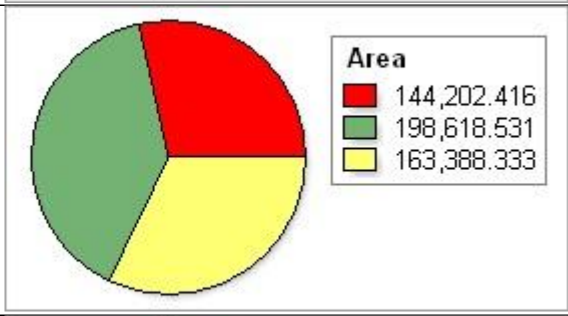
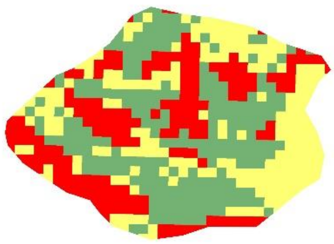
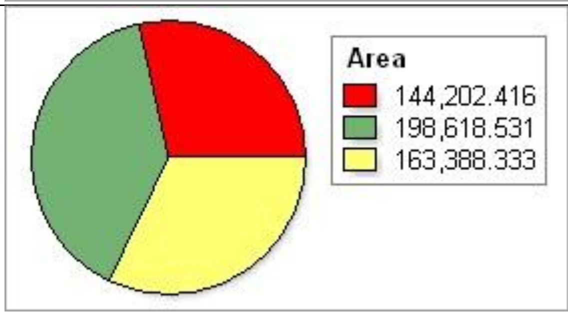
Year	Classification	Statistics “Areas are in meter square unit”
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-52 The development of the eighth natural reserve through time

For ninth natural reserve:

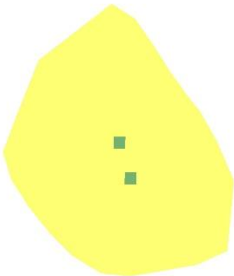
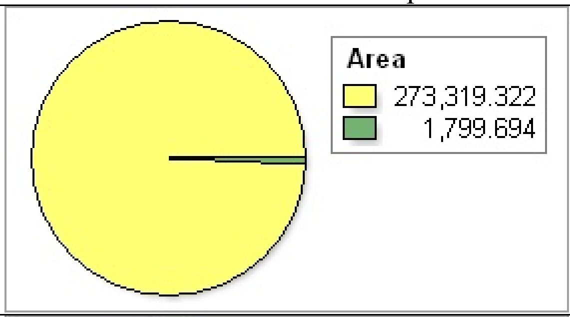
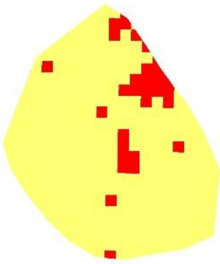
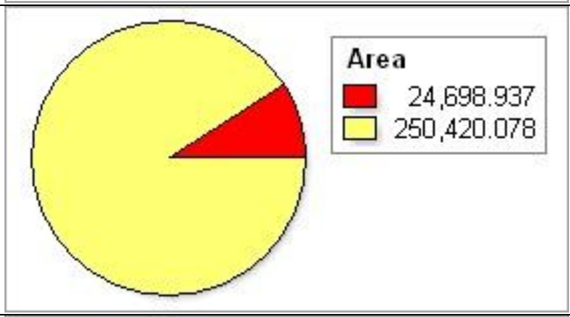
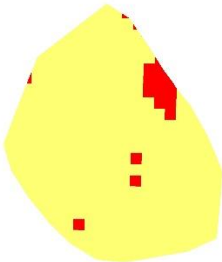
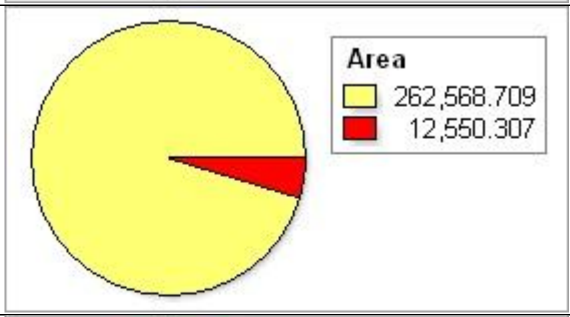
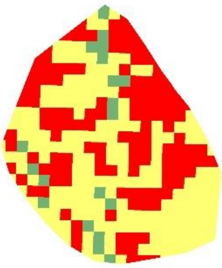
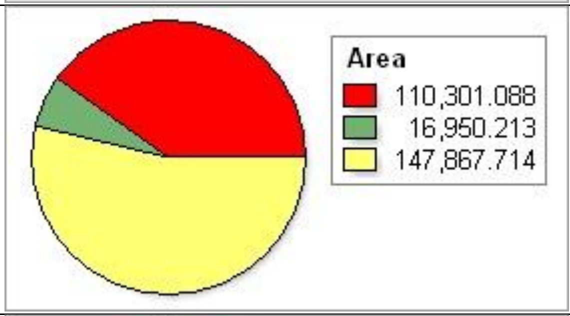
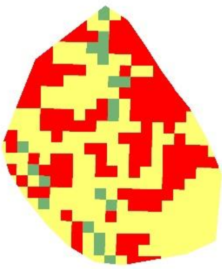
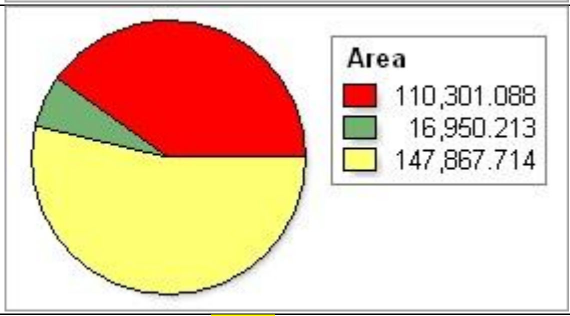
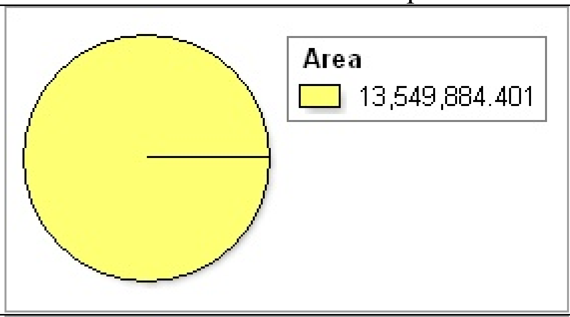
Year	Classification	Statistics "Areas are in meter square unit"
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

Table A-53 The development of the ninth natural reserve through time

For tenth natural reserve:

<table>
<tr><th>Year</th><th>Classification</th><th>Statistics “Areas are in meter square unit”</th></tr>
<tr><td>1984
Landsat 5</td><td></td><td>
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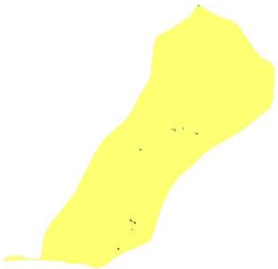
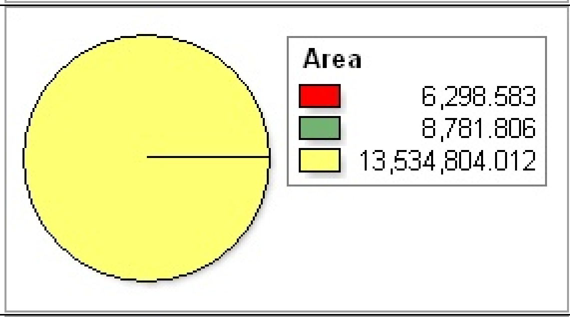
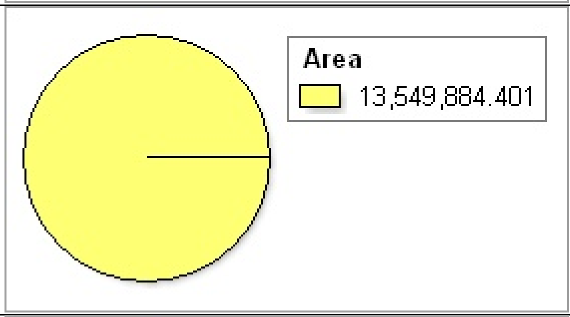
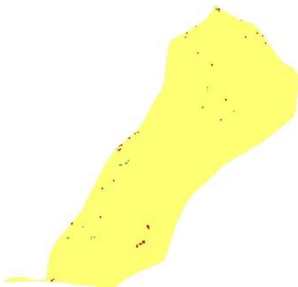
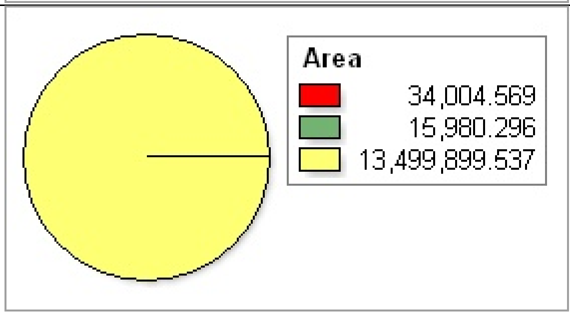
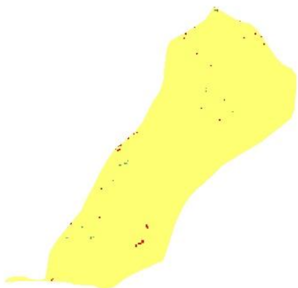
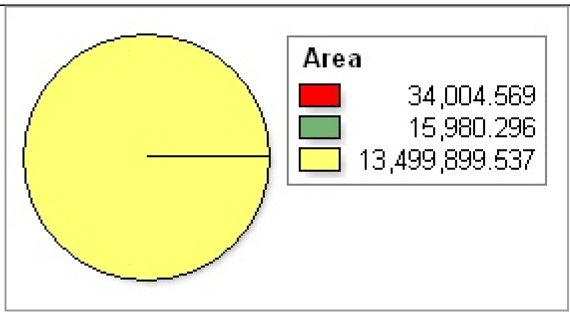
<tr><td>1998 Landsat 5</td><td></td><td>
</td></tr>
<tr><td>2002 Landsat 7</td><td></td><td>
</td></tr>
<tr><td>2015 Landsat 8</td><td></td><td>
</td></tr>
<tr><td>2017 Sentinel 2</td><td></td><td>
</td></tr>
<tr><td colspan="3">Artificial surfaces   Agricultural areas   Forests and seminatural areas</td></tr>
</table>

Table A-54 The development of the tenth natural reserve through time

For eleventh natural reserve:

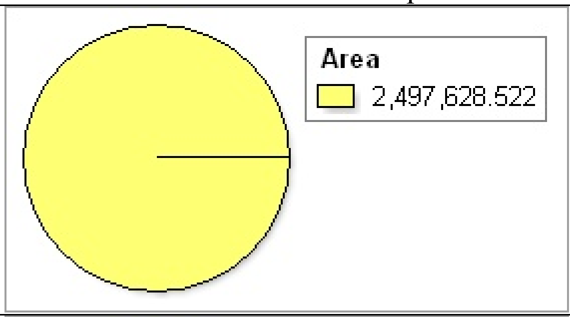
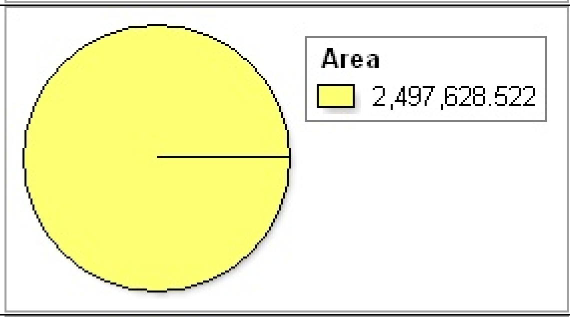
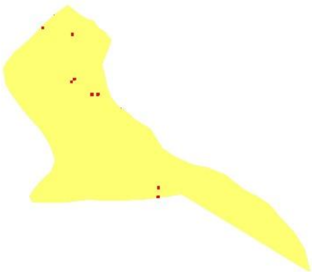
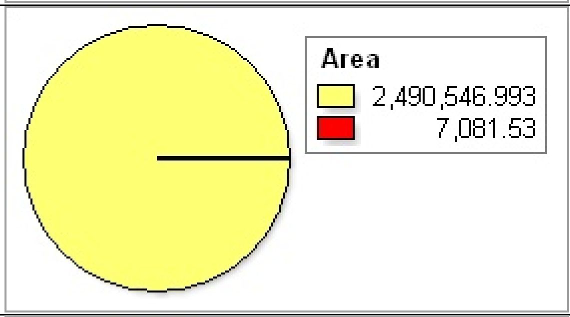
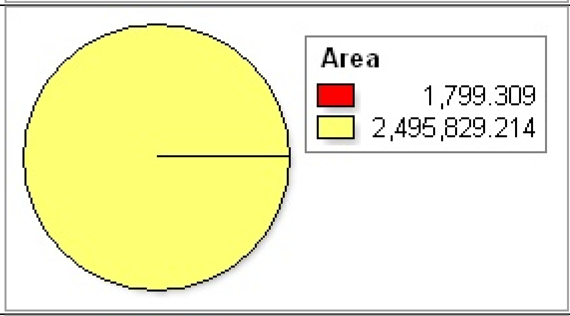
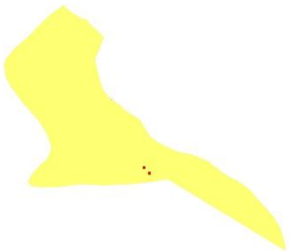
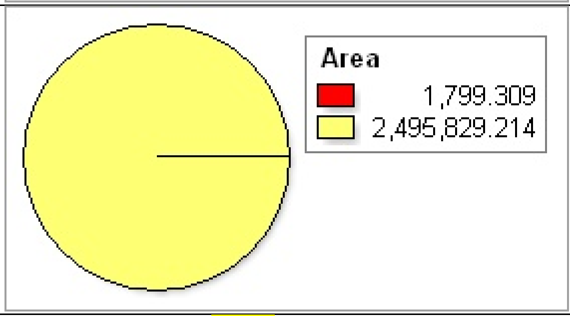
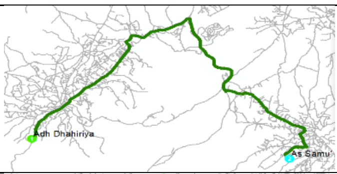
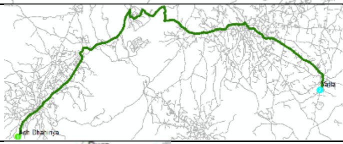
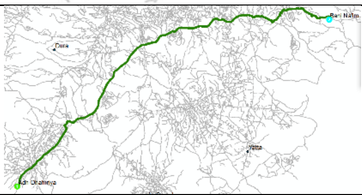
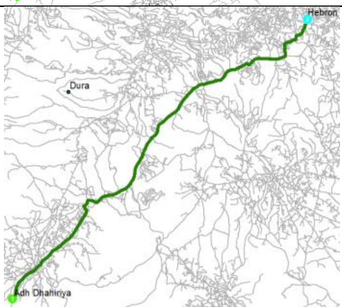
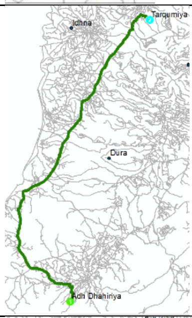
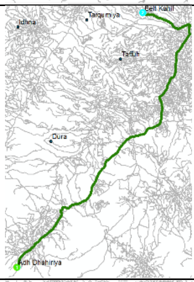
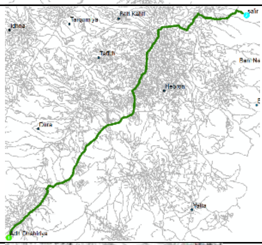
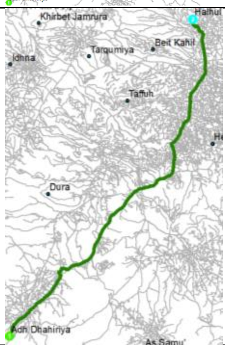
Year	Classification	Statistics "Areas are in meter square unit"
1984 Landsat 5		
1998 Landsat 5		
2002 Landsat 7		
2015 Landsat 8		
2017 Sentinel 2		
Artificial surfaces	Agricultural areas	Forests and seminatural areas

