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Article

Optimal use of Agricultural Land in an Arid Region from Using GIS and Linear Algorithm: Al-Hasaka-SYRIA

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Abstract

This research aims to evaluate the lands of Wadi Khirbet al-Malihah area in Al-Hasaka province (2016-2018) and determine the optimal land use. A geo-pedological soil survey was initiated, and 10 soil profiles representing the physiographic in the study area were collected for some chemical and physical properties analysis. The land evaluation was achieved using LAMIS (Land Management Information System) program under the GIS platform. The evaluation was done applying map-algebra on both crops' requirements with parametric conditions of lands and climate characteristics. The resulting evaluation showed according to the suggested scenario (limited irrigation water), crops with the lowest water requirements were selected: moderate suitable S2 by 41.52%, limit suitable S3 by 28.27% of the study area. Linear programming was used to produce the final optimal land use map according to three criteria: costs, gross margin and water requirements. The results show that there are diversity advantage and the land area of study that suit to be area cropping commodities are tested with an area of 41895 ha. Land use in the Wadi Khirbet al-Malihah achieving profitability with the optimal combination of cropping wheat (29.579%), the lentils (22.257%) and Quinoa (9.283%).

Keywords: Optimal land use/land evaluation, GIS, Linear Programming.

Introduction

The optimal use of lands is very important to obtain permanent development that includes economic, social environmental and political diameters under the recent challenges. The optimal planning of land use are a group of chain procedures that made and done to make the best use of land through studying and evaluating the natural economic and social factors (Edrich, 2005). Optimal crop style that lands are assigned to it for different crops through using limited resources has become one of the most important challenges for obtaining the highest gain. Where optimal agricultural planning is an important issue in the gain operation because it increases the income from low-cost operation (Scarpari and Beaclair, 2010). The maximum economical agricultural land use depends on two things, which are land evaluation suitability and analysis of farmer's agricultural commodities that are cultivated (Ülker et al, 2018). Where stating the proper selection of plants for every type of land is a major issue in an attempt to maximize the overall contribution of land (Sarker et al., 1997). In this study, the Geographic Information System (GIS) with Linear Programming (LP) was used to determine the optimal use of agricultural land. Land area constraints impose a greater need to assess agricultural natural resources. Geographic Information System (GIS) has a strong capacity in data integration and analysis and visualization, a powerful tool to get a solution to problems and building land use planning. The use of GIS will integrate diverse geospatial data, such as topographic, land and soil suitability, vegetation cover, land use and others in GIS database and their joint analysis, which increases the quantity as well as the quality of derived information (Bojorquez-Tapia et al., 2001; Ball, 2002; Hoobler et al., 2003; Malczewski, 2006; Trung et al., 2006). While Line programming treats different issues where it finds best values (x1, x2, x3…. xn) that give the biggest benefits to make a decision to increase gains and reduce costs (Taei et al., 2009). Linear programming techniques have been widely used by agricultural economists. Despite its limitations, the method has proved very useful in studying the decision-making process in the agricultural sector. Agricultural resource allocation issues can be addressed through potent techniques such as LP and the production of optimal solutions (Alsheikh and Ahmed, 2002) In many studies of land optimization, linear programming model has been used to determine the area to be used for different crops for maximum contribution. Such as (Sarker et al., 1997) which developed a linear programming model to identify areas to be allocated to a variety of crops to maximize total contributions from agricultural activities in Bangladesh. Sarker and Quaddus (2002) studied the problem of crop planning at the state level using a multi-objective improvement model that met different objectives. Zander (2005) used

a multi-objective model for land use for sustainable development. Latinopoulos and Mylopoulos (2005) benefited from goals programming for optimal allocation of land and water resources in irrigated agriculture.

Hassan et al (2005) used LP to calculate crop area, production, and revenue in the Dera Khan section of Punjab province. Sharma et al (2007) used fuzzy goal programming for agriculture land allocation problems. Kaur et al (2010) also formulated an LP model to propose an optimal crop pattern to maximizing net revenue and ensure significant savings from groundwater in Punjab, Pakistan Mohammed and Sa'id (2011) modelled an LP crop mix for a limited planning horizon. The optimal enterprise combination in the cassava-based farming system in Nigeria was obtained by using LP by Bamiro et al (2012). Antwi (2016) used linear programming in the problem of allocation of agricultural resources to determine the optimal plan for the allocation of crops to women farmers under land, labor and capital constraints. Imamoğlu and Sertel, (2016) in the study; field interpretation and analysis of different Interpolation methods for soil moisture mapping using remote sensed data.

Linear programming was used to enhance the irrigated areas in Egypt (Osama et al., 2017) where different crops contend for a limited amount of land and water resources. In order to evaluate the relationship between land cover and land surface temperatures by using data perceived remotely by Kaya et al (2017), it was studied in Silivri region of Thrace peninsula. The linear programming model was used to make decisions about crop cultivation patterns by farmers and improve land use for agriculture in Sumedang Regency (Zenis et al 2018). Menegto (2019) conducted similar applications in Nigeria.

