

## SPATIO-TEMPORAL ANALYSIS OF THE INFRASTRUCTURES IN HEBRON DISTRICT USING REMOTE SENSING AND GIS

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### Abstract

The aim of this study is to detect and find a comprehensive solution for some spatial issues in Hebron district for examples the expansion of urban areas and the expansion of the Israeli settlements inside the district and the situation of the current roads network using Earth Observations satellite imagery and aerial Photogrammetry.

Free satellite data (Landsat) was used to analyze the Earth observations in Hebron district and Orthophoto derived from the local Municipalities was used to study the current spatial objects. The satellite imagery was classified to several classes, spatial analysis was conducted to assess the current roads network and to study the ability of proposing new roads locations.

The results show that there was a big growth in the urban areas, shrinkage of the natural reserves areas, and an expansion of the Israeli settlements.

**Keywords:** GIS, Remote sensing, Change detection, Roads.

### 1. Introduction

Earth observation from space has demonstrated its growing scientific, social, economic and political importance by contributing to a better understanding and regular monitoring of the Earth and its environment, by supporting a wide range of applications and by providing essential data for geopolitical purposes (“The Earth-Observation Programme,” n.d.). It provides the evidence necessary for decision making and for monitoring the progress on all geographical scales and aimed to sustainable management. The science of satellite remote sensing integrates the understanding, interpretation and establishment of relations between natural phenomena and measurements of electromagnetic energy that is either emitted or reflected from the Earth's surface.

Today satellite observations are significant data sources for monitoring, measuring and understanding the Earth's terrestrial, aquatic and climatic environments, as well as how they are changing and how each reacts to human influence. Some of the most revolutionary advances brought about by 50 years of remote sensing progress have been in improving and updating maps.

The advent of satellite imagery added further advantages by introducing digital processing, allowing larger areas to be viewed in single scenes, and the availability of imagery are driving down data costs. Free online databases and open distribution of processed imagery are making many types of data available to all.

When talking about Earth observation data we can talk also about aerial Photogrammetry science which is a type of photography with which pictures are taken from an aerial view. This type of photography is rich in information that can be used for monitoring and analyze the earth surface. The most common use of aerial photography is for mapping purposes. Aerial photography allows maps that are incredibly accurate to be made because the entire area can easily be seen.

## 2. Study area

In this study the interest was concentrated on detecting the changes that happened throughout the years in Hebron district, especially the expansion of the Israeli settlements and in addition to that it was concentrated on finding the direction of urban areas expansion to be able for better strategies plans for the future, and evaluate the existing road network and try to enhance it.