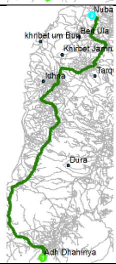
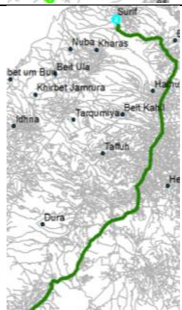
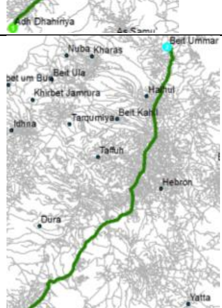
Table A-55 The development of the eleventh natural reserve through time

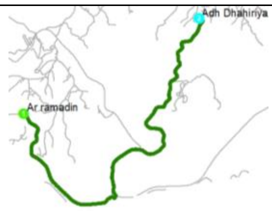
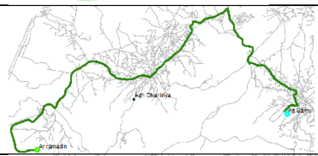
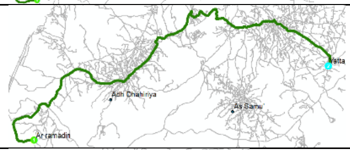
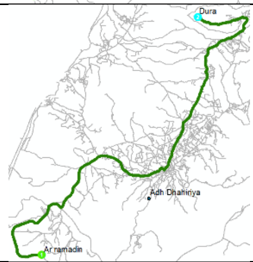
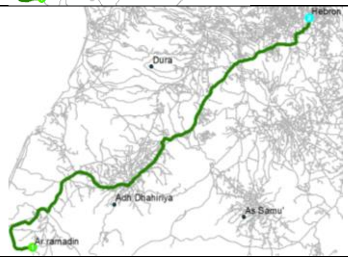
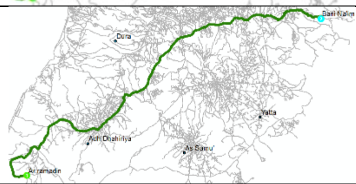
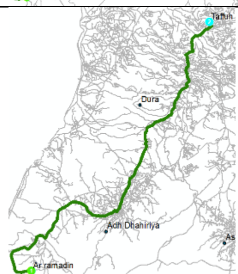
Appendix A.4 Network analysis results

This part of this chapter shows the detailed results of the analysis of the existing road network in details, and the next table contains the results:

First point	Second point	Total travel distance "meter"	Total time "minuets"	Shortest path
Ad-Dahria	As-Samu'	17982.3	13	
Ad-Dahria	Yatta	23989.3	16	
Ad-Dahria	Dura	14700.3	12	
Ad-Dahria	Bani Na'im	29662.2	24	
Ad-Dahria	Hebron	20879.8	15	
Ad-Dahria	Taffuh	20873.1	18	

Ad-Dahria	Idhna	25595.1	19	
Ad-Dahria	Tarqumiya	26154.8	22	
Ad-Dahria	Beit Kahil	298138	21	
Ad-Dahria	Sa’ir	34107.5	25	
Ad-Dahria	Halhul	28386.6	20	
Ad-Dahria	Khirbet Jamrura	29491.9	21	

Ad-Dahria	Khirbet Um Burj	30055.1	22	
Ad-Dahria	Beit Ula	33215.1	25	
Ad-Dahria	Nuba	38096.6	27	
Ad-Dahria	Kharas	37431.1	27	
Ad-Dahria	Surif	39103.8	30	
Ad-Dahria	Beit Ummar	33509.4	23	

Ar-Ramadin	Ad-Dahria	13486.4	9	
Ar-Ramadin	As-Samu’	29970	21	
Ar-Ramadin	Yatta	35905.8	24	
Ar-Ramadin	Dura	26412.6	19	
Ar-Ramadin	Hebron	32952.4	24	
Ar-Ramadin	Bani Na’im	41658.2	32	
Ar-Ramadin	Taffuh	32587.5	26	
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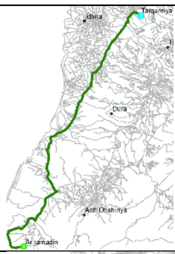
Ar-Ramadin	Tarqumiya	31208.9	25	
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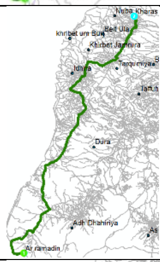
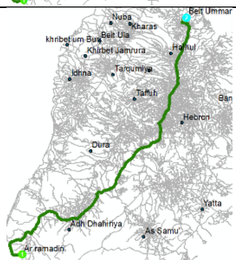
Ar-Ramadin	Sa’ir	46095.2	33	
Ar-Ramadin	Halhul	40337.9	28	
Ar-Ramadin	Khirbet Jamrura	34497.8	23	
Ar-Ramadin	Khirbet Um Burj	35105	24	

Ar-Ramadin	Beit Ula	38447.5	28	
Ar-Ramadin	Nuba	43238.5	30	
Ar-Ramadin	Kharas	42481.6	30	
Ar-Ramadin	Beit Ummar	46007.6	32	
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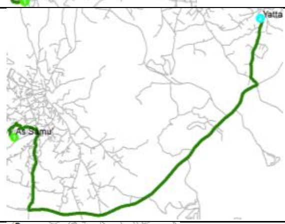
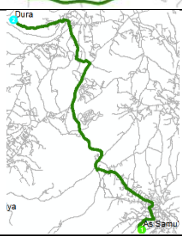
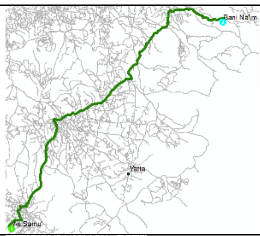
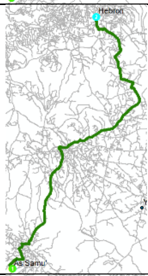
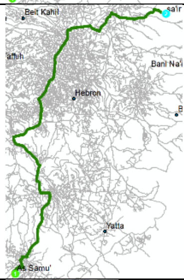
As-Samu’	Yatta	13714.4	10	
As-Samu’	Dura	17798.8	16	

As-Samu'	Bani Na'im	23571.1	20	
As-Samu'	Hebron	20513	16	
As-Samu'	Sa'ir	34417	26	
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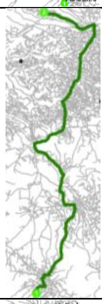
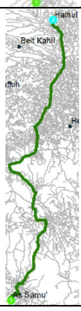
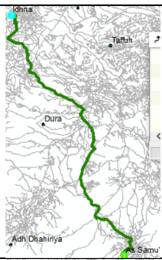
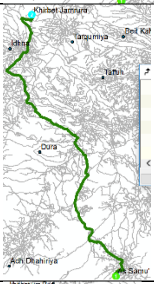
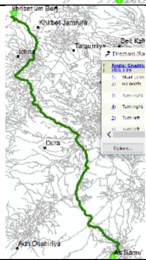
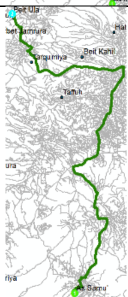
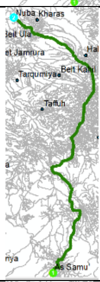
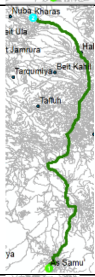
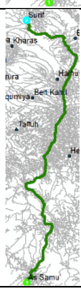
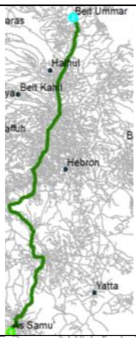
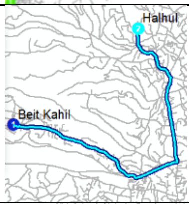
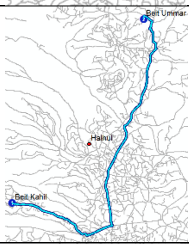
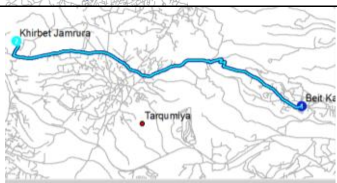
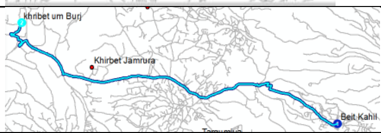
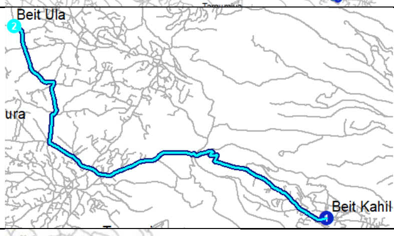
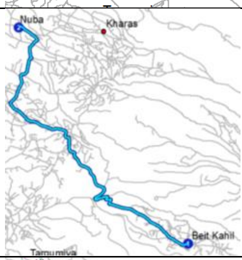
As-Samu'	Tarqumiya	35398.1	25	
As-Samu'	Beit Kahil	29433.8	22	
As-Samu'	Halhul	28804.9	21	

As-Samu’	Idhna	28591.3	26	
As-Samu’	Khirbet Jamrura	32496.6	28	
As-Samu’	Khirbet Um Burj	34387.1	29	
As-Samu’	Beit Ula	39770.1	30	
As-Samu’	Nuba	37441.6	31	
As-Samu’	Kharas	35525.2	29	
As-Samu’	Surif	39490.9	31	