The linear programming issues can be solved through the prepaid and hard to deal programs or through Excel program by SOLVER in it (Vijay, 2002). SOLVER program is used in Excel to determine the best crops depending on joining the results of evaluating lands with the economic factors to make map for the final suggested uses or study Region when the additional function SOLVER is used to solve the line and non-line programming issues where the function SOLVER can solve all line programming issues (Burton Carrol and Wall, 1999). Buzuzi and Buzuzi (2018) evaluated the economic activity on a small-scale farm in the Mutasa district of Manicaland province of Zimbabwe in which maize, cabbages, potatoes, and tomatoes are cultivated. By applying the linear programming model using Microsoft excel SOLVER, and Hamsa and Bellundagi (2018) used a quantitative analytical approach using Microsoft excel SOLVER in optimal crop plan allocation analysis. In this paper GIS was used to determine the suitability of the land for agriculture, then used LP to determine the optimal model for land use. Finally, GIS was applied again to produce the land use map generated by the LP model.

Materials and Methods
Study area

Wadi kherbat ALmliha is a region that belongs to AL-Hasaka province in Syria has an area of 41895 ha at 36˚ 78 length line and 34˚ 89 width line and 300 m above the sea level. It is surrounded by AL-Shaddada and Jerwan hill at the north Markada at the east. AL- Arysh at the west and Deirezzor at the south. the lands of the studied area are plainly topography with low waving. The climate of the study region is tropical medterain with humid warm winter and dry hot summer and it is located between semi-arid and arid regions. rainfall rate is 250-300 mm/year (Climate Atlas of Syria,1977). Due to low rainfall during the last few years, the region faced drought, reducing the agricultural lands, and high levels of desertification (Ali, 2010). Vegetation cover and land use: The plant families in the study area showed that Atlantic pine trees, Palestinian pine bushes, white atriplex, oat, salsola and a number of perennials plants are dominants (Sankri,1987). Main cultivation crops are wheat, barley, some medical ornamental plant like cumin. In addition to these, rearing cows, sheep and goats are there (ASG, 2016).

In this study the geographic information system program (ArcGIS 10.3) and Land information management system (LAMIS), under Arc view 3x (Idriss,2011"1") where used.

The study used survey methods; data collected consists of:

a) Primary data, form of the data
Field work: A 121 land points were studied to test the differences on physiographical unit's map and to choose and prepare 10 soil profiles in different sites, the diagnosing characters and classification of soil was done according to USDA soil taxonomy (Soil Survey Staff,2010), and color index (Munsell soil color charts,2000). the soil profiles were described using mandated form. Soil samples were collected according to the horizons in the soil profile. the samples were air-dried, crushed and sieved at 2 mm.

Soil chemical and physical data, were done in labs by researchers:
- physical analysis
- mechanical analysis Performed on soil texture % using hydrometer method, and general porosity % was calculated.
- chemical analysis
- PH of a saturated paste extracted using PH-meter (Conyers and Davey, 1988), ECe (Desimeise/cm) in a saturated paste extract using ECe-meter (Richards, 1954), total carbonate percentage using calcimeter (Balazs et al., 2005), gypsum percentage using the American method (Rhoades,1990), and organic matter% using wet oxidization method with Di-potassium chromate in a high acidity medium (Walkley and black, 1934) were estimated in labs of General Commission of Scientific Agricultural Research (GCSAR).

b) Secondary data
  i. Meteorological Data obtained from the meteorological department and ICARDA water resources data obtained from the GCSAR and statistical agricultural data obtained from the ministry of agriculture (ASG, 2016).

GIS work

Planning important crops requires two kinds of data: Digital maps made by GIS that describe climate, main characteristics of soil, topography, current land uses and land cover and description data including the environmental requirement for crops and fruiting trees in the form of a table. The factors used in the study, number of standers were used in this study relating soil, climate, topography, recent land uses and land cover (Sys et al.,1993). The standards are as follows:
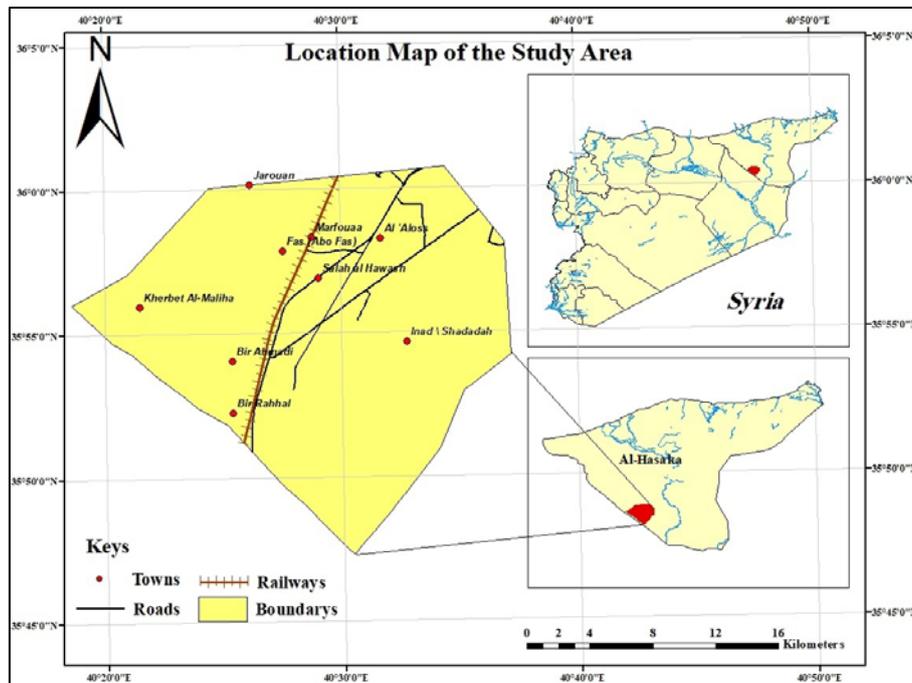