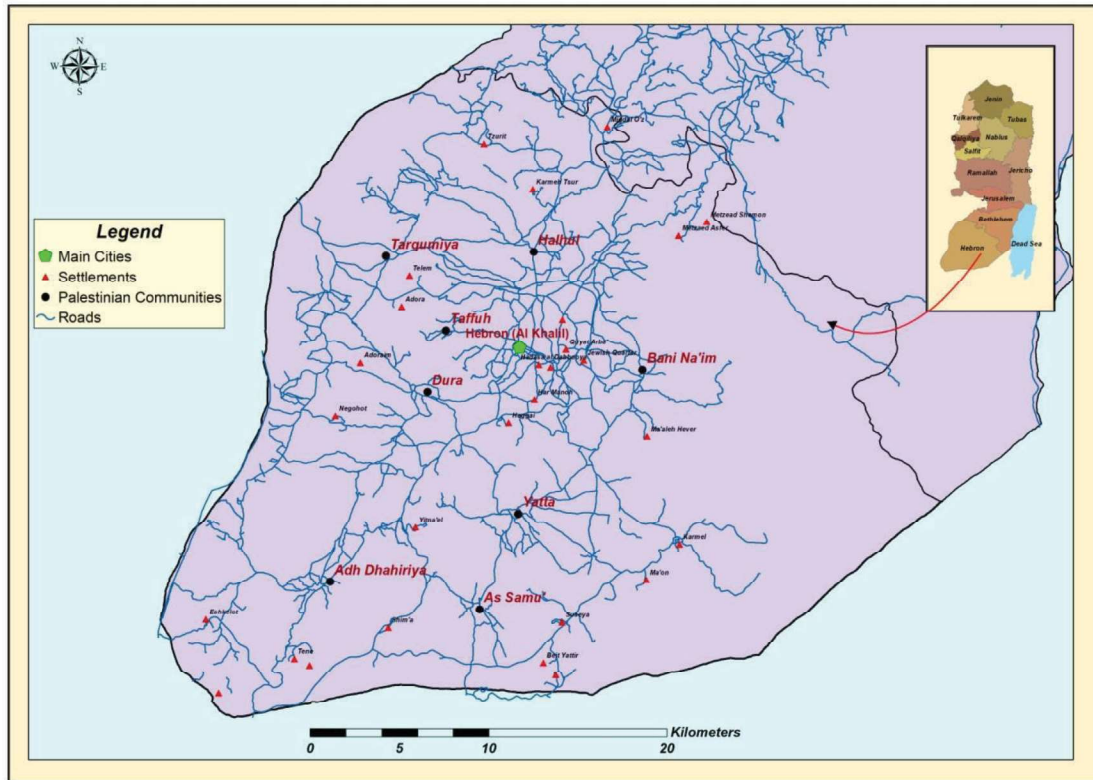


Figure 1. Map of the Study area (Hebron district)

## 3. Methodology

### 3.1 Data Collection

Multispectral images for the study area was derived from Landsat ("EarthExplorer - Home," n.d.) Satellites, three images (Landsat) for Hebron district was obtained and processed to detect changes throughout years (1984, 1998, and 2015).

By getting the latest version of the Orthophoto for Hebron district the digitization of the centerlines of every road in Hebron district was done to derive the current full roads network.

### 3.2 Landcover preparation and analysis

Supervised classification was applied on each satellite image stack (blue, green, red, NIR) using Maximum likelihood method to produce Landcover map for the region, the used class for the classification was (agricultural area, artificial area, Forest and semi-natural area).

To adjust the quality of the output classifications the confusion matrix (Wang and Weng, 2013) was derived for each classified image and it was found the Kappa coefficient (eq.1) for each classification were approximate to one value ( $k \approx 1$ ) (ex. Kappa coefficient=0.97 for classified image 2015) that means a good classification accuracy were derived.

$$\hat{K} = \frac{\sum_{i=1}^p C_{ii} / n - \sum_{i=j=1}^p C_{i.} \times C_{.j} / n^2}{1 - \sum_{i=j=1}^p C_{i.} \times C_{.j} / n^2} \tag{1}$$

- Cij            Number of pixels of training parcel 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 the training parcels in input
- p              Total number of classes
- Ci./n          Percentage of class i over all training parcels

**Table 1.** Example of confusion matrix for the classification produced from Landsat imagery 2015.

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

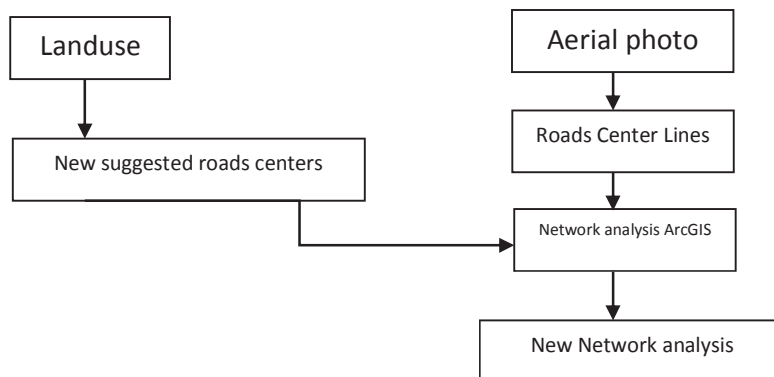
### 3.3 Landuse

Landuse 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 (Bariweni and Andrew, 2017). It also has been defined as "the total of arrangements, activities, and inputs that people undertake in a certain land cover type"(Sims, 1997). The Landuse creation started by collecting the latest aerial photo ("Geomolg for HTML5," n.d.) and by manual photo interpretation the digitization and judgment of the current Landuse were take place according to the following classes (Forests, High value agricultural lands, Medium value agricultural lands, Low value agricultural lands, Built up areas, Roads, Israeli settlements, Natural reserves).

