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Palestinian Strategic Food Security via Land Suitability Analysis for Reclamation

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Abstract Recent assessments concluded that 38% of the Palestinian population is food insecure. In addition, 11% and 16% of the population in West Bank and Gaza Strip respectively, are vulnerable to food insecurity. Increasing food production could be achieved either by increasing the agricultural productivity and/or expanding cultivable land. The main goal of this study is to provide an accurate guide for the unused lands in the Hebron Governorate on its suitability for reclamation and the best usage of these lands for cultivation via GIS techniques. According to the reclamation suitability level, the land was classified into four categories: most, highly, moderate, and least suitable. Main parameters included were landform class (slope, foot slope, hill crest, and drainage depression), slope degree, rockoutcrop percentage, aspect, and climate (arid, semi-arid, and sub-humid).Out of 106,700 hectare of the total area of the Hebron Governorate, only 30% is devoted to various agricultural practices and 62% is still unused and thereby available for land use. Additionally, the study results indicated that a total of 24,560 hectares were suitable for reclamation. Of this, 13%, 60%, and 27% were found to be mostly, highly, and moderately respectively suitable for reclamation. The present study is the first attempt to evaluate the land suitability for reclamation at Palestine level using GIS techniques.

Keywords: *food security, land suitability, GIS, land reclamation*

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1. Introduction

The occupied Palestinian territory is composed of two physically separated areas named as West Bank and Gaza Strip with a total area of 566,100 and 36,200 hectares, respectively.

In the West Bank, the average population density is approximately 4.14 capita / hectare and the total population is about 2.7 million inhabitants irregularly distributed across its eleven governorates [1], including Hebron which is the highest among the other governorates in terms of area and population.

Recent assessments concluded that 38% of the Palestinian population is food insecure. In addition, 11% and 16% of the population in West Bank and Gaza Strip respectively, are vulnerable to food insecurity [2]. Increasing food production could be achieved either by increasing the agricultural productivity and/or expanding cultivable land [3].

Reclamation of the non-agricultural lands is considered as one of the most important mechanisms for expanding the cultivable lands and increasing the agricultural productivity [4]. Analyzing the land suitability for reclamation and development via GIS technique is considered to be the first necessary step to enhance the mechanism of decision making with relevance to the development of land not utilized for agricultural use by providing the required data and information to the decision-makers and technicians to reach the most proper decisions for the most appropriate utilization of this land.

The main goal of this study is to provide an accurate guide for the unused lands in the Hebron governorate on its suitability for reclamation and the best usage of these lands for cultivation via GIS techniques.

2. Materials and Methods

2.1. Study Area

The study covered all of the un-cultivated lands in Hebron Governorate (HG) which located in the southern part of the West Bank. The Governorate has an area of 106,700 hectares which comprising about 19% of the West Bank area [5]. The total agricultural land comprises about 30%; the un-cultivated land comprises about 62% while the artificial surface (i.e. built-up and different construction areas) comprises about 8%.

2.2. Tools, Materials and Methods

The following tools, materials and methods were used:

2.2.1. Aerial Photographs

Aerial photographs at a detailed scale (1:5000) were obtained for the purpose of terrain analysis and mapping unit delineation.

2.2.2. Land Use/Cover Map

Land use/cover map analysis for the West Bank using EU CORINE land cover classification (Coordination for Environment) methodology for land use/cover preparation [6].

2.2.3. ArcGIS Software

ArcGIS 9.3.1 was utilized for all GIS functions used in the layers (shape-files) and data analysis.

2.2.4. Contour Lines With 5 m Intervals

2.2.5. Mapping Unit Delineation

Land form element (Figure 1) was selected as the basic mapping unit to fulfill the objectives of the study. The following land form elements were identified and delineated using the on-screen digitizing method: Hill Crest – Summit Surface (H), Plain (P), Valley (V), Drainage Depression (D), Foot Slope (F), and Slope (S).