Fig. 1. Location map of Study area, Wadi kherbat ALmliha, AL-Hasaka province (Syria).

Environmental factors
- Frost length (below 0 c°) in a day.
- Absolute minimum temperature for the coldest month of the year which is the lowest temperature during the year. this is used to determine the rate of reducing the temperature from plant resistance. When some species growing or die at low temperatures.
- Temperature average for the coldest month of the year (temperature during winter and spring). Considering the dormancy stage for perennial and fruiting trees.
- Absolute maximum temperature for the hottest month of the year. Temperature average the hottest month of the year (temperature during summer growth). This is used in two sides: it's important for the maturity of summer crops and it may lead to stop crop growth at its non-tolerance of temperature.
- Growth length determines humidity the temperature length of the growth period and defined as the period (number of days) that rainfall exceeds half of the evaporation rate when the temperature is above 0 c this is used for rainfall crops.
- Rainfall quantity

Soil factors
- Soil texture
- soil PH
- soil salinity
- soil depth
- soil fertility
- calcium carbonate
- gypsum
- productivity map.

Topographical work

Slope degree: a map of slope degree was made and classified into degree using DEM, though this factor may not directly affect plant growth, reduces using machinery and increases soil removal while irrigating crops. Factors relating of land use and land cover.
- Recent land uses: it describes the present function of land uses in the study region. Though recent land uses may not affect the agricultural plants, but it is taken into consideration to avoid urban lands, forests, and orchards from agricultural planning.
- Land cover: Describes the form of the natural lands that are used by man and it also doesn't affect the agricultural plan 2.

Water availability factor
- Availability of irrigation water: agricultural plant must be done according to the optimal conditions but performing is done with water availability.
- The area suffers from water scarcity due to dryness of the Khabour River, and it has some wells that are used for drinking for human and livestock.

Data were checked, entered the computer and linked with GIS where spatial data entered and linked with description data that were obtained from the field and lab measurements using ArcGIS 10.3 program, then these data were deal and put on purpose map.

Procedures
The theme of used standards of the study was made using the previous map extracting in ArcGIS 10.3
1. Table of standards was made in excel program including ID field and crops field along with the previous standards where names of the standards of the theme must match the names of the previous standards in the table and then keeping the form as dbf.
2. Adding standards theme and standards table to Arc view 3.x program and activating the extension LAMIS V 1.0
3. using the order: build the parameters table from intersected them to rebuild the environmental requirements for crops
4. Producing suitability map for crops where LAMIS program perform the following operations (Idriss,2001"2").
5. Check items of parameters table that contained the determined factors which have yes and no and put them in one lest (the determined factors list).
6. Searches in the fields that represent the determined factors and writes against each value of no value (N) and put the cause in the causes field.
7. Reads fields of the rest parameters and look for the values that express crop requirements and then compare it with the theme. if they all matched it writes S1 (best suitability) and leave the cause field empty.
8. Each factor of the undetermined factors that don't match the crop requirements leads to a change in the value one class. the difference of one factor gives the value S2, two factors S3. Three factors S4 and four factors S5 and more than that gives the value N1 giving the reason.

The same thing repeated in each record of the theme records until finishing the intersected map records. Determining the type of optimal use of crops. Types of uses compete for highly productive lands while appropriate patterns for medium and low land in their productive capacity are limited (Bani et al.2003). Three Variables were used in this study;

1. costs: (state group of the ministry of agriculture, 2016).

2. gross margin using (state group of the ministry of agriculture, 2016). Based on the wholesale cost average.
3. water requirements for crop irrigation at m3 /h.

SOLVER program in Excel was used to obtain a map of land uses: The SOLVER is a part of group orders sometimes called "what-if analysis".

With SOLVER, you can find the maximum or minimum values of one cell called a targeted cell in a working paper through changing other cells.