### 3.4 Existing road network

"Selecting best route location and highway alignment process very complicated due to the many variables that must be taken into consideration, for achieving the best results GIS can easily model such variables including topography, environment, built-up areas, and geology variables" (Dawwas et al., 2005). In order to test and improve the efficiency of the current roads network, the roads center lines of Hebron district was digitized from the Orthophoto then we use Networks analyst extension (ESRI ArcGIS) ("Esri: GIS Mapping Software, Spatial Data Analytics & Location Intelligence," n.d.) to build and test the existing roads networks inside Hebron district.

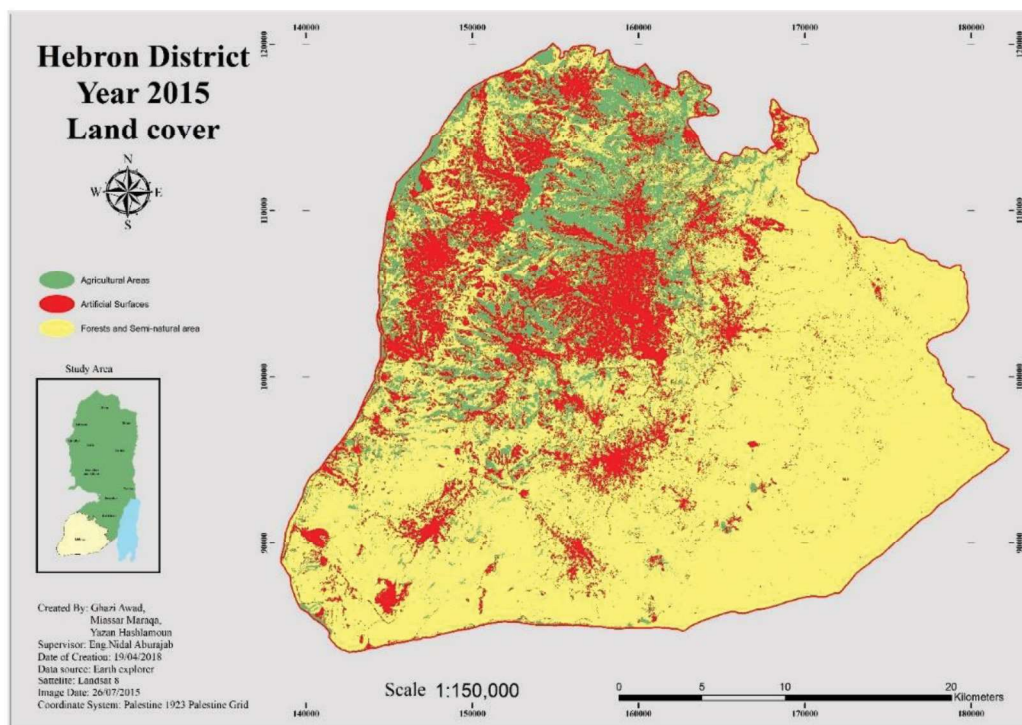
One of the types of the network analysis is the optimal routing, which can be defined as the process of choosing the best route to get from one location to one or more locations ("Route analysis—Help | ArcGIS Desktop," n.d.). Depending on the user’s preference the best route could be the shortest, the quickest. For this study, 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 roads database was supplied with (speed, barriers, roads slope distance...) then the best route between major cities was tested, and to improve the roads Network the prepared Landuse was used to propose new roads centerlines according to several scientific methodologies inside the district.