As-Samu’	Beit Ummar	33744.2	24	
Beit Kahil	Halhul	7324.2	7	
Beit Kahil	Beit Ummar	12394.9	11	
Beit Kahil	Khirbet Jamrura	9228.9	9	
Beit Kahil	Khirbet Um Burj	12770.3	12	
Beit Kahil	Beit Ula	8935.1	10	
Beit Kahil	Nuba	10100.9	10	
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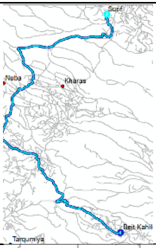
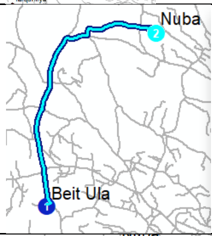
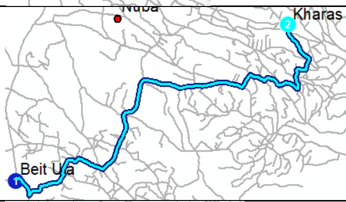
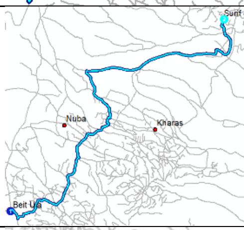
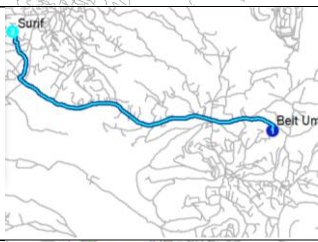
Beit Kahil	Surif	16826.2	17	
Beit Ula	Nuba	3480.6	4	
Beit Ula	Kharas	6490.6	6	
Beit Ula	Surif	11041.9	11	
Beit Ummar	Surif	6794.1	8	
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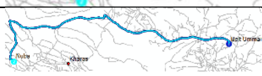
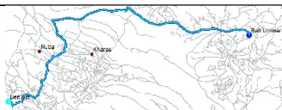
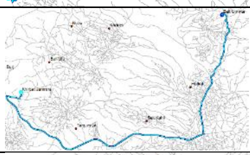
Beit Ummar	Nuba	12315	14	
Beit Ummar	Beit Ula	15667.4	17	
Beit Ummar	Khirbet Jamrura	23758.5	17	
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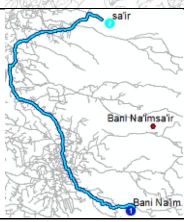
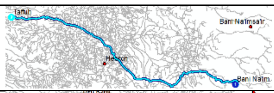
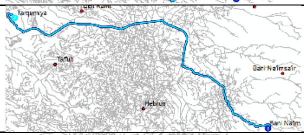
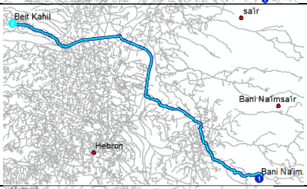
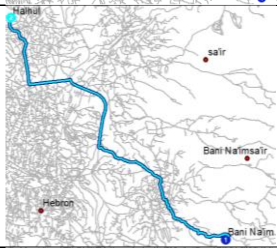
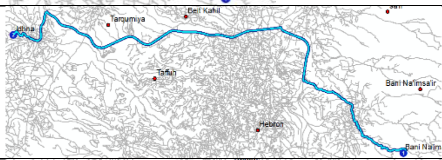
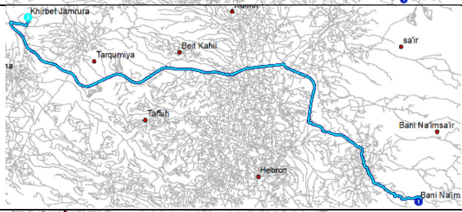
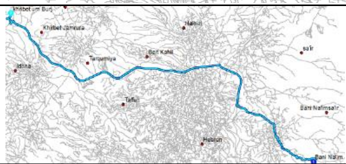
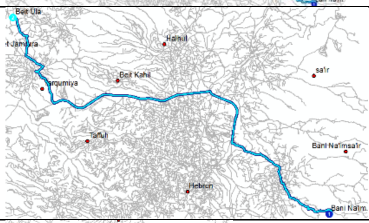
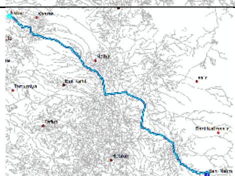
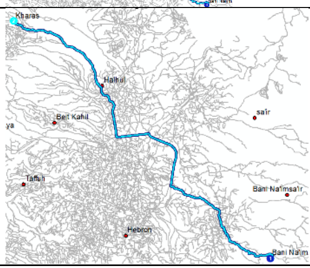
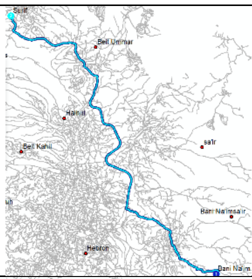
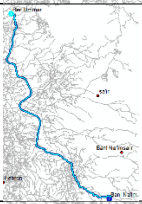
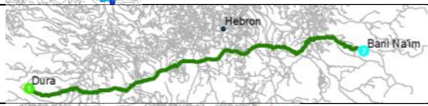
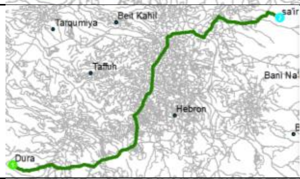
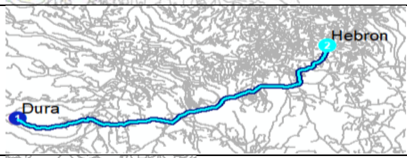
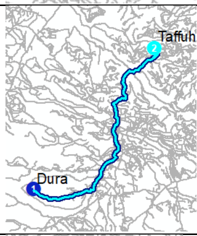
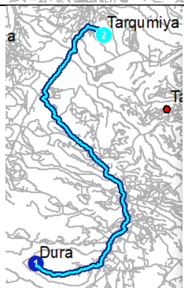
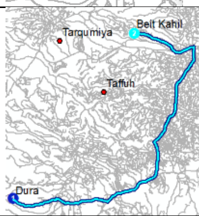
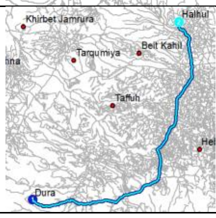
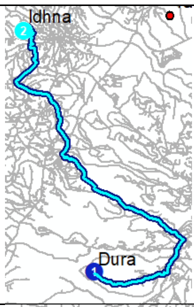
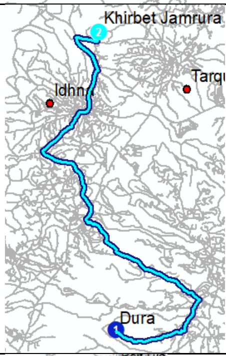
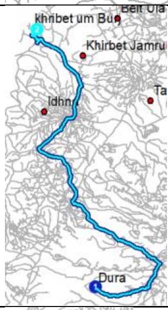
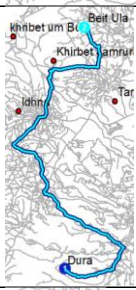
Bani Na'im	Sa'ir	14990	18	

Bani Na'im	Taffuh	17447.5	21	
Bani Na'im	Tarqumiya	23957	22	
Bani Na'im	Beit Kahil	17911.1	18	
Bani Na'im	Halhul	17346.1	17	
Bani Na'im	Idhna	30154.6	26	
Bani Na'im	Khirbet Jamrura	29304.8	24	
Bani Na'im	Khribet um Burj	31220.8	26	
Bani Na'im	Beit Ula	28401	26	
Bani Na'im	Nuba	25916.3	27	
Bani Na'im	Kharas	24127.6	25	

Bani Na’im	Surif	26908.9	26	
Bani Na’im	Beit Ummar	21239.8	19	
Dora	Bani Na’im	21998.6	22	
Dora	Sa’ir	26758.5	24	
Dora	Hebron	13627.1	14	
Dora	Taffuh	11890.6	14	
Dora	Tarqumiya	16348.7	19	
Dora	Beit Kahil	21633.5	19	
Dora	Halhul	21045.5	18	

Dora	Idhna	16945.4	17	
Dora	Khirbet Jamrura	20783.8	19	
Dora	Khribet um Burj	22643.5	21	
Dora	Beit Ula	24717.4	23	
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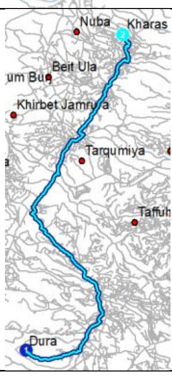
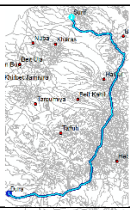
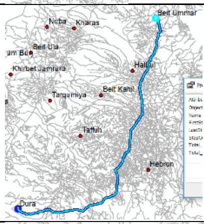
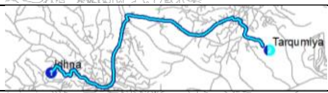
Dora	Kharas	23651.6	25	

Dora	Surif	31767.3	29	
Dora	Beit Ummar	26070.2	22	
Idhna	Tarqumiya	7805.2	7	
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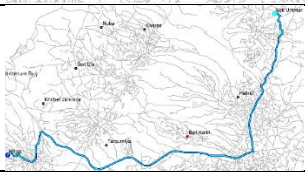
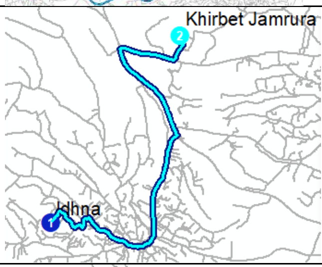
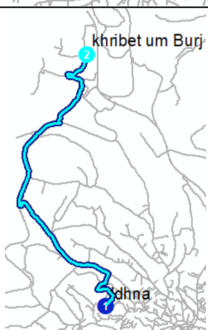
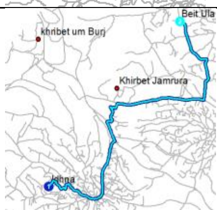
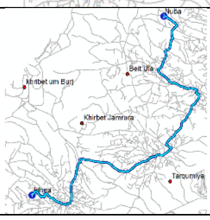
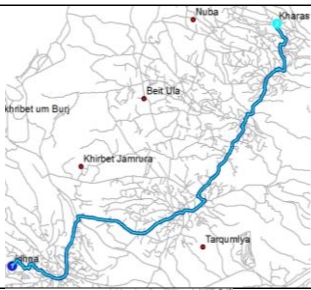
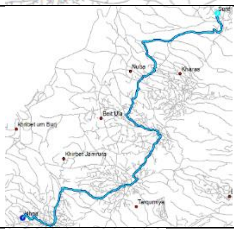
Idhna	Beit Ummar	24569.5	18	
Idhna	Khirbet Jamrura	6408.5	5	
Idhna	Khribet um Burj	6212.8	7	
Idhna	Beit Ula	10289.3	10	
Idhna	Nuba	15008.1	12	

Idhna	Kharas	14361.4	12	
Idhna	Surif	21718.3	18	
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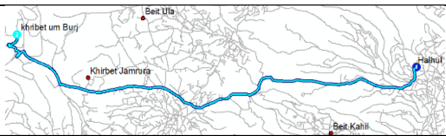
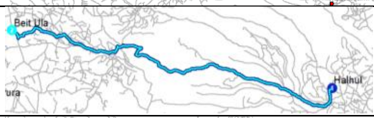
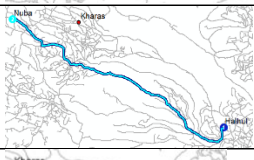
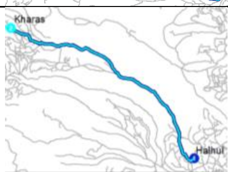
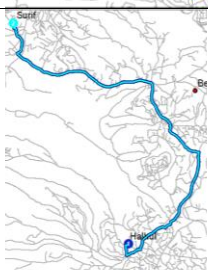
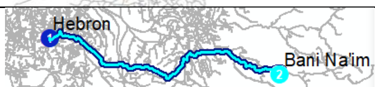
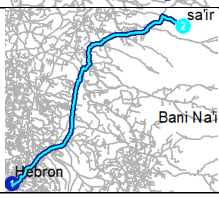
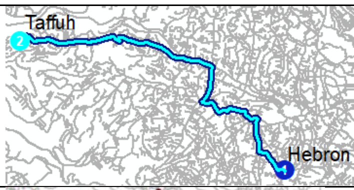
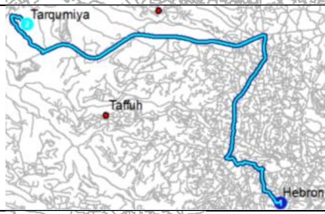
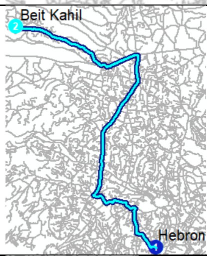
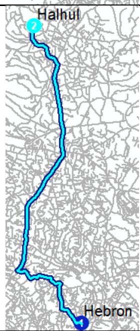
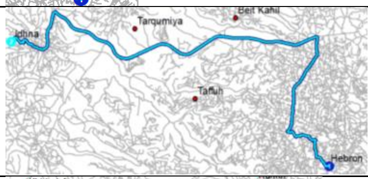
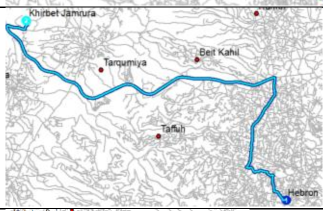
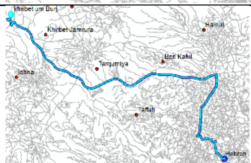
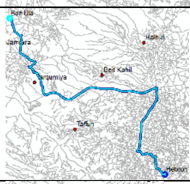
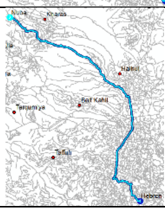
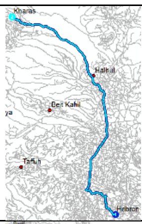
Halhul	Khribet um Burj	15743.2	15	
Halhul	Beit Ula	10831.7	12	
Halhul	Nuba	9735.2	11	
Halhul	Kharas	7050.1	8	
Halhul	Surif	12498.9	14	
Hebron	Bani Na’im	10529.3	12	
Hebron	Sa’ir	11899.8	13	

Hebron	Taffuh	8628.2	10	
Hebron	Tarqumiya	17595.6	15	
Hebron	Beit Kahil	11580.5	11	
Hebron	Halhul	10966.1	10	
Hebron	Idhna	23793.3	19	
Hebron	Khirbet Jamrura	22926.7	17	
Hebron	Khirbet Um Burj	24841.9	19	
Hebron	Beit Ula	21951.4	19	
Hebron	Nuba	19554.9	20	

Hebron	Kharas	17723.6	18	
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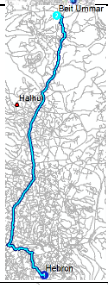
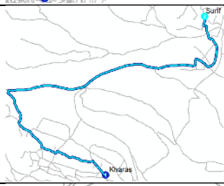
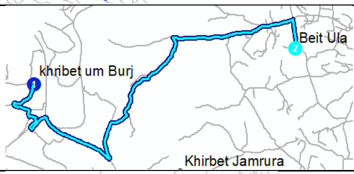
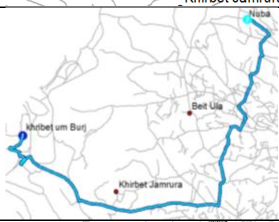
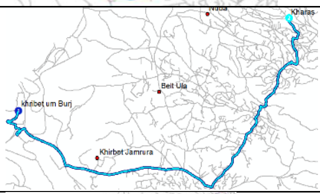
Hebron	Beit Ummar	15984	13	
Kharas	Surif	7440.7	7	
Khirbet Um Burj	Beit Ula	7393.7	8	
Khirbet Um Burj	Nuba	12098.3	11	
Khirbet Um Burj	Kharas	13838.3	11	
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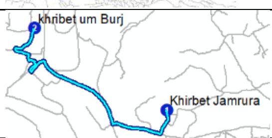
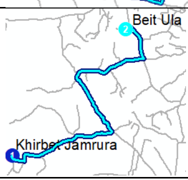
Khirbet Jamrura	Khirbet Um Burj	4401.8	4	
Khirbet Jamrura	Beit Ula	4437.6	5	