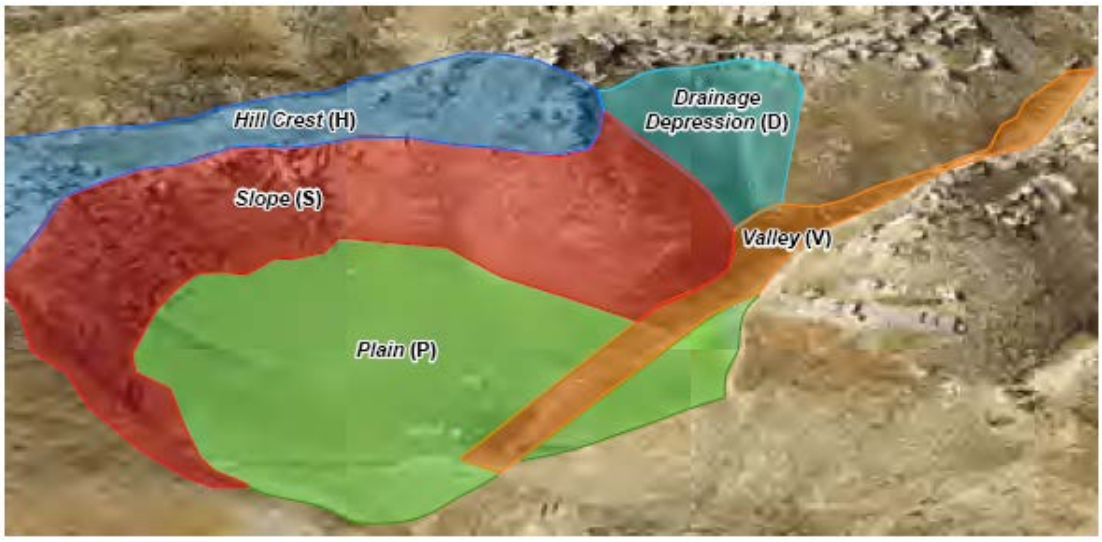

Figure 1. Landform elements sample

2.3. Terrain Characteristics Identification

The following terrain characteristics were identified for each delineated landform elements:

2.3.1. Slope

the following slope classes were identified: S0 (<3% "Plain, Valley, Hill Crest" without any slope; S1 (3% - 8%),S2 (8% - 18%),S3 (18% - 32%), and S4 (>32%).

2.3.2. Aspect

Aspect class map derived from DEM data could be grouped according to the requested land form classes depending on the final purpose for using the map. These maps were found to be useful in the higher, more rugged terrain where aspect has an influence on the soil temperature and moisture regimes. The dominant aspect for each land form element is presented in Table 1.

Table 1. Aspect Class (Degree)

Aspect Class (Degree)	Description	Abbreviation
0	Flat	No
0-22.5 and 337.5-360	North	N
22.5-67.5	Northeast	NE
67.5-112.5	East	E
112.5-157.5	Southeast	SE
157.5-202.5	South	S
202.5-247.5	Southwest	SW
247.5-292.5	West	W
292.5-337.5	Northwest	NW

2.3.3. Land Use

The dominant land use was assigned to each delineated landform element. The following general land use classes were identified in the Study area: Trees = T, Arable = A, Quarries = Q, Urban = U, Colony = C, Non = N.

2.3.4. Rockoutcrop

The rock-outcrop class was assigned to each delineated landform element based on the percentage of the covered area of the land surface by rocks utilizing the aerial photographs (Table 2).

Table 2. Rockoutcrop Class

Rockoutcrop Class	Status
0	Free
5	Slight
10	Moderately available
20	Available
30	Highly covered
>40	Rocky area

2.3.5. Climate

An aridity index utilizing De Martonne approach was assigned to each landform element. The identified classes are: arid, semi-arid and sub-humid.

2.4. Limiting Factors Matrix Construction

Since many factors determine the land suitability for reclamation, a matrix for these factors was constructed by

giving a weight for each factor according to FAO criteria. Table 3 displays the components of this matrix.