Selection of variables

Max. $x1+ x2+x3+\cdots= z$ subject to $x1+ x2+x3+\cdots\ldots xn \leq L$ (land limitations)
$g1x1+g2x2+g3x3+\cdots\ldots + gnxn \leq G$ (gain)
$w1x1+w2x2+w3x3+\cdots\ldots + wnxn \leq W$ (water requirements)
$p1x1+p2x2+p3x3+\cdots\ldots + pnxn \leq P \quad x1, x2,3\ldots\geq 0$ (production cost)

To know the economic feasibility of farming can be defined by the Benefit-Cost Ratio.

Results and discussion
Land suitability
The results of applying LAMIS software on conditions map and requirements table were the following land suitability classes (Idriss,2001"2").

S1: High land suitability for all crop's cultivation was not found in the study area.
S2: medium land suitability for cultivation at simple to medium in Caso4 and an area of 17373.11 h. and makes 41.52% of the total area. After removing the determining factors, it becomes suitable in the future.
S3: limited land suitability for cultivation due to the presence of medium to high determines in soil parameters (2 factors) (salinity, Caso4, slope. Max temperature, productivity, LGP) area of 11829.8 h and makes 28.27% of the total area.
S4: limited land suitability for cultivation due to the presence of high determines in soil parameters (3 factors) (Caso4, Caco3 slope, Max temperature, ECE, LGP) area of 5730.911 h and makes 13.70% of the total area. Suitable for agricultural constructions.

N: non-land suitability for cultivation due to limitation factors (water and urban) with an area of 14.81ha (0.035%) of the total area.
N1: non- land suitability for cultivation due to the presence of high determines in the soil parameter (5 factors) (Caso4, Caco3, organic matter, ECE, min temperature, fertility) with an area of 6893.33% and makes 16.47 of the total area. After removing the determining factors in the future by reforming this class, might convert into suitable class S1.

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Table 1. Classification of the studied crops according to the cultivation season and irrigation method

group	crop	season	irrigation
Cereals	Wheat- Quinoa	winter	Rain fed and supplemental irrigation
legumes	lintel	winter	Rain fed and supplemental irrigation
fruiting trees	Apple- pistachio -almond	perineal	supplemental irrigation
Forage crops	Forage beet-red oat	winter	supplemental irrigation

Table 2. Suitability classes according to land use

Suitability classes	Semi suitability classes	Land use %			Area H	Percent % of the total area
		Agricultural lands	pastures	Barren		
S2	CaSo4	55.79	31.49	12.66	17373.11	41.52
S3	EC, CaSo4, Tmax, slope, lgp productivity	30.38	59.44	10.15	11829.8	28.27
S4	Caco3, EC, CaSo4, Tmax, slope, lgp, CEC	12.06	80.95	6.99	5730.911	13.70
N	-	-	-	-	14.81	0.035
N1	CaCo3 CaSo4, Tmin, slope, CEC, stone, om	1.97	93.49	4.54	6893.33	16.47
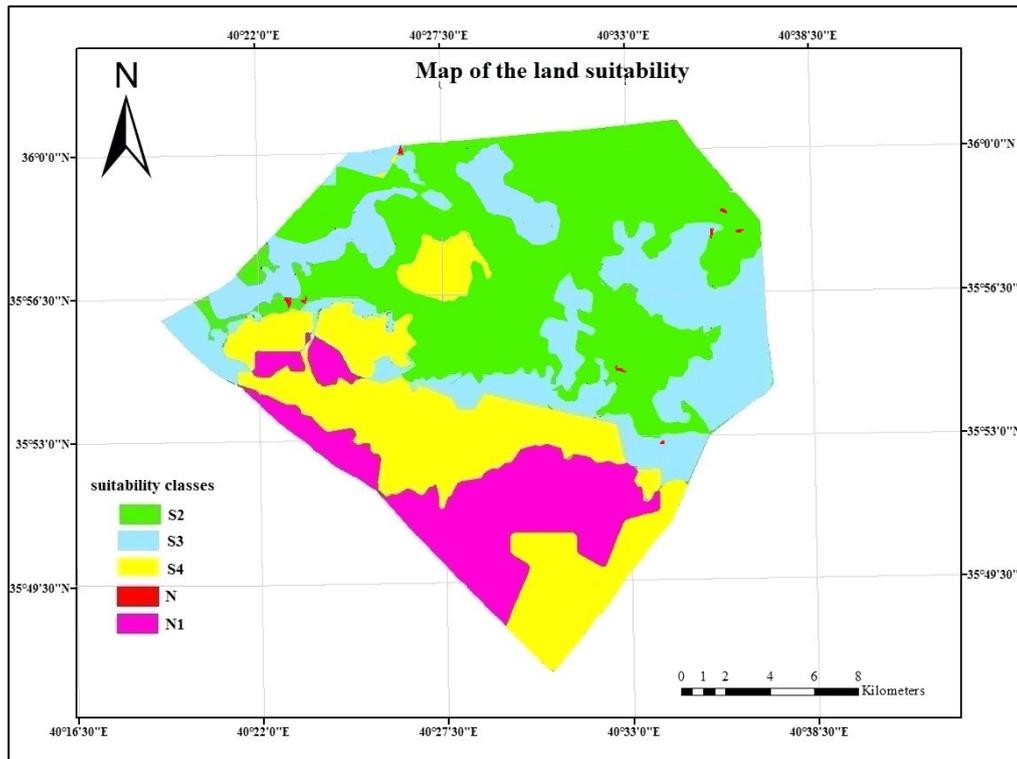
Fig. 2. Map of the land suitability.