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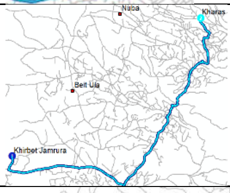
<tr><td>Khirbet Jamrura</td><td>Kharas</td><td>10344.5</td><td>9</td><td>
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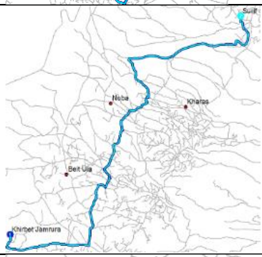
<tr><td>Khirbet Jamrura</td><td>Surif</td><td>15299.2</td><td>15</td><td>
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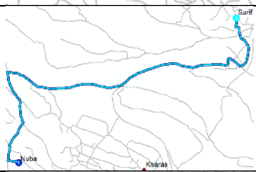
<tr><td>Nuba</td><td>Surif</td><td>7683.2</td><td>8</td><td>
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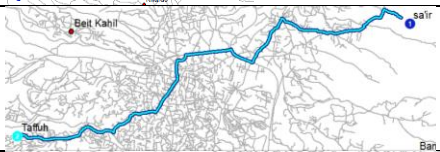
<tr><td>Sa’ir</td><td>Taffuh</td><td>16419.5</td><td>16</td><td>
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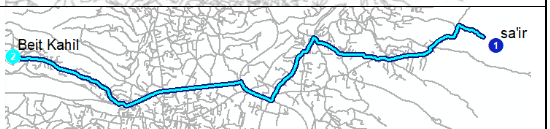
<tr><td>Sa’ir</td><td>Beit Kahil</td><td>13056.3</td><td>13</td><td>
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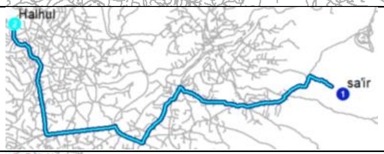
<tr><td>Sa’ir</td><td>Halhul</td><td>12460.0</td><td>12</td><td>
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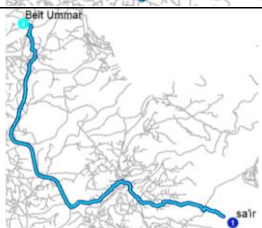
<tr><td>Sa’ir</td><td>Beit Ummar</td><td>13486.2</td><td>13</td><td>
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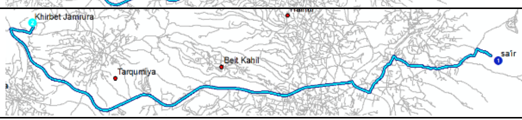
<tr><td>Sa’ir</td><td>Khirbet Jamrura</td><td>24442.4</td><td>19</td><td>
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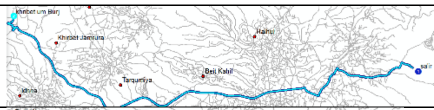
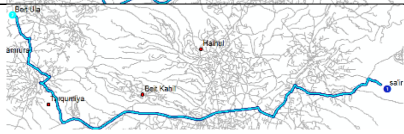
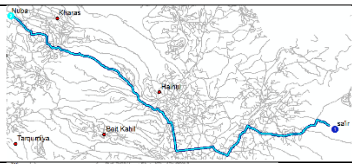
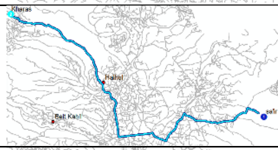
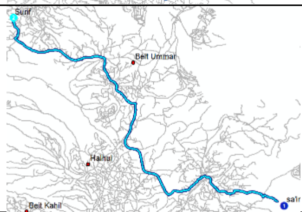
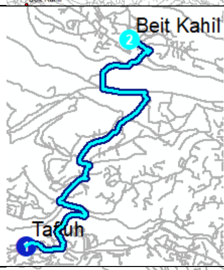
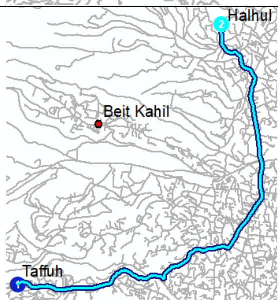
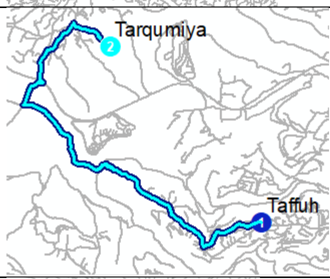
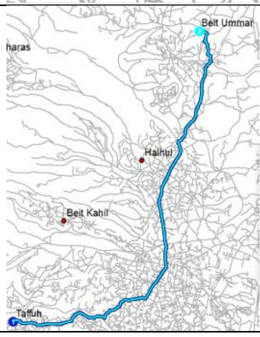
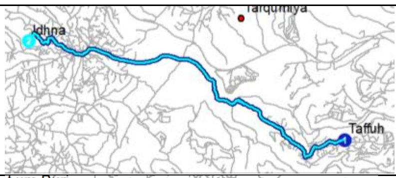
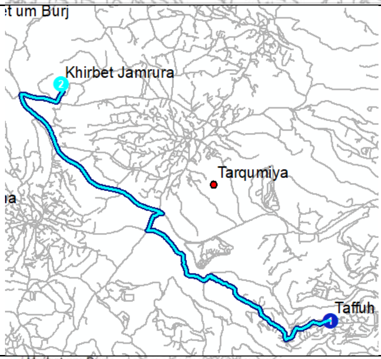
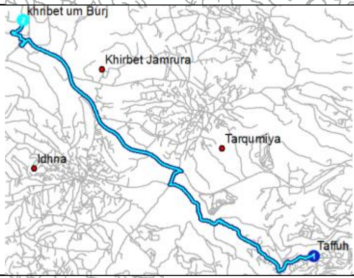
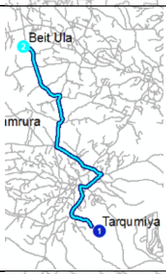
Sa'ir	Khribet um Burj	26347.5	21	
Sa'ir	Beit Ula	23500.5	21	
Sa'ir	Nuba	20997.2	22	
Sa'ir	Kharas	19230.7	20	
Sa'ir	Surif	19143.5	20	
Tafuh	Beit Kahil	7527.5	9	
Tafuh	Halhul	10841.5	11	
Tafuh	Tarqumiya	8143.5	10	
Tafuh	Beit Ummar	15788.1	14	

Tafuh	Idhna	10166.1	12	
Tafuh	Khirbet Jamrura	11789.1	12	
Tafuh	Khribet um Burj	13681.9	13	
Tafuh	Beit Ula	11778	14	
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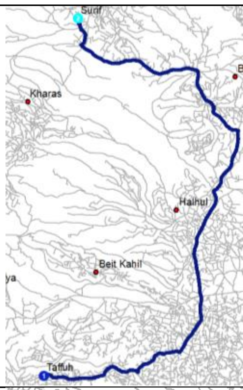
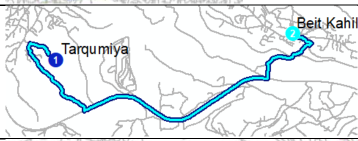
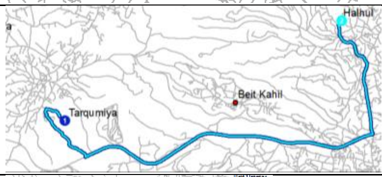
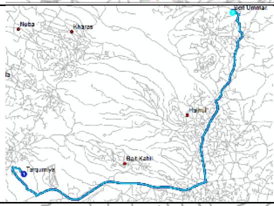
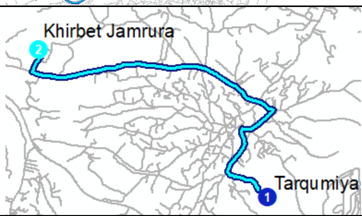
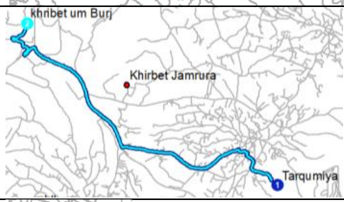
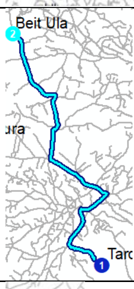
Tafuh	Surif	21434.2	21	
Tarqumiya	Beit Kahil	7647.8	7	
Tarqumiya	Halhul	13395.7	11	
Tarqumiya	Beit Ummar	18419.8	14	
Tarqumiya	Khirbet Jamrura	5970.3	5	
Tarqumiya	Khribet Um Burj	8627.0	7	
Tarqumiya	Beit Ula	5726.8	6	
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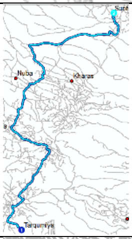
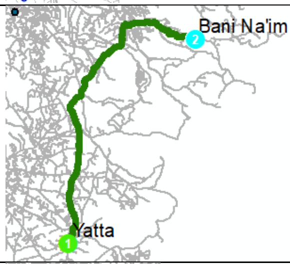
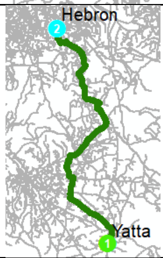
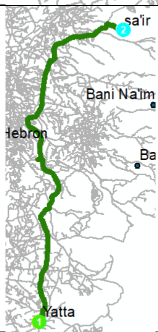
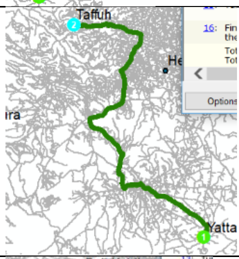
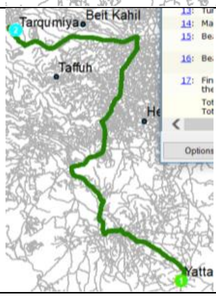
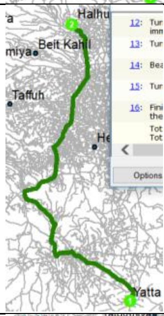
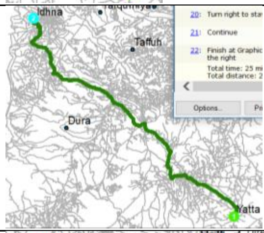
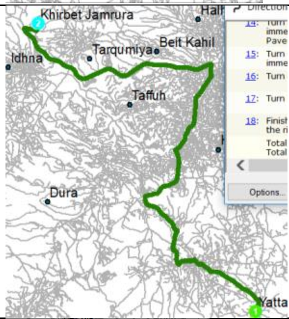
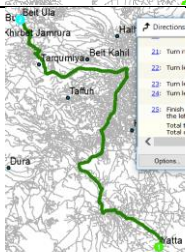
Tarqumiya	Surif	15868.7	14	
Yatta	Bani Na’im	15453.4	16	
Yatta	Hebron	14657.9	12	
Yatta	Sa’ir	23398.9	23	
Yatta	Taffuh	24491.4	19	
Yatta	Tarqumiya	33494.7	24	

Yatta	Beit Kahil	27544.4	20	
Yatta	Halhul	26802.8	19	
Yatta	Idhna	28631.8	25	
Yatta	Khirbet Jamrura	38861.5	26	
Yatta	Khribet um Burj	40711.5	28	
Yatta	Beit Ula	37936.1	28	
Yatta	Nuba	35460.8	29	

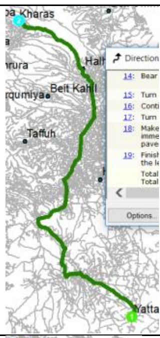
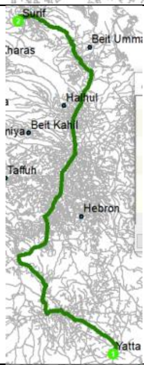
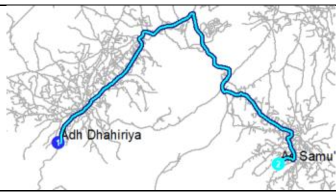
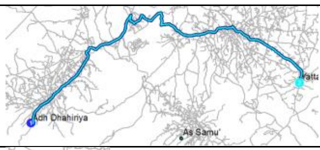
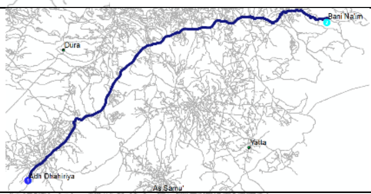
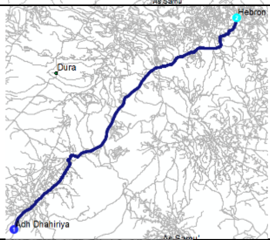
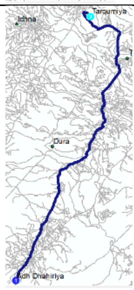
Yatta	Kharas	33580.5	27	
Yatta	Surif	38277.2	30	
Yatta	Beit Ummar	31864.4	22	
Yatta	Dura	19626.8	16	

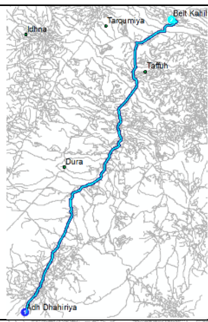
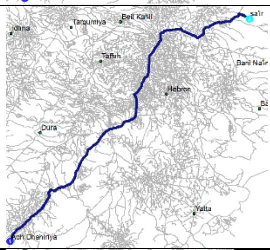
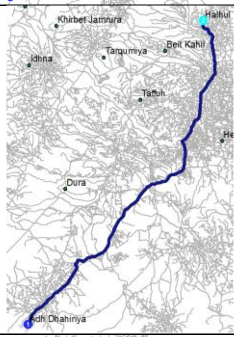
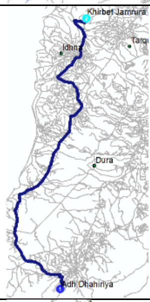
Table A-56 Detailed results for the network analysis for the existing road network