Table 3. Weights of factors determine land suitability for reclamation

Class 10%				Slope 25%				Rockoutcrop 30%				Aspect 5%				Climate 30%		
S	F	H	D	S0	S1	S2	S3	≤ 10	10-20	20-30	30-40	NW,W	SW,S	NE,N	SE,E	Arid	Semi Arid	Sub Humid
3	5	7	10	5	20	25	10	10	25	15	5	5	4	3	2	15	30	20
Min		Max		Min		Max		Min		Max		Min		Max		Min		Max
3		10		5		25		5		25		2		5		15		30

According to Table 3: the land suitability for reclamation classified as follows: most suitable (81%-100%), highly suitable (61%-80%), moderately suitable (41%-60%), and least suitable (32%-40%).

2.5. Identifying Land Suitable for Reclamation

According to the matrix shown in Table 3, each polygon has been assigned a value classifying its suitability for reclamation. The suitable lands for reclamation should possess the following criteria:

- Slope should be less than 32% (excluding plains and valleys).
- Rockoutcrop should be less than 40%.
- Rainfall should be more than 300 ml/year.

2.6. Identifying Land Suitable for Forests

The land suitable for forests is assigned according to the following criteria (the existence of each of the following conditions is a killing factor for land reclamation):

- Slope is > 32%.
- Rockoutcrop is > 40% in areas where rainfall is > 300 ml/year.
- Rockoutcrop is < 40% in areas where rainfall is < 300 ml/year.

2.7. Identifying Land Suitable for Rangelands

The land suitable for rangeland is assigned the following criteria:

- Slope is less than 32%.
- Rockoutcrop is >40% in the areas where rainfall is > 300 ml/year.
- Rockoutcrop is <40% in the areas where rainfall is < 300 ml/year.

3. Results and Discussion

GIS is a collection of hardware and software compounds and geo-referenced data, which being used by qualified personnel, is able to acquire, store, update, process, analyze, and display/print information according to the needs of a specific application field of activity [7]. The target of GIS for land reclamation works is to provide to the decision-makers a complex decision support system for revealing, rehabilitating, and monitoring the land reclamation works.

Accordingly, we determined the landform classes to consist of 15,900 ha (slope), 90 ha (footslope), 5,590 ha (hillcrest), and 2,980 ha (drainage depression) (Figure 2). Additionally, we found the slope steepness classes to consist of slightly (S0, <3%), gently (S1, 3-8%), moderately (S2, 8-18%) and steep inclined slopes (S3, 18-32%), corresponding to areas of 890, 6,060, 9,910 and 7,700 hectare, respectively (Figure 3). Aspect class data indicated that the non-oriented flat area with (0) aspect degree represents a small area of 1,470 hectare (5.9%). It is composed mainly of flat hillcrests. In Palestine, areas with northern and western aspects (Mighian) are normally considered much better for agriculture than those with eastern and southern aspects (Mishmas). The first part has an area of about 4,870 hectare while the second part is about 7260 hectare. Moreover, regarding the rockoutcrop classes parameters, the majority of the area (33,350 hectare, 95.1%) has high rockoutcrop (≥ 20%). The presence of large areas with high percent of rockoutcrop is an indication of the natural reason for non-cultivation rather than human reasons. Indeed, natural reasons can be attributed mainly to the slope steepness resulting in high rate of erosion, as well as the rainfall distribution.