**Figure 2.** Flowchart shows the process of the roads network

#### 4. Results and discussion

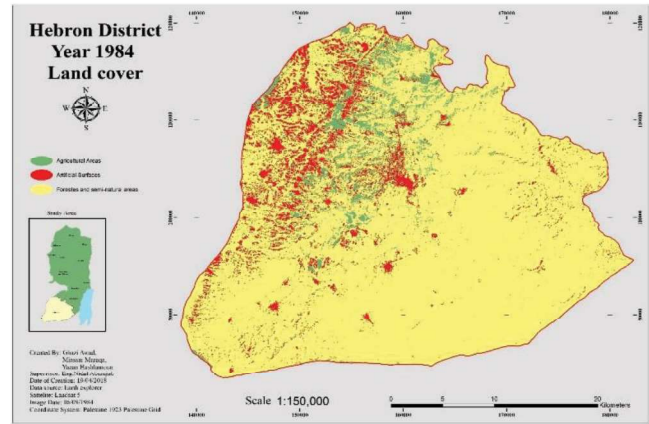
As we mentioned before the classification results derived from the Landsat imageries of the years (1984, 1998, and 2015) was used to analyze the urban spreading inside Hebron district.



**Figure 3.** Results of classification for Landsat imagery 2015.



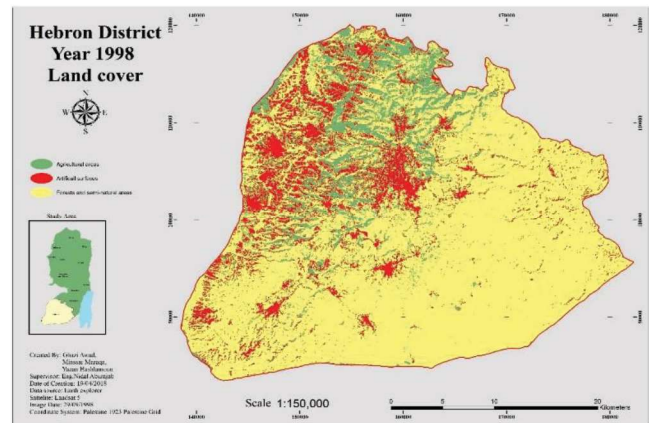
Hebron District (Landsat image) 1984



Classification result 1984



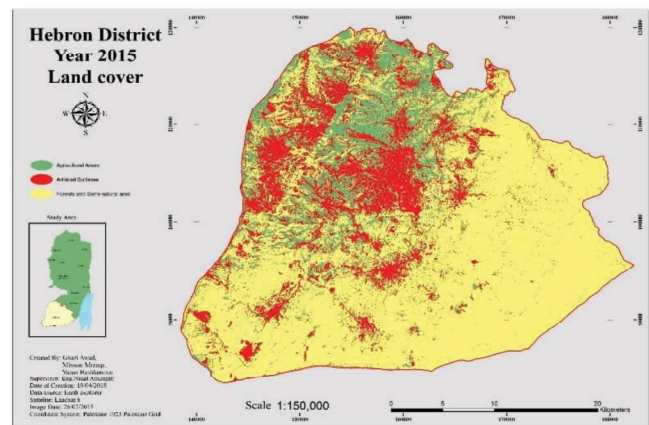
Hebron District (Landsat image) 1998



Classification result 1998



Hebron District (Landsat image) 2015

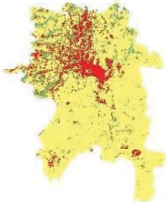
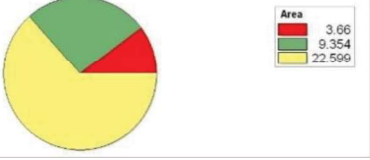
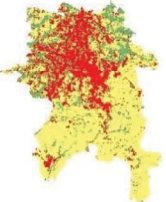
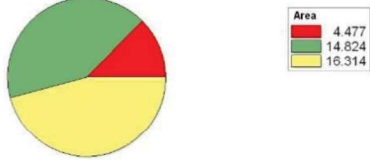
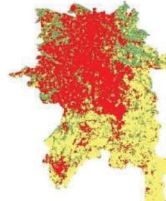