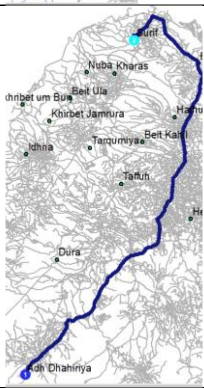
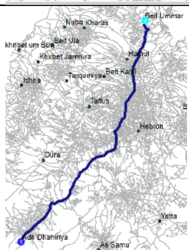
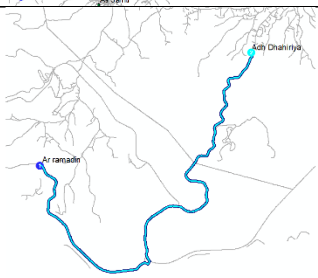
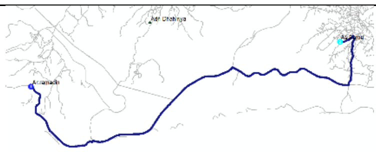
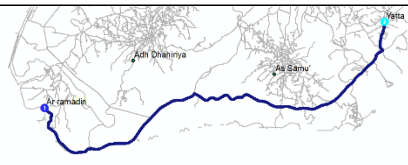
Appendix A.5 Suggested road network analysis results

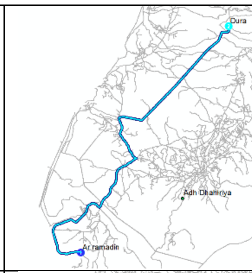
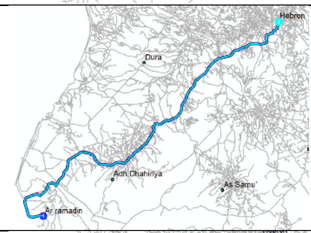
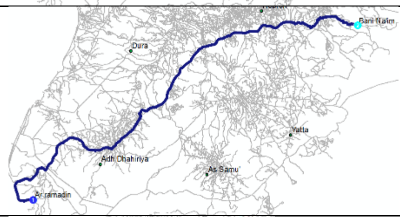
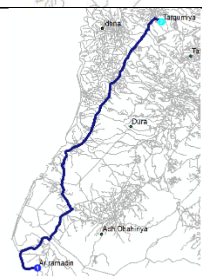
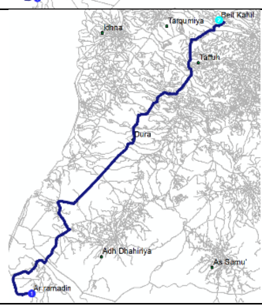
This part of this chapter shows the detailed results of the analysis of the suggested road network in details, and the next table contains the results:

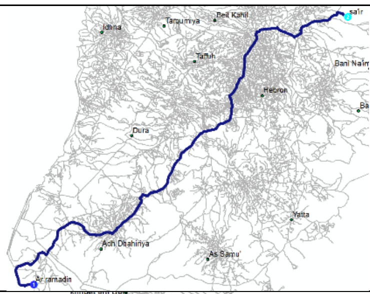
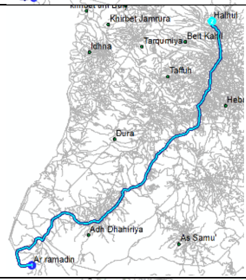
First point	Second point	Total travel distance “meter”	Total time “minuets ”	Shortest path
Ad-Dahria	As-Samu’	17860.3	12	

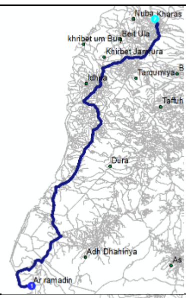
Ad-Dahria	Yatta	23890.6	16	
Ad-Dahria	Dura	12411.8	10	
Ad-Dahria	Bani Na’im	29630.6	24	
Ad-Dahria	Hebron	20877	15	
Ad-Dahria	Taffuh	19710.6	16	
Ad-Dahria	Idhna	25280.3	18	
Ad-Dahria	Tarqumiya	25340.1	20	

Ad-Dahria	Beit Kahil	25169.2	20	
Ad-Dahria	Sa’ir	33871.4	25	
Ad-Dahria	Halhul	28454.4	20	
Ad-Dahria	Khirbet Jamrura	29423.8	20	
Ad-Dahria	Khirbet Um Burj	31317.1	22	
Ad-Dahria	Beit Ula	32297.8	23	

Ad-Dahria	Nuba	35325.8	26	
Ad-Dahria	Kharas	32287	25	
Ad-Dahria	Surif	42083.4	29	
Ad-Dahria	Beit Ummar	33481	23	
Ar-Ramadin	Ad-Dahria	13433.1	9	
Ar-Ramadin	As-Samu’	22251.4	15	
Ar-Ramadin	Yatta	29135.5	19	

Ar-Ramadin	Dura	20949.6	14	
Ar-Ramadin	Hebron	32907.9	23	
Ar-Ramadin	Bani Na'im	41682.8	32	
Ar-Ramadin	Taffuh	30635.7	21	
Ar-Ramadin	Idhna	30721.2	22	
Ar-Ramadin	Tarqumiya	31242.8	25	
Ar-Ramadin	Beit Kahil	36058.3	25	

Ar-Ramadin	Sa’ir	45932.82	33	
Ar-Ramadin	Halhul	40485.28	28	
Ar-Ramadin	Khirbet Jamrura	34586.4	23	
Ar-Ramadin	Khirbet Um Burj	36424.9	25	
Ar-Ramadin	Beit Ula	37568.3	26	
Ar-Ramadin	Nuba	40511	29	

Ar-Ramadin	Kharas	41810.5	28	
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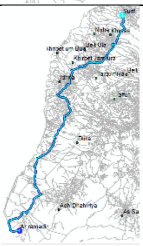
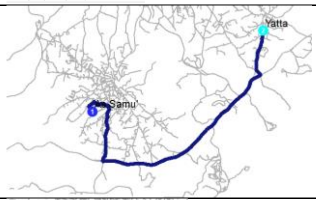
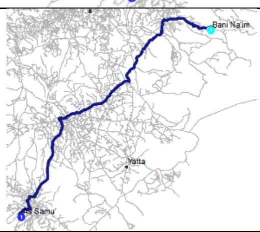
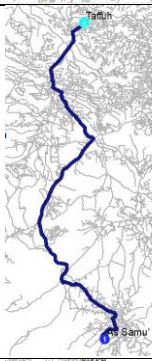
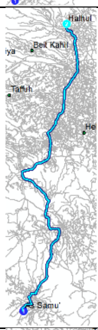
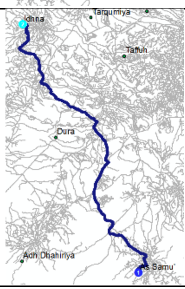
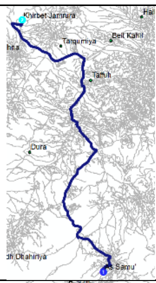
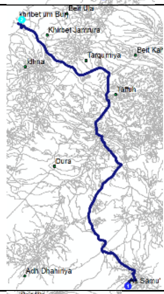
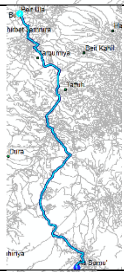
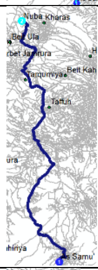
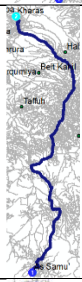
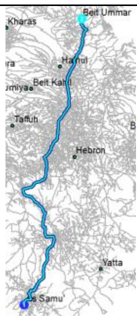
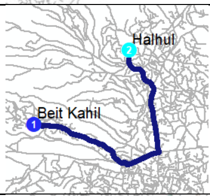
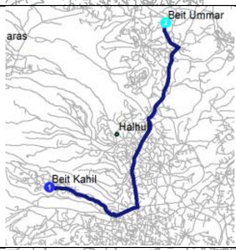
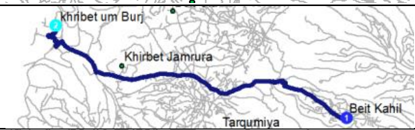
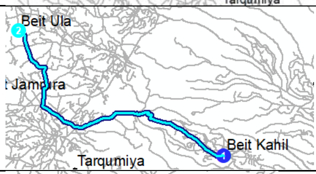
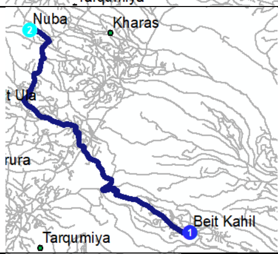
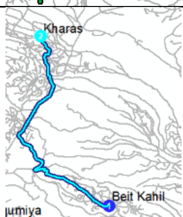
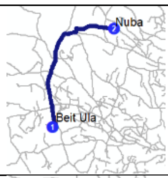
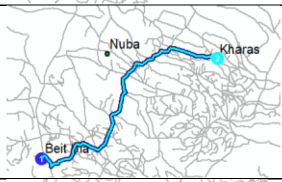
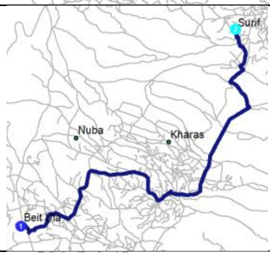
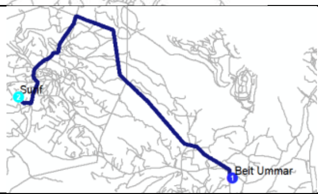
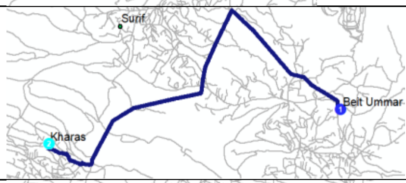
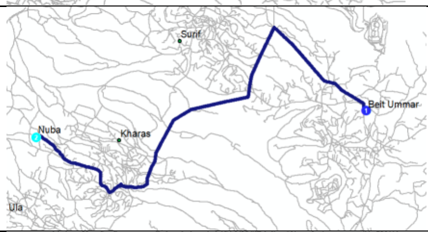
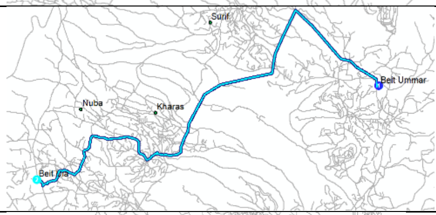
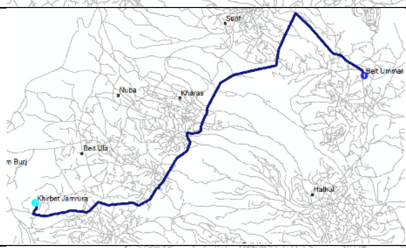
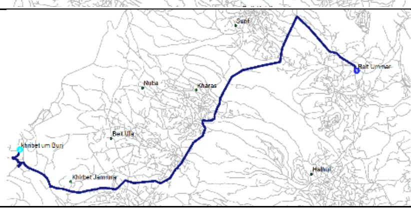
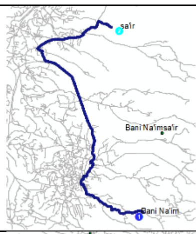
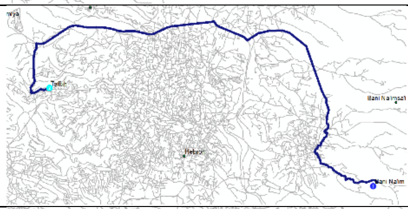
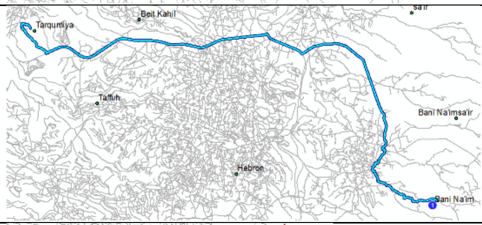
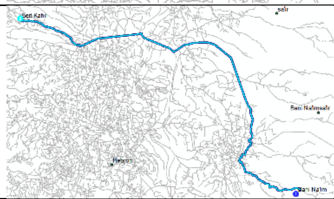
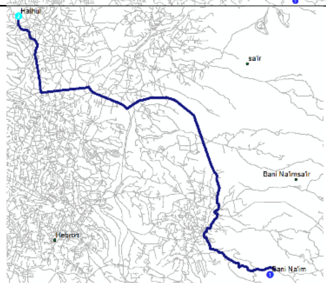
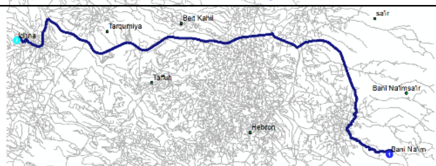
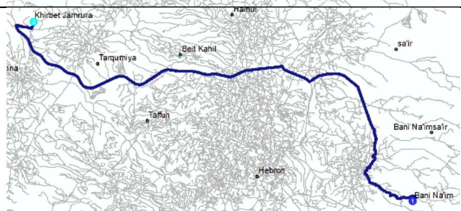
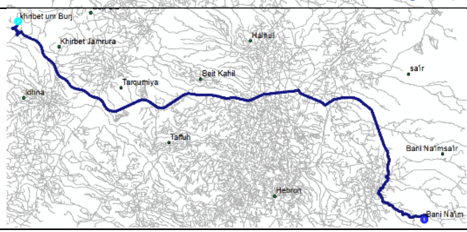
Ar-Ramadin	Surif	45707.5	32	
As-Samu’	Yatta	13668.3	10	
As-Samu’	Dura	17973.6	15	
As-Samu’	Bani Na’im	23571.1	20	
As-Samu’	Hebron	20503.7	16	

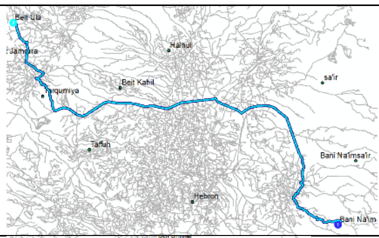
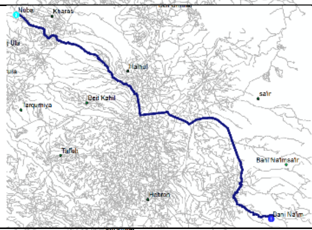
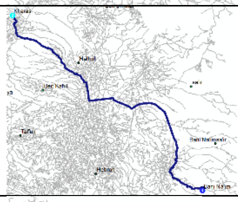
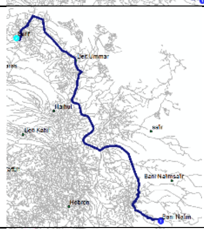
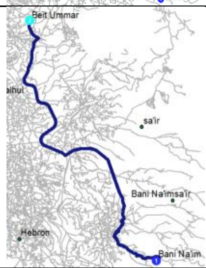
As-Samu’	Sa’ir	34220.6	26	
As-Samu’	Taffuh	23219.2	19	
As-Samu’	Tarqumiya	28778.7	24	
As-Samu’	Beit Kahil	29368.9	22	
As-Samu’	Halhul	28724.4	21	
As-Samu’	Idhna	25898.9	26	