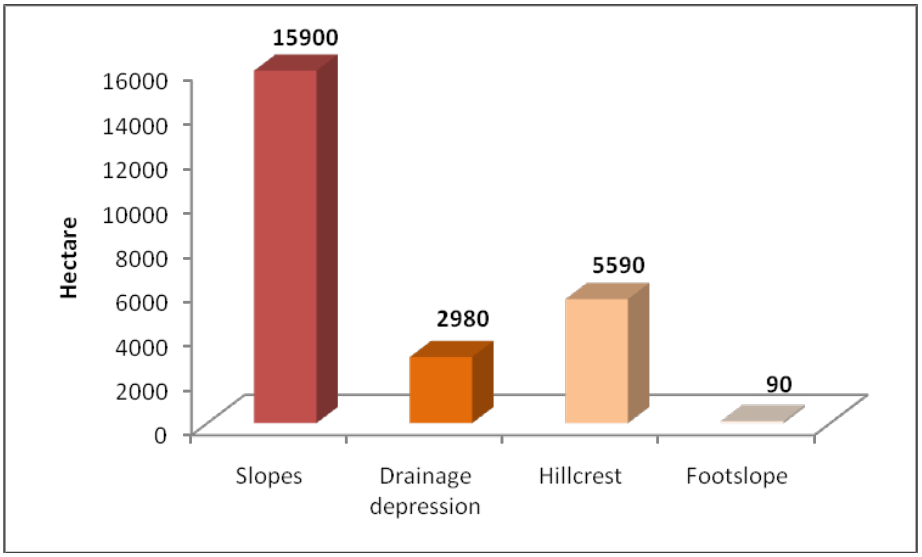

Figure 2. Land form elements area (hectare) in the non-agricultural land of Hebron Governorate

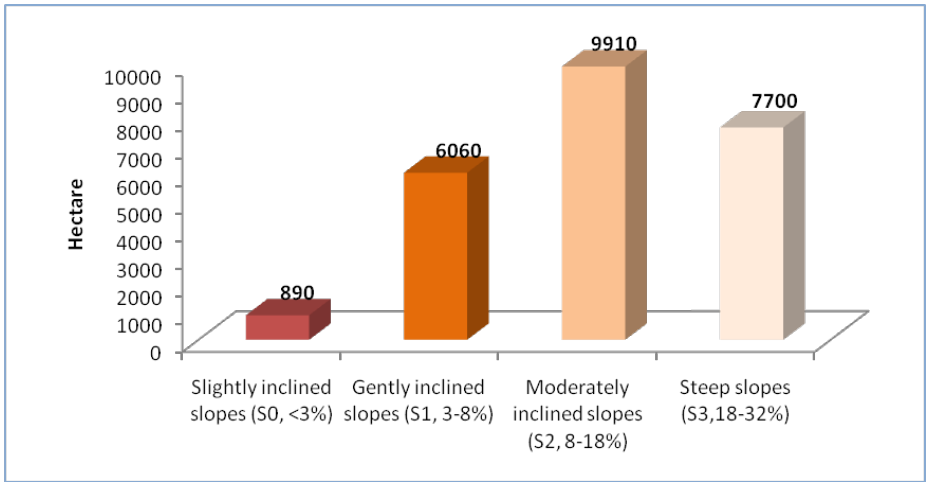

Figure 3. Slope classes' area (hectare) in the non-agricultural land of Hebron Governorate

Finally, concerning the climate classes, the total area of the arid class is 16,290 hectare, which comprises about 66.3% of the NA; the area of the semi arid part is 6,610 hectares, which comprises about 26.9% of the NA; and the sub humid area is 1,660 hectares, which constitutes about 6.8% of the NA (Figure 4). Indeed, the majority of the NA area is suffering from aridity and is occupying most of the area (about 93%). This degree of aridity puts severe and diverse restrictions on utilizing this land for agriculture, especially in the absence of control and special management [8]. The semi-arid areas, which are promising agricultural land, unfortunately suffer from urbanization sprawl as a result of the high population growth rate and the wide range of population distribution; the same situation is applicable to the sub-humid area (6.8%) which is heavily populated. The vast area of the arid climate instigates the salinization process, especially with the high rate of evaporation and the limited amount of rainfall, which are the main driving forces to desertification in this area.