Table 3. Crop distribution areas and percentage of this distribution

| Crop type	Area h	Percentage %
N	39.15	0.09
N1	5968.67	14.25
farm structures	10185.83	24.31
lentil	7436.21	17.75
Lentil-almond	62.29	0.15
Wheat-forage beet-red oat	6792.24	16.2
Wheat-almond-forage beet-red oat	4049.82	9.67
Wheat-almond-apple-forage beet -red oat	20.89	0.05
Wheat-forage beet	1510.69	3.61
Wheat-lentil-forage beet-red oat	1346.2	3.21
Wheat-lentil-almond-apple-forage beet-red oat	249.68	0.6
Wheat-lentil-almond-forage beet-red oat	278.4	0.66
almond	165.89	0.41
almond-apple	1562.64	3.73
wheat-Quinoa-forage beet-red oat	158.346	0.378
wheat-Quinoa-almond-apple-forage beet-red oat	2049.75	4.887
wheat-almond-forage beet-red oat	18.3	0.045
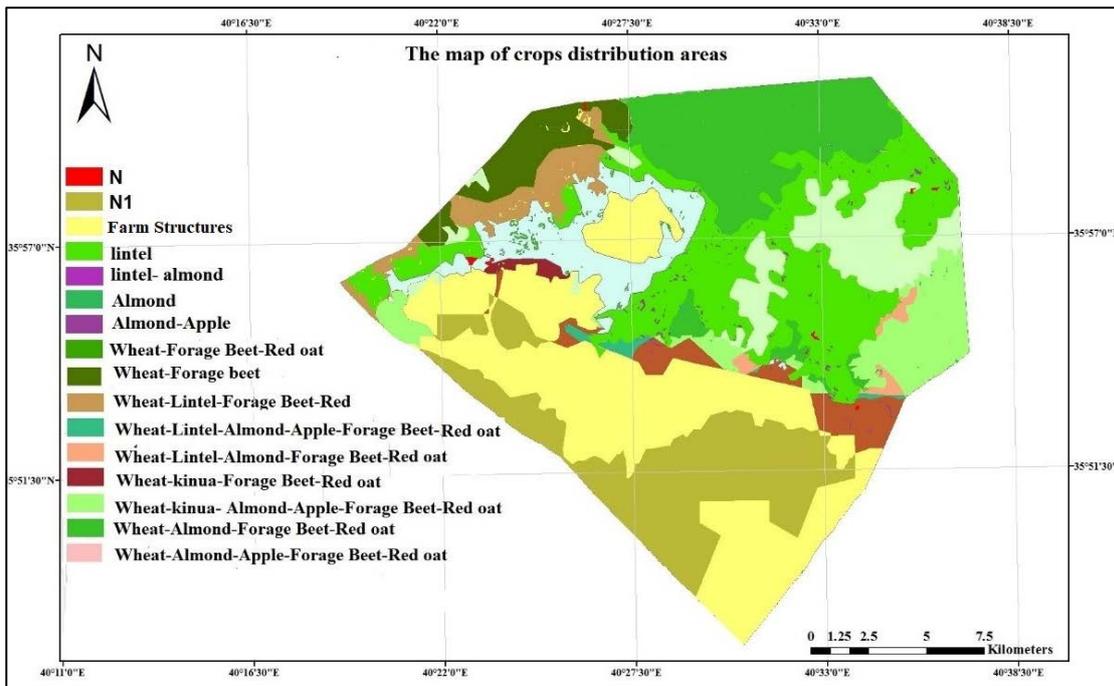
Fig. 3. Map of optimal use crops

Optimal crops use
Types of uses compete for highly productive lands while appropriate patterns for medium and low land in their productive capacity are limited (Bani et al.2003). Three Variables were used in this study:

1. Costs: (Agriculture statistical group, 2016).
2. Gross margin using (Agriculture statistical group, 2016). Based on the whole sale cost average.
3. Water requirements for crop irrigation at m3 /h.

where:
$x1 + x2 + x3 \leq 6792.24h$
$158283.4x1 + 203808x2 + 185160x3 \leq 210000$ s.p
$202200x1 + 308800x2 + 109675x3 \leq 300000$ s.p
$3220x1 + 1500x2 + 2000x3 + \leq 2000$ m3
$x1, x2, x3 \geq 0$

Table 4. Proposed crops and production constraints

Factors	Red Oat	Wheat	Forage Beet
area			
Cost (s.p)	**158283.4**	**203808**	**85160**
Gain (s.p)	**202200**	**308800**	**109675**
Water requirements m3/h	3220	1500.000	2000

To resolve the model of optimal crops uses, SOLVER under Excel was used:

Step 1: The target cell and limitations are entered to SOLVER program
Step 2: pressing add Where the option add is to add limitations by pressing it
Step 3: In cell reference, the limited value (constraint) was entered while in the cell of the constraint was filled by the limitation's values.
Step 4: pressing the SOLVER button. at the end, we press the button ok to obtain the output.