As-Samu’	Khirbet Jamrura	34145.5	26	
As-Samu’	Khirbet Um Burj	35972	28	
As-Samu’	Beit Ula	33171.9	28	
As-Samu’	Nuba	36689.1	30	
As-Samu’	Kharas	35613.9	29	
As-Samu’	Surif	42460.7	29	

As-Samu'	Beit Ummar	33771.4	23	
Beit Kahil	Halhul	7309	7	
Beit Kahil	Beit Ummar	12133.6	10	
Beit Kahil	Khirbet Jamrura	9273.3	9	
Beit Kahil	Khirbet Um Burj	12809.3	12	
Beit Kahil	Beit Ula	8989.2	10	
Beit Kahil	Nuba	10188.6	10	
Beit Kahil	Kharas	9027.1	9	
Beit Kahil	Surif	12913.5	12	

Beit Ula	Nuba	3519.5	4	
Beit Ula	Kharas	5823.3	6	
Beit Ula	Surif	11564.4	10	
Beit Ummar	Surif	8978.5	6	
Beit Ummar	Kharas	10370.9	8	
Beit Ummar	Nuba	13971.9	10	
Beit Ummar	Beit Ula	16407.3	12	
Beit Ummar	Khirbet Jamrura	18611.7	13	
Beit Ummar	Kherbit Um Burj	22124.3	16	

Bani Na’im	Sa’ir	14556.3	15	
Bani Na’im	Taffuh	24265	19	
Bani Na’im	Tarqumiya	25050.4	20	
Bani Na’im	Beit Kahil	19076.4	17	
Bani Na’im	Halhul	18356.9	16	
Bani Na’im	Idhna	31218.2	24	
Bani Na’im	Khirbet Jamrura	30353.2	23	
Bani Na’im	Khribet um Burj	32281.7	25	

Bani Na’im	Beit Ula	29446.4	25	
Bani Na’im	Nuba	27211	25	
Bani Na’im	Kharas	25245.9	24	
Bani Na’im	Surif	30995.1	24	
Bani Na’im	Beit Ummar	22172.7	17	
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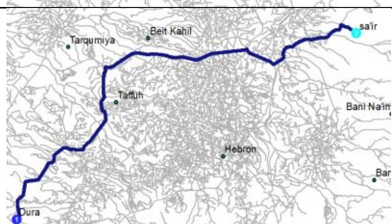
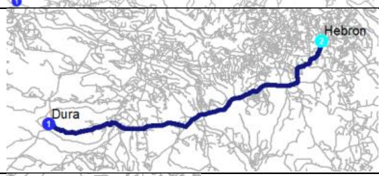
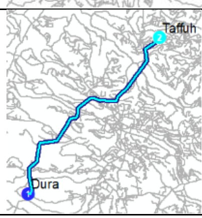
Dora	Sa’ir	26475	21	
Dora	Hebron	13561.9	14	
Dora	Taffuh	9749.6	7	

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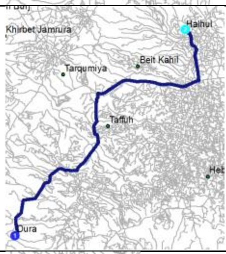
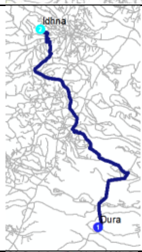
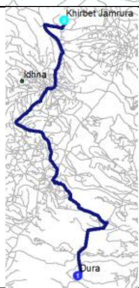
Dora	Beit Kahil	15187	11	
Dora	Halhul	20869.6	15	
Dora	Idhna	13053.7	12	
Dora	Khirbet Jamrura	17359.1	14	
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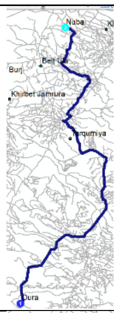
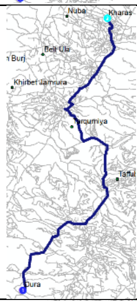
Dora	Beit Ula	19722.2	16	

Dora	Nuba	23158	18	
Dora	Kharas	22292	17	
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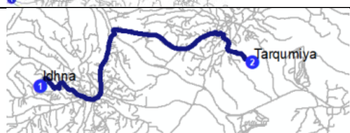
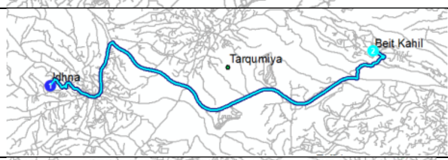
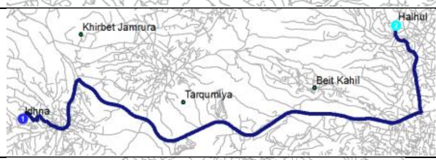
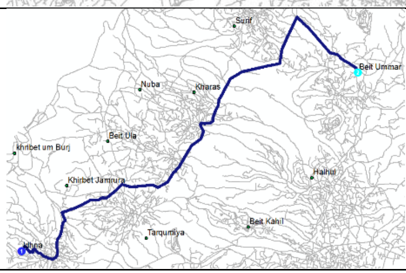
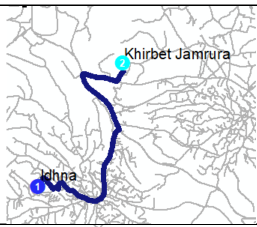
Dora	Beit Ummar	25792.1	18	
Idhna	Tarqumiya	7805.2	7	
Idhna	Beit Kahil	13790.1	11	
Idhna	Halhul	19514.2	15	
Idhna	Beit Ummar	22435.8	16	

Idhna	Khirbet Jamrura	6463.1	5	
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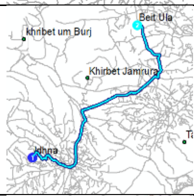
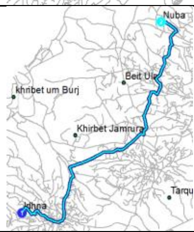
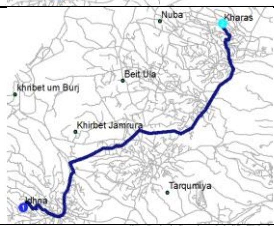
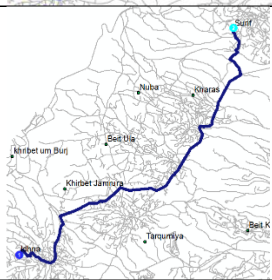
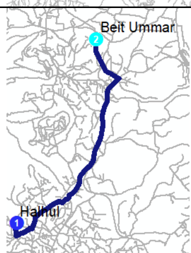
Idhna	Beit Ula	9395.3	8	
Idhna	Nuba	12305.7	11	
Idhna	Kharas	13617.1	10	
Idhna	Surif	17574.7	14	
Halhul	Beit Ummar	6538.6	5	
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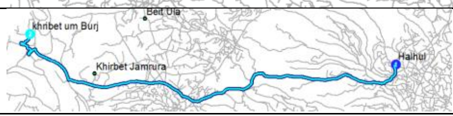
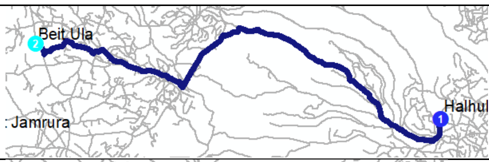
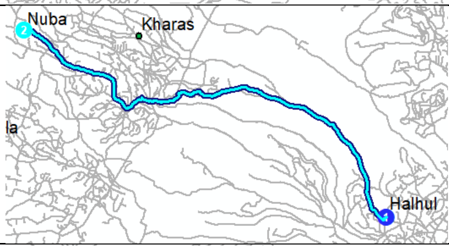
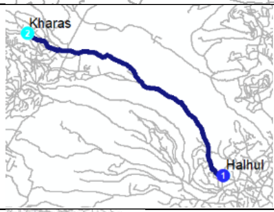
Halhul	Khribet um Burj	15686.1	15	

Halhul	Beit Ula	11398.8	12	
Halhul	Nuba	9930.9	11	
Halhul	Kharas	7027.5	8	
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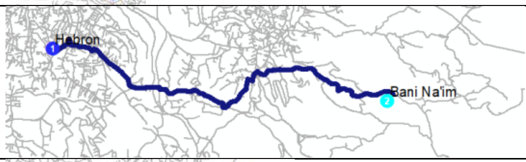
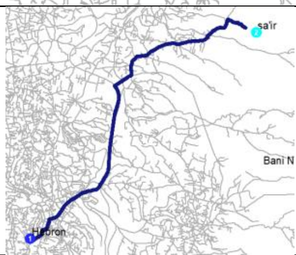
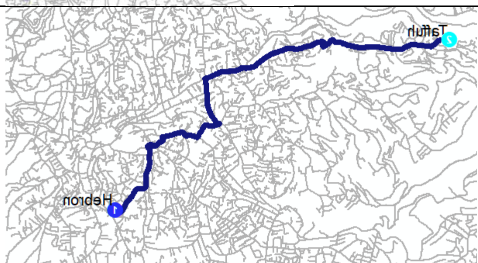
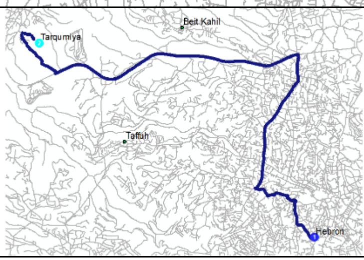
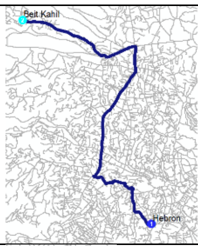
Hebron	Bani Na’im	10547.2	12	
Hebron	Sa’ir	11910.8	12	
Hebron	Taffuh	8432.6	10	
Hebron	Tarqumiya	17522.6	15	