Classification result 2015

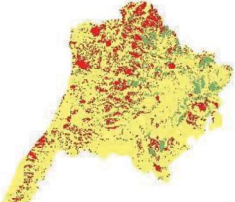
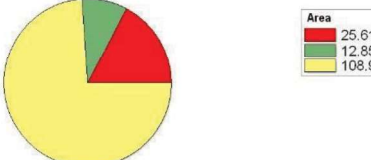
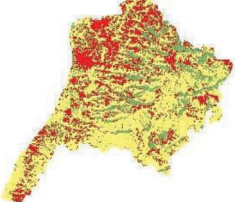

**Figure 4.** Classifications results from all used Landsat imagery in Hebron district.

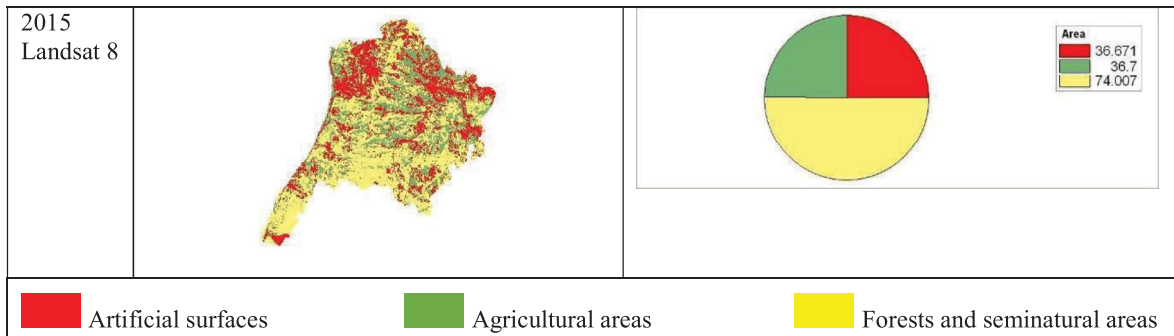
The results of the classified imagery was used to study the changes in the Landcover in the major cities of Hebron districts (Hebron, Halhul, Yata, Dura, Ad-Dahria ) and to study the changes in Landcover of Israeli settlements inside the district such as (Adora, Autnil, Hagai, Karmi Tzur, Kfar Etzion), an example of the results below.

**Table 2.** Landcover changes in Hebron City


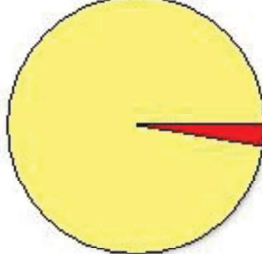
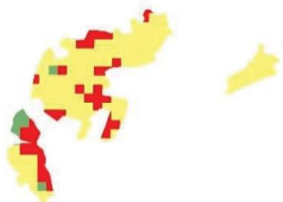
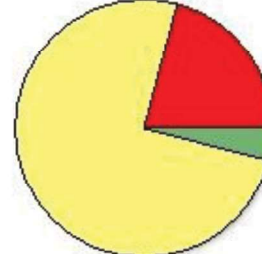
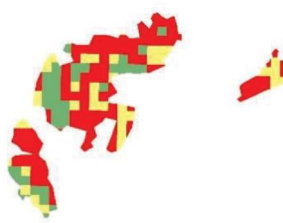
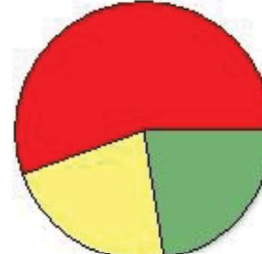
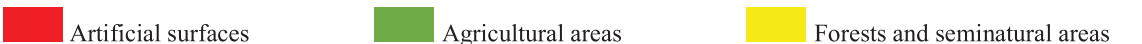
Year	Classification	Areas (KM2)				
1984 Landsat 5		 <table border="1"> <tr><th>Area</th></tr> <tr><td>3,66</td></tr> <tr><td>9,354</td></tr> <tr><td>22,596</td></tr> </table>	Area	3,66	9,354	22,596
Area						
3,66						
9,354						
22,596						
1998 Landsat 5		 <table border="1"> <tr><th>Area</th></tr> <tr><td>4,477</td></tr> <tr><td>14,824</td></tr> <tr><td>16,314</td></tr> </table>	Area	4,477	14,824	16,314
Area						
4,477						
14,824						
16,314						
2015 Landsat 8		 <table border="1"> <tr><th>Area</th></tr> <tr><td>7,298</td></tr> <tr><td>21,215</td></tr> <tr><td>7,101</td></tr> </table>	Area	7,298	21,215	7,101
Area						
7,298						
21,215						
7,101						
						