The resulting solution indicates that wheat crop cultivation occupied the largest area of 6059.421 while oats occupied 733 hours. Then beet fodder with 0 hours so it is not recommended to plant it here.

Table 5. The resulting solution

Factors	Red oat	wheat	Forage beet
area	0	6059.42	733
Cost (s.p)	158283.4	203808	85160
Gain (s.p)	202200	308800	109675
Water requirements m3/h	3220	1500.00	2000

MS Excel Screen-1

MS Excel Screen-2
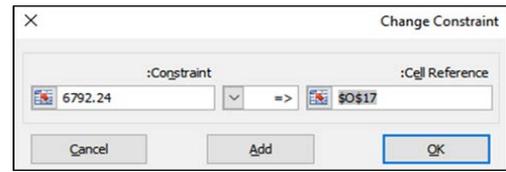
MS Excel Screen-3
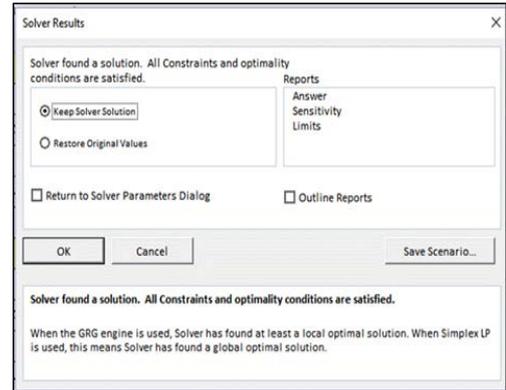
Figure 4. SOLVER program intrerface
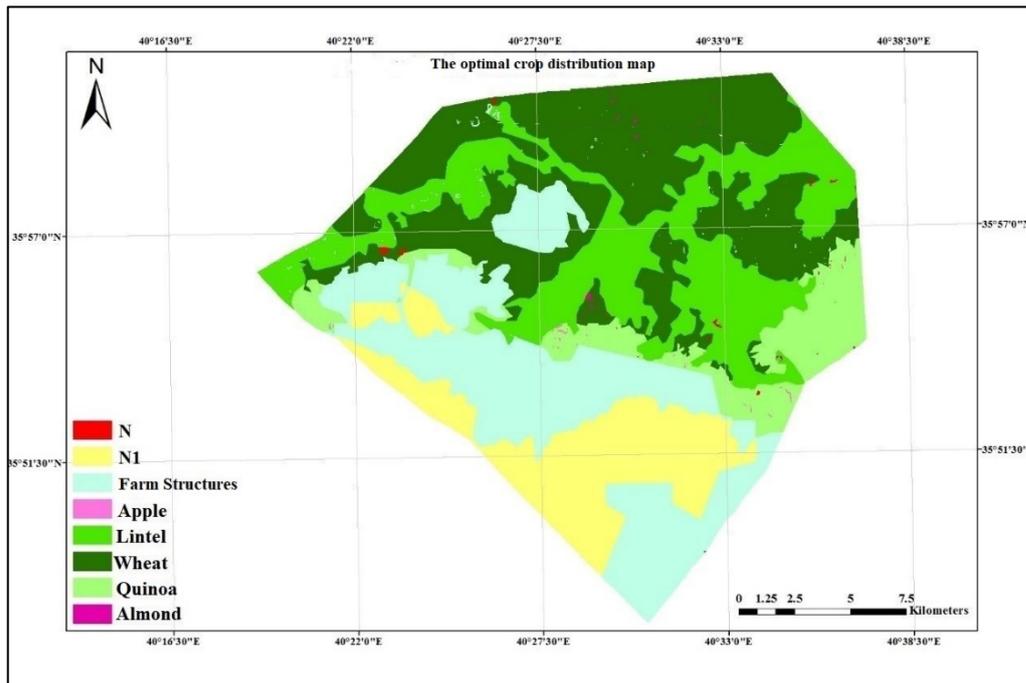
Fig. 5. The optimal crop distribution map

Table 6. The optimal crops distribution and percentage

crop	area	Percentage %
N	39.21	0.094
N1	5977.65	14.268
farm structures	10201.15	24.349
Apple	26.96	0.064
Lentil	9324.47	22.257
Wheat	12391.94	29.579
Quinoa	3888.93	9.283
almond	44.69	0.107

Conclusions

This study attempted to obtain a model for optimal land use in the study area. From the results, the study concluded:

1. Models of land use to get the optimization advantages of farming in the study area with a combination of planting: Wheat 12391.94 ha, Lentil 9324.47ha, Quinoa 3888.93ha, almond 44.69 ha, and Apple 26.96ha.