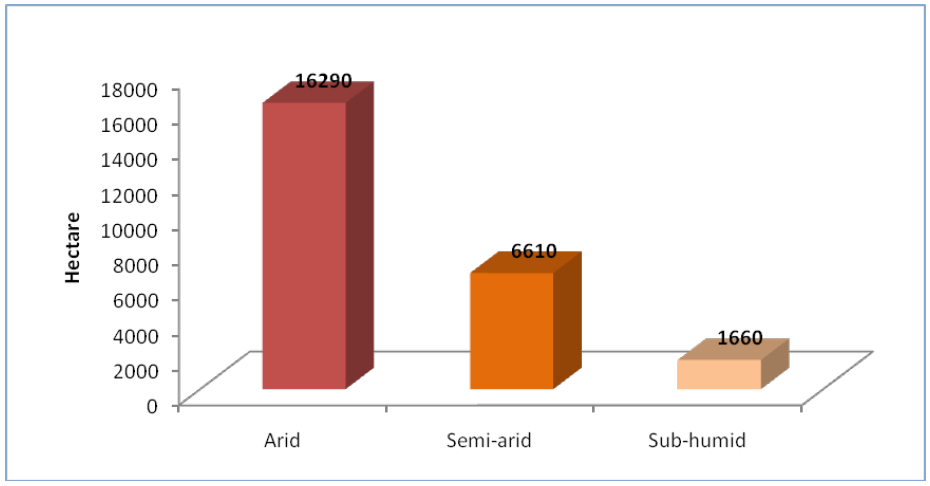

Figure 4. Climate classes' area (hectare) in the non-agricultural land of Hebron Governorate

These results represented in the physical features of the non-agricultural area constitute the core of the analysis for the preparation of the land suitability map of the NA. The analysis depends on the intersection of the different classes in the aforementioned four layers by using GIS. Therefore, a map displaying the land suitability classes for reclamation, rangeland and forestry in HG were constructed (Figure 5).

Overall, the total area of the non-agricultural land that would be mostly, highly and moderately suitable for reclamation was 3,120; 14,950 and 6,800 hectares respectively. Consequently, these areas constitute about 23.0% of the HG area. The most suitable class for reclamation represents the smallest percentage (12.7%) of the total area among all classes. This class is mainly located in the central, northeastern and northwestern parts of HG. Most suitable classes of reclamation are closer to Halhul, Beit-Ummar and Sair towns that are known with their relatively high agricultural productivity and comparatively they have a high amount of precipitation and sub-humid climate.

Also, the socio-economic analysis (data not shown) pointed out that the economic situation at these parts is relatively good, adding a positive driving force for reclamation processes to be successful through the financial share and cooperation of the peasants in these built-up areas.

This result indicates that the work at the most suitable spots for reclamation should aim primarily at increasing the agricultural productivity throughout the improvement of the existing management and practices, rather than eradicating poverty or combating land degradation represented mainly by soil erosion. These moderately suitable parts are located at the eastern and southeastern parts of HG and at the western fringes of the central heights. The main characteristic of these parts is that they have a relatively high steepness of slopes.