Hebron	Beit Kahil	11467.6	11	
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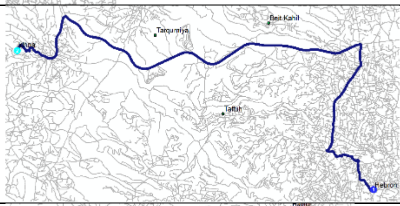
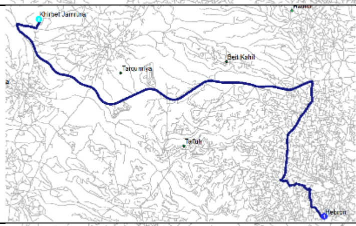
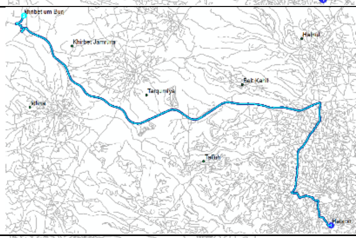
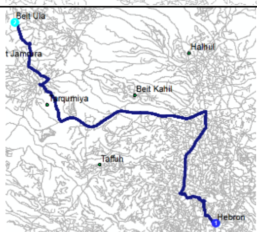
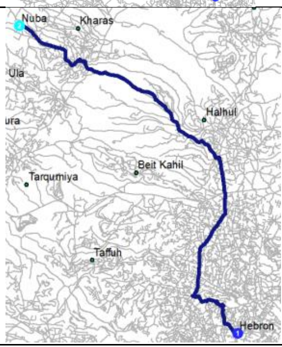
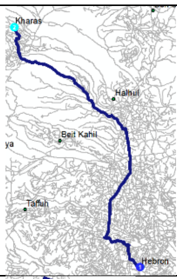
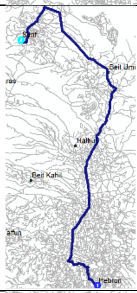
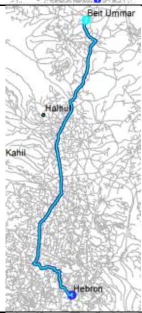
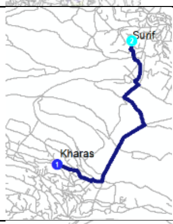
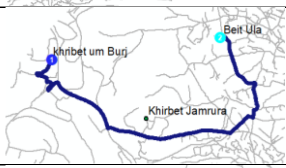
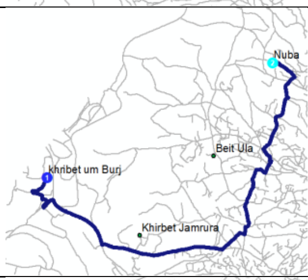
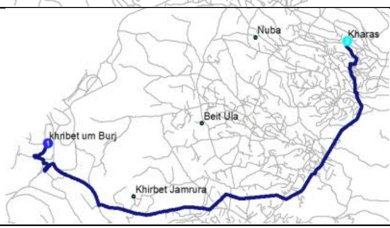
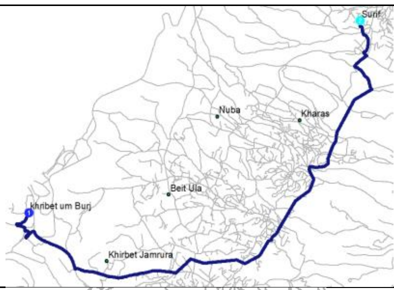
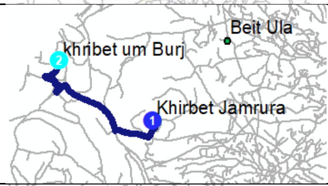
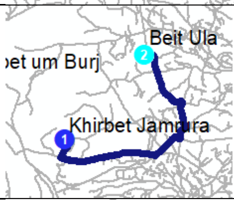
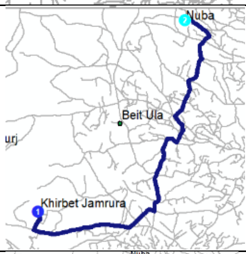
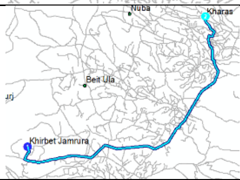
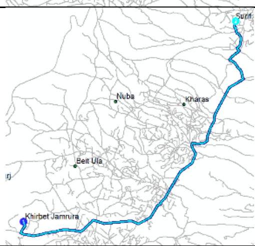
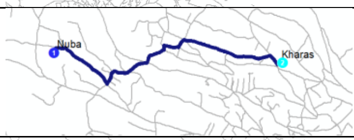
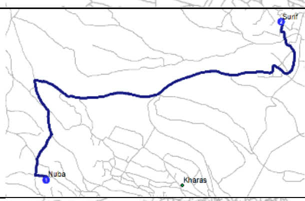
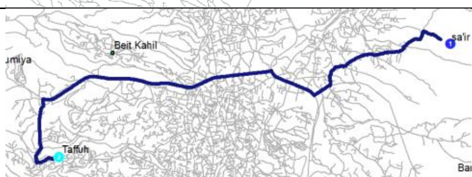
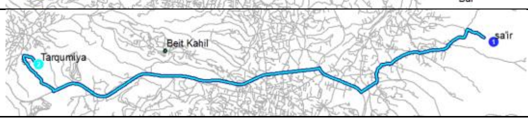
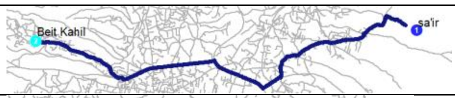
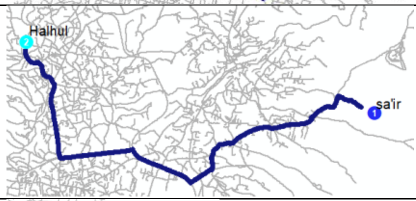
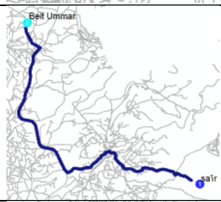
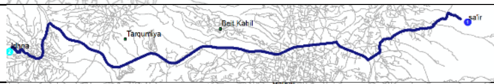
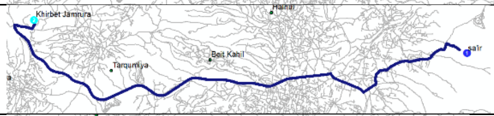
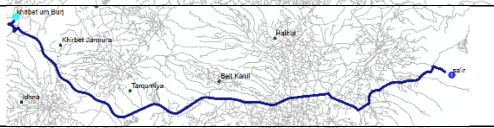
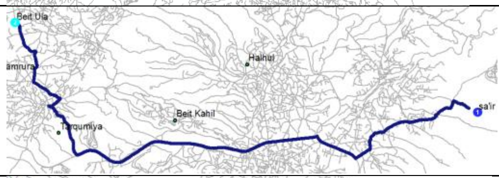
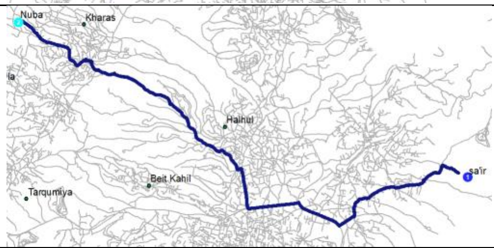
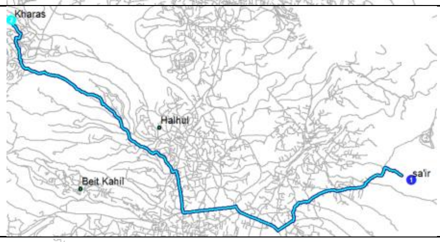
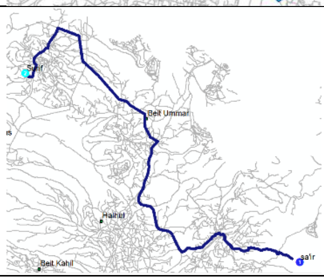
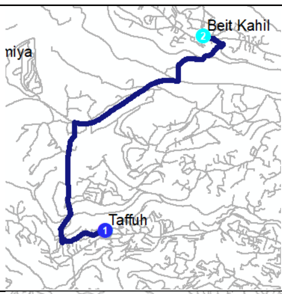
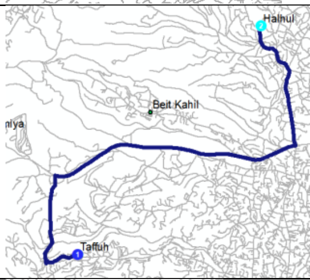
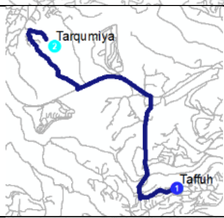
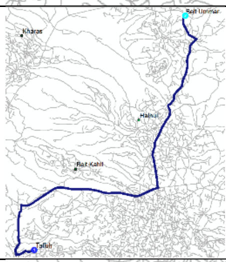
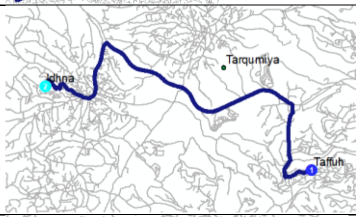
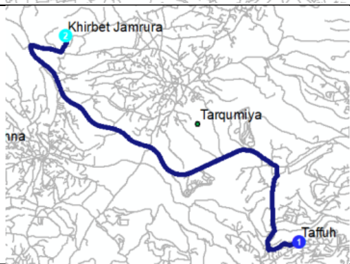
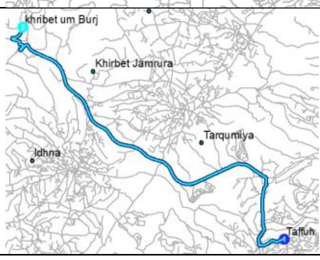
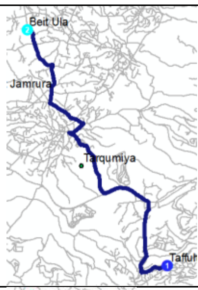
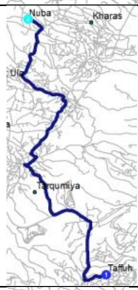
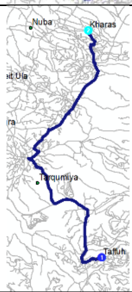
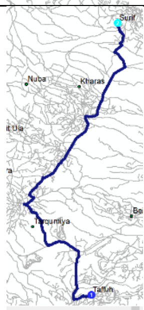
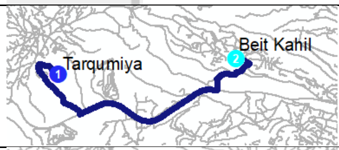
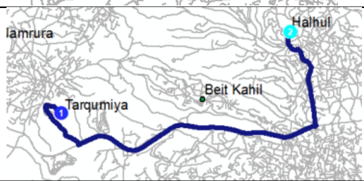
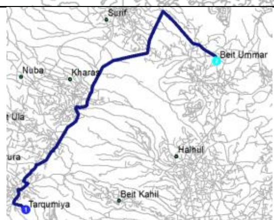
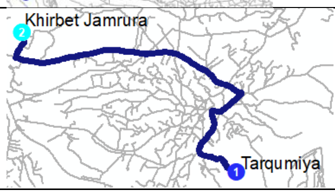
Hebron	Idhna	23682	18	
Hebron	Khirbet Jamrura	22826.9	17	
Hebron	Khirbet Um Burj	24745.9	19	
Hebron	Beit Ula	21823.5	19	
Hebron	Nuba	19641.6	19	

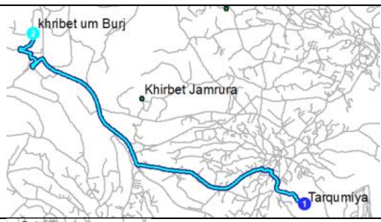
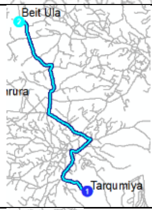
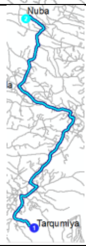
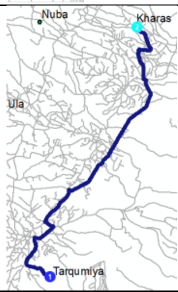
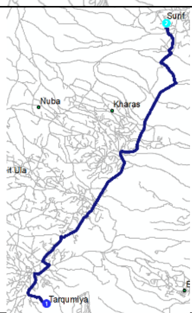
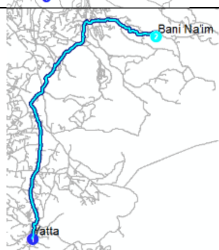
Hebron	Kharas	17727.2	18	
Hebron	Surif	24516.4	18	
Hebron	Beit Ummar	15681.8	12	
Kharas	Surif	5461	5	
Khirbet Um Burj	Beit Ula	89082.5	8	
Khirbet Um Burj	Nuba	11946.1	11	
Khirbet Um Burj	Kharas	13257.5	10	

Khirbet Um Burj	Surif	17196.7	14	
Khirbet Jamrura	Khirbet Um Burj	4418.6	4	
Khirbet Jamrura	Beit Ula	5598.2	5	
Khirbet Jamrura	Nuba	8441.8	8	
Khirbet Jamrura	Kharas	9770.6	7	
Khirbet Jamrura	Surif	13703.1	11	
Nuba	Kharas	2776.6	3	
Nuba	Surif	7692.5	8	
Sa’ir	Taffuh	18074.5	15	
Sa’ir	Tarqumiya	18897	16	

Sa’ir	Beit Kahil	12833.6	13	
Sa’ir	Halhul	12215.7	12	
Sa’ir	Beit Ummar	13255.1	12	
Sa’ir	Idhna	25056.4	20	
Sa’ir	Khirbet Jamrura	24215.7	19	
Sa’ir	Khribet um Burj	26116.6	21	
Sa’ir	Beit Ula	23275.7	21	
Sa’ir	Nuba	21003.8	21	
Sa’ir	Kharas	19154.9	19	
Sa’ir	Surif	22122.3	18	

Tafuh	Beit Kahil	6831.8	6	
Tafuh	Halhul	12617.4	10	
Tafuh	Tarqumiya	6989.1	6	
Tafuh	Beit Ummar	17407	12	
Tafuh	Idhna	13141.1	10	
Tafuh	Khirbet Jamrura	12335.2	9	
Tafuh	Khribet um Burj	14209.3	11	

Tafuh	Beit Ula	11369.8	11	
Tafuh	Nuba	14785.7	12	
Tafuh	Kharas	13924.2	12	
Tafuh	Surif	17861	15	
Tarqumiya	Beit Kahil	7581.7	7	
Tarqumiya	Halhul	13389.8	11	
Tarqumiya	Beit Ummar	17041.3	12	
Tarqumiya	Khirbet Jamrura	6028.9	5	

Tarqumiya	Khribet um Burj	8640.1	7	
Tarqumiya	Beit Ula	5773.3	6	
Tarqumiya	Nuba	9170.6	7	
Tarqumiya	Kharas	8448.2	7	
Tarqumiya	Surif	12207.3	10	
Yatta	Bani Na’im	15413.9	16	
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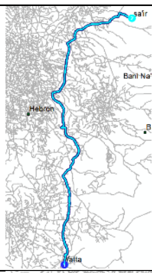
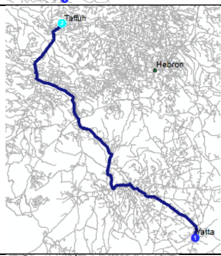
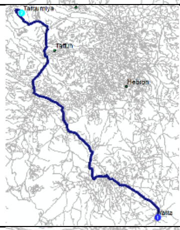
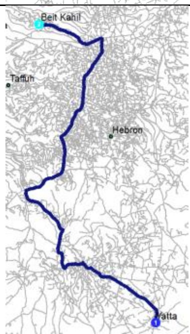
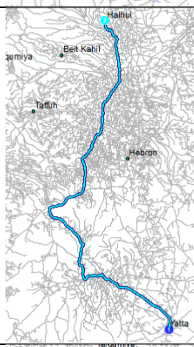
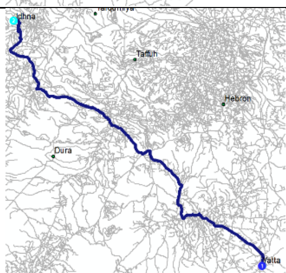
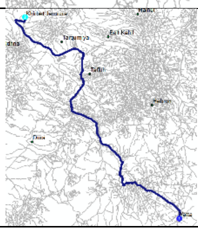
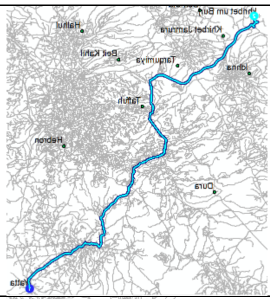
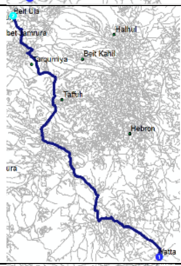
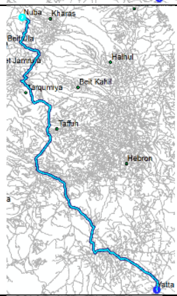
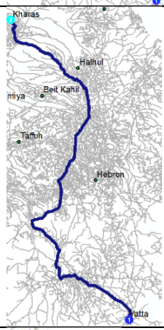
Yatta	Sa’ir	23369.3	23	
Yatta	Taffuh	21115.6	17	
Yatta	Tarqumiya	26737.2	22	
Yatta	Beit Kahil	27408.3	20	
Yatta	Halhul	26877.6	19	
Yatta	Idhna	28813.1	25	
Yatta	Khirbet Jamrura	32103.9	25	

Yatta	Khribet um Burj	34070.8	27	
Yatta	Beit Ula	31084	26	
Yatta	Nuba	34580.2	28	
Yatta	Kharas	33725.4	27	
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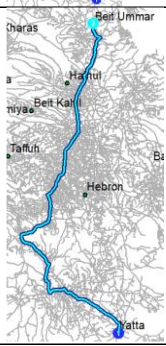
Yatta	Beit Ummar	31714.3	21	

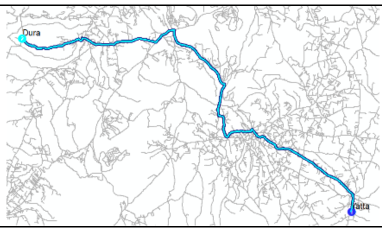
Yatta	Dura	19638.1	16	

Table A-57 Detailed results for the network analysis for the suggested road network

Appendix-A.6 Primary maps and data

This part of the chapter contains other data that has been used in this project.