2. GIS is an effective tool for mapping, creating database, spatial description, and land uses requirements mapping.
3. LAMIS was adequate software to evaluate land suitability for single or multiple crops in the study area.
4. Typing and solving of the optimal use of field can be made using SOLVER program in excel that doesn't need big knowledge of the complicated mathematical concepts.
5. An agricultural plan can guide farmers to produce varieties and crops required in the local and out markets.
6. Good management of land resources to conserve the land, can support the national economy and improve the farmer's income.
7. The study showed that the best crops from the viewpoint of economic are those don't need more water, high yield, and low cost.

References

Ali, M. (2010). *Years of Drought: A Report on the Effects of Drought on the Syrian.* Peninsula, Heinrich-Böll-Stiftung - Middle East Office.

Alsheikh, M., Ahmed, M. (2002). *Development of Mixed Farming System in a Newly Reclaimed Area in Egypt.* Session No. LMP3.12. Abstract No. 107

Andrew, J. (2007). Mason *"Solving linear programs using Microsoft Excel SOLVER"* University of Auckland.

Antwi, K.D. (2016). Optimal Resource Allocation Decision Among Women Farmers in the Northern Region of Ghana, African Journal of Agriculture and Food Security: *International Scholars Journals,* 4(3):161-166.

ASG (Agriculture Statistical Group) (2016). Syrian Ministry of Agriculture and Agrarian Reform, *Division of Agricultural Statistics Computer Centre.* Damascus, Syria.

Balazs, O., Opara, N., Beesea, F. (2005). A simple method for measuring the carbonate content of soil. *Soil Sci. Soc. Am. J.,* 69, 1066–1068.

Ball, J. (2002). Towards a methodology for mapping 'regions for sustainability'using PPGIS. *Progress in Planning,* 58(2), 81-140.

Bani, N., Jamal, R.H.,Farshad, A.(2003). *Land evaluation for land use planning with especial attention to sustainable fodder production in Rouzeh Chi catchment of Orumiyeh area –Iran international Institute for geo- information science and Earth observation Enschede,* The Netherlands. Master Thesis.

Bojorquez-Tapia, L. A., Diaz-Mondragon, S., Ezcurra, E. (2001). GIS-based approach for participatory decision making and land suitability assessment. *International Journal of Geographical Information Science,* 15(2), 129-151.

Burton, Carrol., Wall. (1999). *Quantitative Methods for Business & Economics,* Longman, NY.

Buzuzi, G. Buzuzi, A. N. (2018). A Mathematical Programming Technique to Crop Mix Problem on a Farm in Mutasa, Manicaland Province, Zimbabwe, *International Journal of Economics and Management Studies,* 5(11), 6-10.

Climate Atlas of Syria.(1977). *Ministry of Defence. Meteorological* Department. Climate Division Service of military geography, 150.

Conyers, M., Davey, B. (1988). Observations on some routine methods for soil pH determination. *Soil Science,* 145: 29-36.

Edrich, M. (2005). *Strategies and Policies for Sustainable and Integrated Planning in Nablus City,* Unpublished Master Thesis, College of Graduate Studies, An-Najah National University, p 30.(in Arabic)

Hamsa, K. R., Bellundagi, V. (2018). *Economic optimum crop planning for maximization of farm net income in central dry zone of Karnataka: An application of linear programming model.*

Hassan, I., Raza, M.A., Khan, I.A., Ilahi, R. (2005). Use of Linear Programming Model to Determine the Optimal Cropping Pattern, Production and Income Level: A Case Study from Dera Ghazi Khan Division. *Journal of Agriculture & Social Sciences,* 1813-2235/2005/01-1-32-34

Hoobler, B. M., Vance, G. F., Hamerlinck, J. D., Munn, L. C., Hayward, J. A. (2003). Applications of land evaluation and site assessment (LESA) and a geographic information system (GIS) in East Park County, Wyoming. *Journal of Soil and Water Conservation,* 58(2), 105-112.

Idriss Younes (2011)"1", *Land Use Classification System, LUCS 3.4V.* General organization for Remote Sensing. Damascus

Idriss, Y. (2011)"2". *Land Management Information System (LAMIS). first edition. General organization for Remote Sensing.* Damascus. 25 p. (in Arabic)

İmamoğlu, MZ. Sertel, E. (2016). Analysis of Different Interpolation Methods for Soil Moisture Mapping Using Field Measurements and Remotely Sensed Data. *International Journal of Environment and Geoinformatics (IJEGEO),* 3(3), 11-25.

Kaur, B., Sidhu, R.S., Vatta, K. (2010). Optimal Crop Plans for Sustainable Water Use in Punjab. *Agricultural Economics Research Review* 23, 273-284.