**Table 3.** Landcover changes in Dura City

Year	Classification	Areas (KM2)				
1984 Landsat 5		 <table border="1"> <tr><th>Area</th></tr> <tr><td>25,614</td></tr> <tr><td>12,853</td></tr> <tr><td>108,91</td></tr> </table>	Area	25,614	12,853	108,91
Area						
25,614						
12,853						
108,91						
1998 Landsat 5		 <table border="1"> <tr><th>Area</th></tr> <tr><td>35,383</td></tr> <tr><td>25,61</td></tr> <tr><td>86,385</td></tr> </table>	Area	35,383	25,61	86,385
Area						
35,383						
25,61						
86,385						



**Table 4.** Landcover changes in Autnil Settlement

Year	Classification	Areas (m2)				
1984 Landsat 5		 <table border="1" data-bbox="1166 749 1365 888"> <thead> <tr> <th>Area</th> </tr> </thead> <tbody> <tr> <td>127,166.578</td> </tr> <tr> <td>3,204.425</td> </tr> <tr> <td>19,088</td> </tr> </tbody> </table>	Area	127,166.578	3,204.425	19,088
Area						
127,166.578						
3,204.425						
19,088						
1998 Landsat 5		 <table border="1" data-bbox="1177 1050 1365 1188"> <thead> <tr> <th>Area</th> </tr> </thead> <tbody> <tr> <td>27,254.995</td> </tr> <tr> <td>97,855.48</td> </tr> <tr> <td>5,279.615</td> </tr> </tbody> </table>	Area	27,254.995	97,855.48	5,279.615
Area						
27,254.995						
97,855.48						
5,279.615						
2015 Landsat 8		 <table border="1" data-bbox="1177 1350 1365 1488"> <thead> <tr> <th>Area</th> </tr> </thead> <tbody> <tr> <td>72,101.483</td> </tr> <tr> <td>29,147.106</td> </tr> <tr> <td>29,141.502</td> </tr> </tbody> </table>	Area	72,101.483	29,147.106	29,141.502
Area						
72,101.483						
29,147.106						
29,141.502						
						


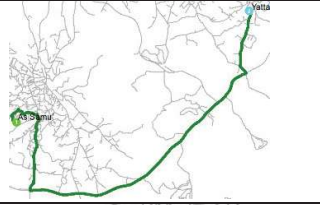
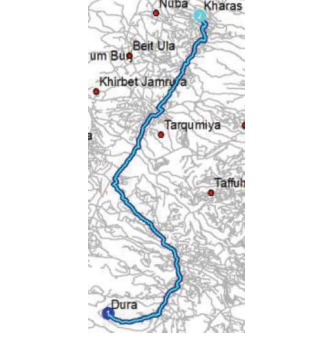
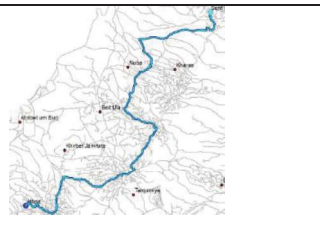
After getting the Landcover maps for each year, the Landcover maps were used to determine the changes happened in the main cities and the Israeli settlements. These changes were observed thoroughly, and these are the results:


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

- For the settlements, the statistics shows that many of the settlements started established between 1998 and 2002, and its artificial surfaces area grew rapidly, some of them already existed before the study period, but all of them grew rapidly.
- Some of the settlements were used as agricultural lands and the agricultural area got bigger through time, as a proof that the land was used for planting and agricultural purposes.
- The Built up areas expand in the direction of north-west in the district. That's because of the Israeli settlements intensified in the east and south of Hebron district, due to that and the district citizens needs for more living areas due to their normal increasing, they had to expand in the opposite side of the Israeli settlements.