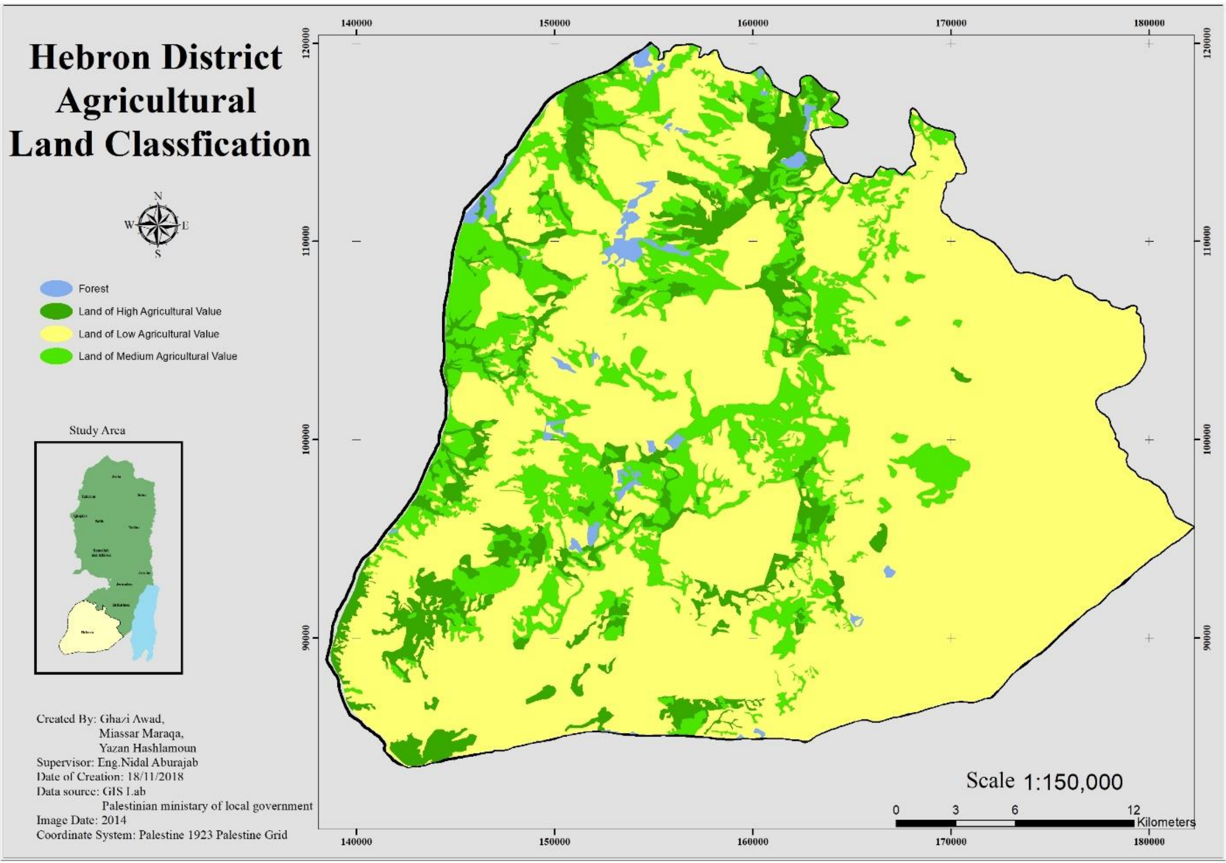


Figure A-11 Hebron district agricultural land classification

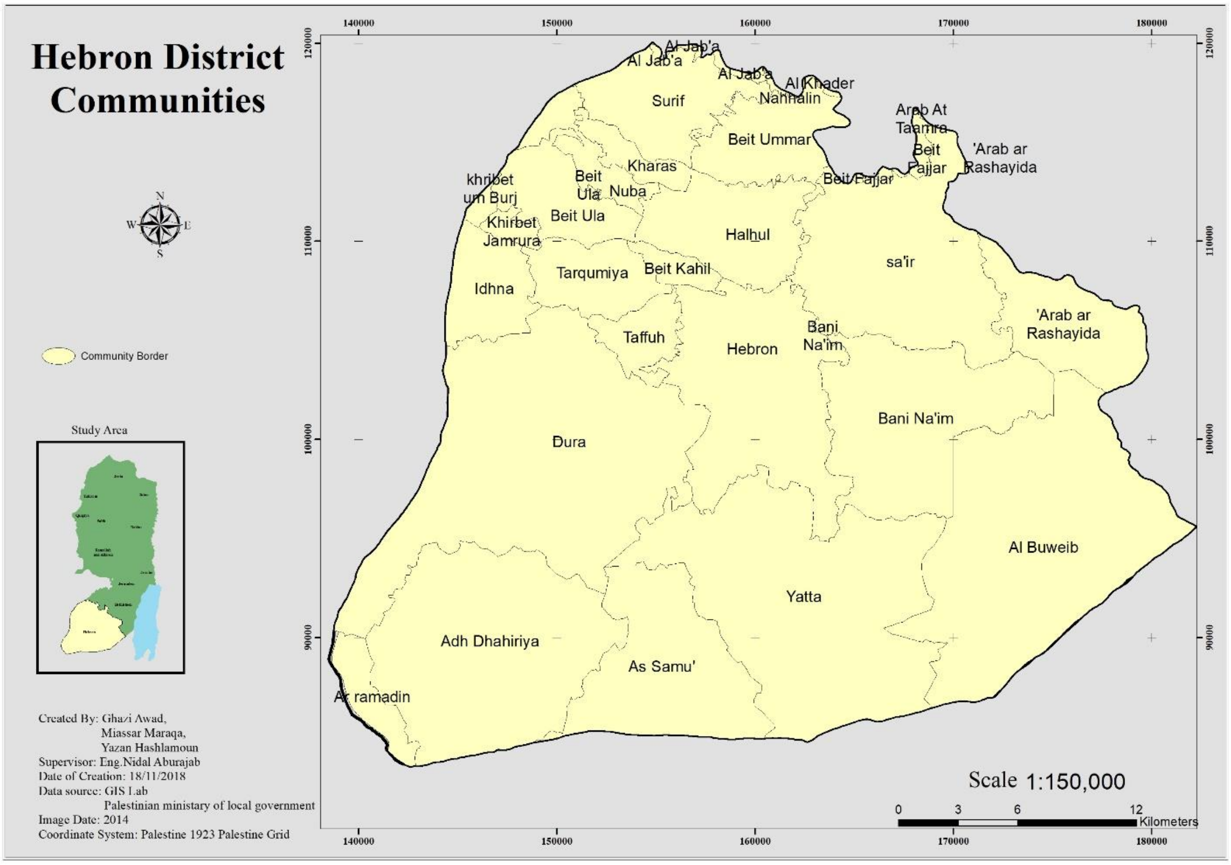


Figure A-12 Hebron district communities border

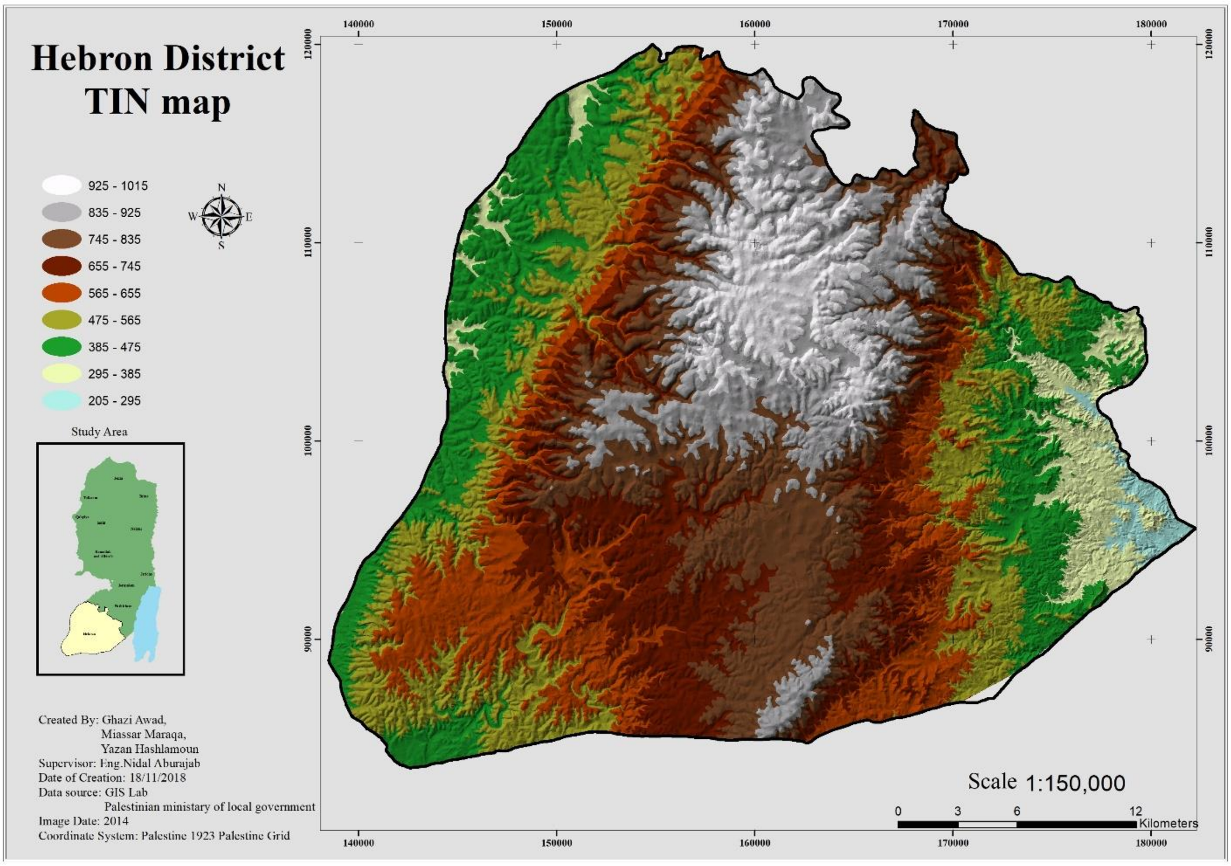


Figure A-13 Hebron district TIN map

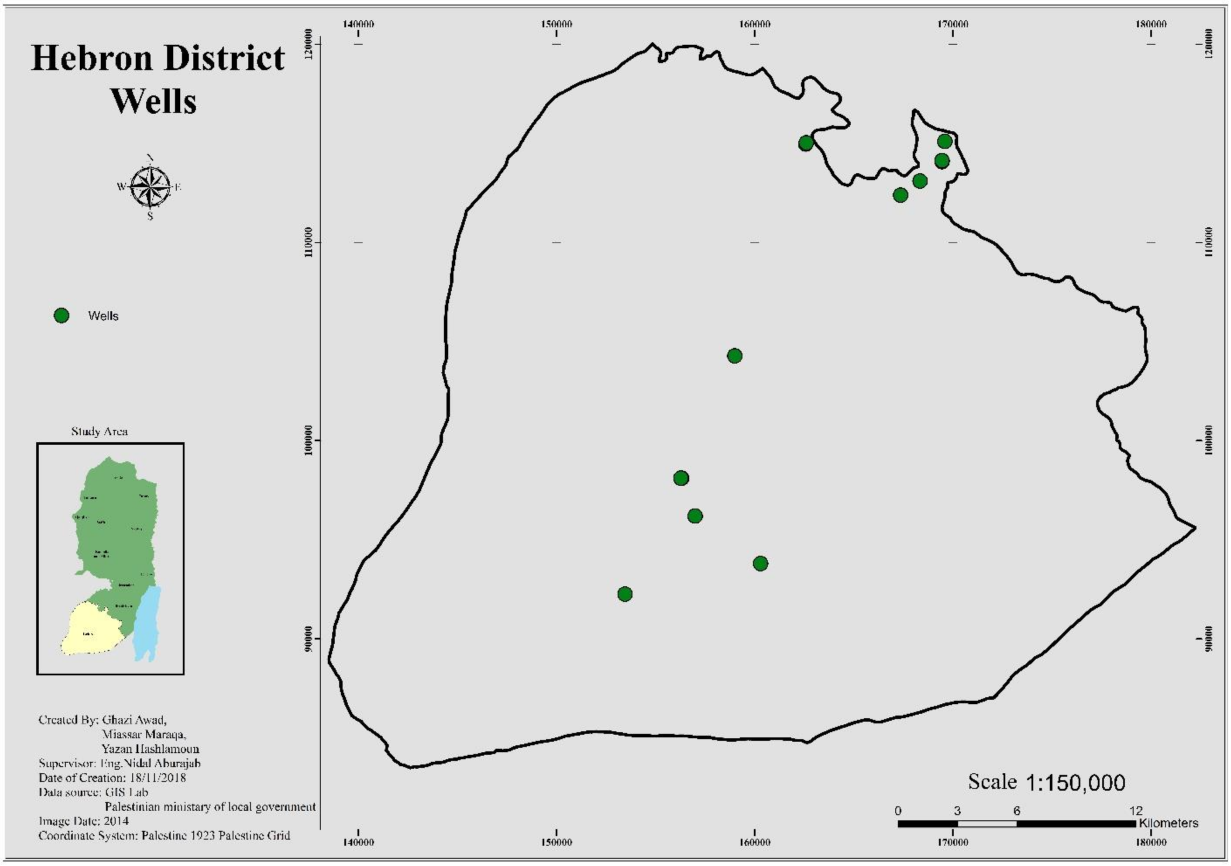


Figure A-14 Wells locations in Hebron district

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