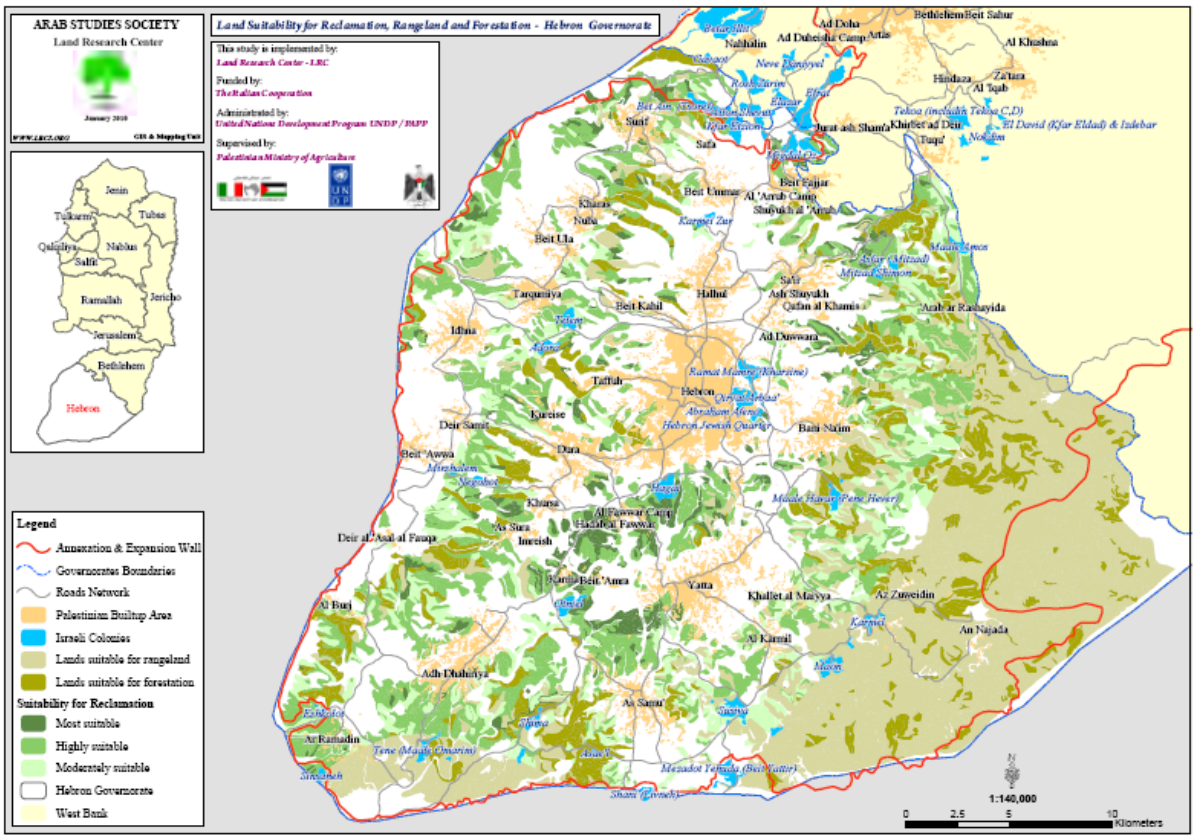

Figure 5. Classes of land suitability for reclamation, forests and rangeland in the Hebron Governorate

The total area in HG that is classified as suitable for forests and rangeland is estimated at about 26,543 hectares. This land is qualified for such classification as a result of the presence of one or more than one restriction of the slope, rockoutcrop and the climate. For example, lands suitable for forests should have 300 ml/year of rainfall or more in areas where rockoutcrop is greater than 40%. As a result of this analysis, the total area of the lands that are classified as suitable for forestry is estimated at about 3,813 hectares (Figure 6). This area represents about 16 % of the HG area. This percent does not mean that this is the only land available and suitable for forestry but it means that this land acquired high suitability for forestry compared to other lands in the study area, and of course, after excluding the land suitable for reclamation. The percent land that is suitable for forestry from the total land suitable for forests and rangeland is small (14%).

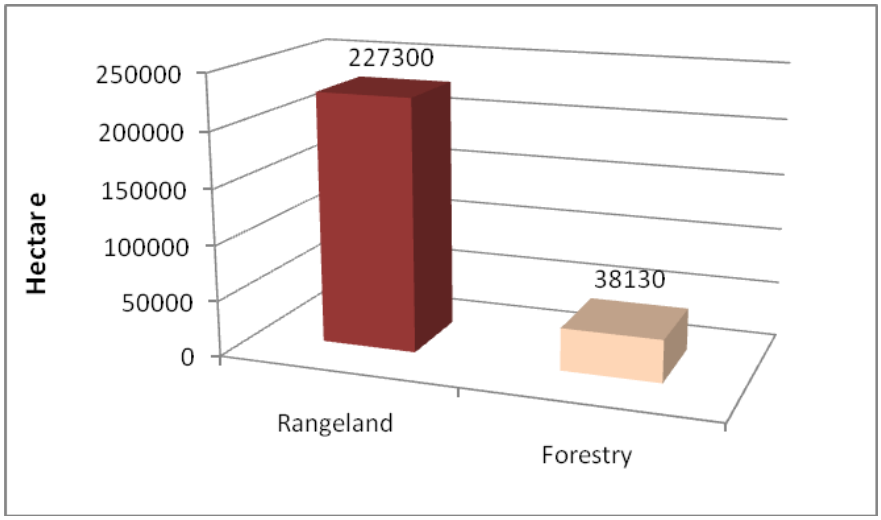

Figure 6. Land suitability area (hectares) for forest and rangeland in the Hebron Governorate

The results indicated that the majority of the land in HG which is not suitable for reclamation is suitable for rangeland (40%). This result pointed out to the importance of rehabilitating rangeland for the promotion of livestock production in the HG.

In conclusion, in this study, GIS data based on landform elements, slope steepness, aspect, rockoutcrop, and climate characteristics were found to be of substantial help in determining the land suitability for reclamation, rangeland, and forestations in the non-agricultural land.

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