Kaya, Ş., Çelik, B., Gazioğlu, C., Algancı, U. Şeker, DZ. (2017). Assessment of the Relationship between Land Cover and Land Surface Temperatures Utilizing Remotely Sensed Data: A Case Study of Silivri, *19th MESAEP Symposium on Environmental and Health Inequity,* Rome, ITALY, 3-6 Dec 2017.

Lationpoulos, D., Mylopoulos, Y. (2005), "Optimal allocation of land and water resources in irrigated agriculture by means of goal programming: application in Loudias river basin," *Global Nest Journal* 7(3): 364-273.

Malczewski, J. (2006). GIS-based multicriteria analysis: a survey of the literature. *International Journal of Geographic Information Science,* 20: 703–726.

Menegto, E. (2019). Locational Analysis of Surface Water Quality, Sediment and Dredge Spoil At Nembe, Bayelsa State, Nigeria, International Journal of Environment and Geoinformatics (IJEGEO), 6(2),15-21.

Ministry of Agriculture and Agrarian Reform. (2016). *Annual Agricultural Statistical* Abstract. Damascus. (in Arabic)

Mohamad, N.H.J., Said, F. (2011). A Mathematical Programming Approach to Crop Mix Problem. *African Journal of Agricultural Research.* 6(1), 191-197.

Munsell Soil Color Charts. (2000). GretagMacbeth, 10p.

Osama, S., Elkholy, M., Kansoh, R. M. (2017). Optimization of the cropping pattern in Egypt. Alexandria Engineering Journal, 56(4), 557-566.

Rhoades,D.(1990). Determining soil salinity from measurements of electrical conductivity. Commun. *Soil Sci. Plant Anal.* 21: 1887-1926.

Richards, L.A. (1954). *Diagnosis and improvement of saline and alkali soils. USDA Agric. Handbook* 60. Washington, D. C

Sankri, N. (1987). *Environment, vegetation and grazing areas of the dry and highly drought areas of Syria,* Publications of the Faculty of Agriculture, University of Aleppo. Aleppo, Syria, 793 p. (in Arabic).

Sarker, R. A., Quaddus, M. A. (2002). Modelling a nationwide crop-planning problem using a multiple criteria decision-making tool. *Computers & Industrial Engineering,* 42(2-4), 541-553

Sarker, R., Talukdar, S., Anwarul, H. (1997). "Determination of optimal crop mix for crop cultivation in Bangladesh." *Appl. Math. Sciences,* 21(10):621-632.

Scarpari, S., Beaclair, F.(2010). "Optimized agricultural planning of Sugarcane using linear programming" *Revistainvestigacionoperacional,* 31(2), 126-132.

Sharma, D.K., Jana, R.K. Gaur, Avinash. (2007). Fuzzy goal programming for agriculture land allocation problems. *Yugoslav Journal of Operations Research* 17(1): 31-42.

SoilSurvey, S. (2010). *Keys to soil taxonomy,* 11th edn. United State Department of Agriculture. Natural Resources Conservation Service, Washington DC.

Syria Climate Atlas. (1977). *Syrian Arab Republic, Ministry of Defense,* Directorate General of Meteorology, Directorate of Climate, this Atlas was prepared and printed under the supervision of the Directorate General of Meteorology. (in Arabic)

Taei, D., Obeidi, M., Abdel Hamid, A., Omar, N .(2009). *Applications and Analysis of Quantitative Business System WinQSB.* (Memory library). Baghdad, Iraq. Number of pages 220. (in Arabic)

Trung, N. H., Tri, L. Q., Van Mensvoort, M. E. F., Bregt, A. K. (2006). XIV. Comparing Land-use Planning Approaches in the Coastal Mekong Delta of Vietnam. *Environment and Livelihoods In Tropical Coastal Zones,* 177.

Ülker, D., Ergüven, O. Gazioğlu, C. (2018). Socioeconomic impacts in a Changing Climate: Case Study Syria. *International Journal of Environment and Geoinformatics (IJEGEO),* 5(1), 84-93.

Vijay, G.(2002). *Financial analysis using Excel.* VJ books Inc, Canada.p227.

Walkley, A. Black, I.A. (1934): An examination of the Degtjareff method for determination soil organic matter, and a proposed modification of the chromic acid titration method. *Soil, Sci.*34:29-38.

Walkley, A., Black, I.A. (1934). An examination of the Degtjareff method for determination soil organic matter, and a proposed modification of the chromic acid titration method. *Soil, Sci.*34:29-38.

Zander, P Kachele, H. (2005). Modeling multiple objective of land use for sustainable development. *Agricultural Systems,* 59(3): 311-325.

Zenis, F. M., Supian, S., Lesmana, E. (2018, March). Optimization of land use of agricultural farms in Sumedang regency by using linear programming models. *In IOP Conference Series: Materials Science and Engineering,* 332(1), 012021. IOP Publishing.