The full roads network early prepared in this study was used to determine the best route between major cities. The existing roads network suffers from the unnecessary turns that make the distance longer, and the lack of highways, which makes the travel time longer. The next table shows some of the results of the network analysis process:

**Table 5.** Roads Networks analysis.

First point	Second point	Total travel distance "meter"	Total time "minutes "	Shortest path
Ad-Dahria	As-Samu'	17982.3	13 – 25	
As-Samu'	Yatta	13714.4	10 - 25	
Dora	Kharas	23651.6	25 – 40	
Idhna	Surif	21718.3	18 - 30	

Khirbet Um Burj	Kharas	13838.3	11 - 20	
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Suggestions of new roads centerline to enhance the existing roads network and limiting the time needed to get from one city to another; the suggested roads was expected to reduce the amount of traffic jam and reduce the time needed to travel.

The selection method requires a set of parameters and constrains that defines where this roads should pass through, in order to reduce land cuts, and to avoid any archeological sites buildings and high agricultural value lands. These parameters were as follow:

1. The road must not harm any archeological sites.
2. The road should take away as less as possible from the low value agricultural lands and must not touch the high value ones.
3. The road must avoid built up areas.
4. The road must cost as less as possible.
5. The road must avoid natural reserves.
6. The road must not harm any water resources.
7. The road must follow the political boundaries and must not interfere with geopolitical issues.

The generated Landuse database for Hebron District as seen in the following figure was used for planning the possibility of constructing future new roads centerlines.

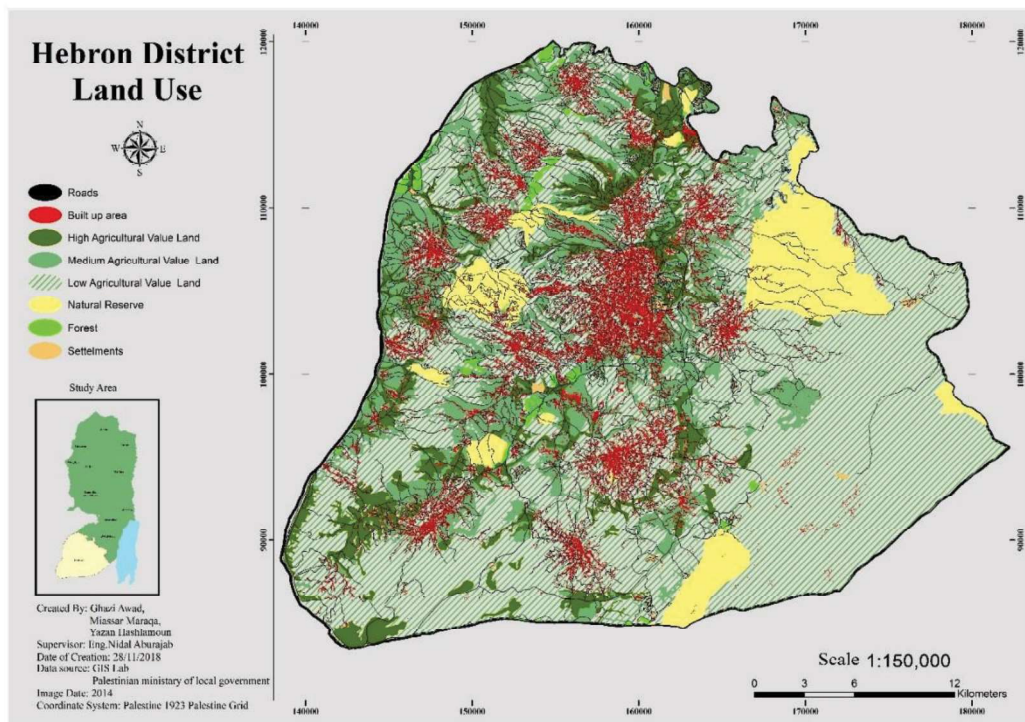
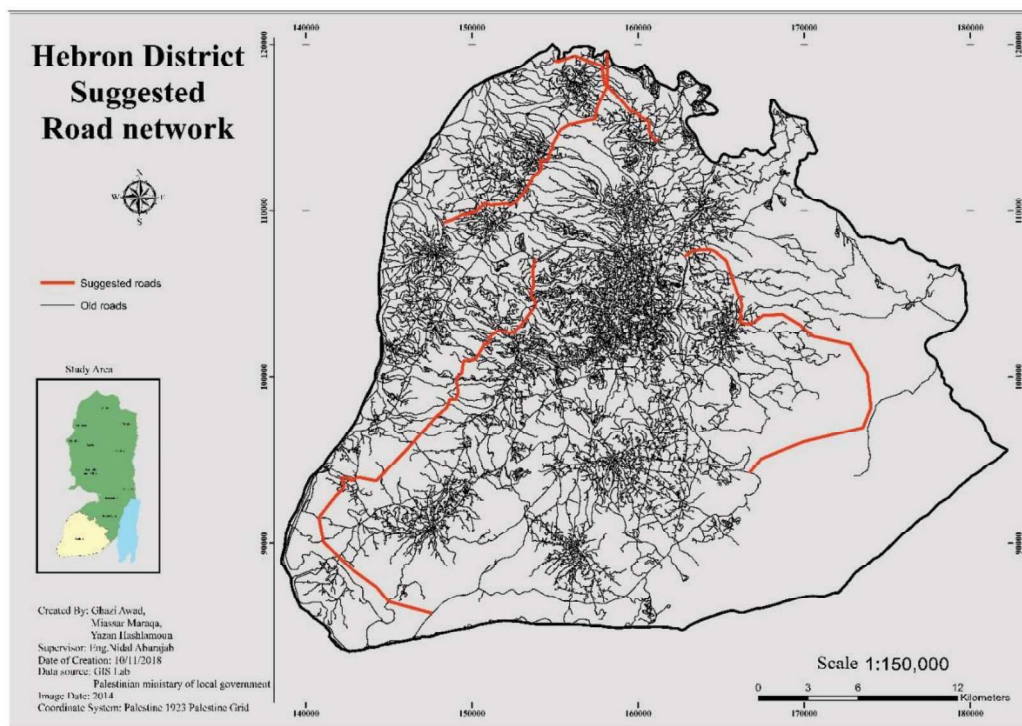


Figure 5. Hebron district Landuse.

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 performed along the study area in order to determine the centerline of the new suggested road. Some of the results were as follow:



**Figure 6.** Suggested roads network

The new suggested roads centerlines were integrated in the road networks in the GIS networks analyst extension and were tested for its efficiency, examples shown below.

**Table 6.** Example of Network analysis results of the suggested road network

Idhna	Surif	17574.7	14	
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The suggested roads aims was to reduce the time the user needs to get from one place to another, so by adding the suggested centerlines to the existing road network in GIS. And after running network analysis in GIS and comparing the results of the two network analysis procedures, it can be seen that how much the usefulness of the new proposed roads in reducing the travel time and the traffic jam.

## 5. Conclusion

It is very clear and obvious as shown from the satellite imagery that the current situation of the built-up areas inside Hebron district increasing only inside the current boundaries of the cities and there was no extra expansions of the cities due to Israeli occupation rules, the Israeli occupation used the Oslo agreement to prevent the Palestinians communities from normal expansions which produced a high crowded mixed (residential, Industrial) areas inside Palestinians communities.

A need for solutions for traffic jams is one of the crucial issues that disturbing municipalities and decisions makers, for that construction of new roads centerlines inside the district may reduce this jam and also may enhance the future residential and industrial Palestinians life.

## 6. References

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