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Estimating the Land Production Potential for Wheat, Using Gis Method

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Abstract: A land potential for estimating the Land Production Potential of wheat was used on the crop requirements crop, and climatic and physical-chemical soil properties which will allow the prediction of yields. Regarding to FAO model, the estimated LPP values for the study area was varied between 38 to 4000 kg. ha^{-1} respectively. The lowest values was found in the map unit 3.1. where soil conditions were unfavourable due to high salinity and alkalinity. This unit is located the southern part of the study area. The Higher estimated LPP values(map unit 2.1) is located side of the northern of the study area. This study showed that the average farmers' yields was upper than the LPP values that can be related to calculate rating and weight of effective factors on wheat by expert. The computed values of net biomass production and yield showed the wheat potential productivity is unsuitable in the majority map units of Damghan plain.

Key word: Land, Production Potential, Damghan, Gis, Wheat

INTRODUCTION

Computation of crop productivity should go beyond the concept of primary productivity, and the FAO (1978) provided one of the best examples of the calculation of crop productivity. Different empirical modelling approaches to predict land productivity for crops under wide range of weather and soil conditions have been described (FAO, 1975; De Wit and Van Iceulen, 1987; Thomasson and Jones 1991; Tang *et al.*, 1992; Darousin *al.*, 1993). Information on radiation and temperature within the growing period is used together with the actual photosynthetic capacity of crops and the fraction of the net biomass which crops can convert into economically useful yield to calculate the net biomass production and yield of crops. The Food and Agriculture Organization of the United Nations (FAO) developed a methodological framework to assess food production, which widely known as the Agro-ecological zoning (AEZ) methodology (FAO, 1978-80, FAO/IIASA, 1991). The AEZ approach presents a useful preliminary evaluation of this potential, and ensures that representation is maintained at an appropriate biogeographic scale for regional sustainable development planning. Geographic information system (GIS) is a computer-based information system for the capture, storage, retrieval, analysis and display of geographic features tied to a common geographic coordinate system (Goodchild, 1992; Clarke, 1997, Goodchild, 1992; Clarke, 1997, BURROUGH, 1991). With the aid of Geographic information system (GIS), agro-ecological cells can be defined in grid, which form the basic unit of analysis used in AEZ applications, and a program, which combining overlaid spatial information with the calculation of crop productivity, is developed. In this paper, we did GIS-based model for wheat potential production in Damghan plain of Iran.

MATERIAL AND METHODS

Study Area:

The study area is located in the south of Damghan Plain and in Semnan province of Iran. This study was carried out in an area including 5400 ha between 36 º 02´ 31.6″ - 36 º 08´ - 28.5″ of the northern latitude and 54º 21´ 56.7″ 'E- 54 º 27´ 24.1″ of the eastern longitude in the form of survying at a semi-detailed surveying level for determination of soil characteristics and illustration of soil maps.

The production potentials for irrigated wheat have been determined using a model that considers following steps ordered production situations:

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1. Radiation-thermal Production Pstelatial (RPP): As temperature and radiationr regimes during the crop cycle can nt normaly be manipulated, these factors detemine, within the physiologicol capacity of the crop the potential production level in a specific area. The RPP of a crop is then only determined (within limits set by the crop's physiological propertîes) by the irradiance of photosynthetically active radiation that the crop can intercept, and the temperature regime of the production environment. Calculation of the RPP is based on the crop growth model of the Agro-Ecological Zones prqject (FAO, 19781), and is derived using the following equation:

$$RPP = \frac{0.36.bgm.H.KLAI}{(1/L) + 0.25.Ct}$$

2. Land Production Potential :The land production potential (LPP) has been calculated using an equation on which the effects of climate, and selected soil characteristics on crop production.

$$LPP = RPP * S$$

S is a soil suitability inde, . obtained by multiplping a physical soil index with a chemical soil index. Determination of both indices implies matching of soil characteristics with the barley soi1 requirements and attribution of a numerical rating value to each characteristic (SYS *et al.,* 1991, 1993).

The methodology used for the detemination of the production potential of wheat requires a climatological data set consisting of monthly averages of the following parameters: daily mean, maximum and minimum temperature (T^{C}). Rainfall (mm). After calculating weather records of station in the studied area this data were analyzed. Rainfall and temperature are the major parameters that determine the climatological suitability for wheat growth. The information such as temperature and precipitation was entered ArcGIS as attributes. Using potential production biomass simulation model, photosynthesis rate and photosynthetically active radiation is calculated, and then gross biomass production and net biomass production can be determined. Then RPP were determined for each map unit. The results are a series of estimated agronomically attainable yields for each land unit (grid).

The soil map of the studied area at the scale of 1:50, 000 covers different mapping units. There are tables for exhibiting the physical (texture, soil depth and stoniness)and chemical (sum of basic cations, pH, organic carbon) properties needy for plant. In order to facilitate the use of profile data to support crop rnodelling and spatial interpolation was prepared weighted mean of soi1 properties, each profile is cross-linked with the polygon in which it falls. Each soil polygon is characterized by the attributes of a profile with the same classification name as the dominant soil type of the mapping unit. Assessment of land suitability for barley is carried out by a combination of matching constraints with crop requirements. Evaluation of the soil characteristics resulted in soil suitability index (S) for individual soil units. *An* overlay of both raster, using the multiply of RPP and S, yielded a new map with the LPP results.

This activity is normally carried out in two main stages, in which firstly the agro-climatic suitability is assessed, and secondly the suitability classes are adjusted according to edaphic or soil constraints. Figure 1 gives a general overview of the flow and integration of information implemented in the global land suitability evaluation

Results:

The values of rating and weight of land suitability ceriteria are shown in table 1. The highest weight related to Salinity (0.33) and lowest to slop (0.002). The results of land suitability evaluation for wheat cultivation (table 2) shows that land units 1.1, 1.2 (S3) had most suitable and lowest suitable related to map units2.1, 2.2, 2.3, 3.1, 3.2 and 3.3 (N2). Fig 2, shows the maps of land suitability classes in the region by means of GIS method. Research showed that the wheat growth cycle on Damghan plain was 1 Nov (Planting) to 21Jun (Harvest). Regarding to FAO model, the estimated LPP values for the study area was varied between 38 to 4000 $kg.ha^{-1}$ respectively (Table.3). The lowest values was found in the map unit 3.1. where soil conditions were unfavourable due to high salinity and alkalinity. This unit is located the southern part of the study area. The Higher estimated LPP values(map unit 2.1) by same method is located side of the northern of the study area. Table 3 and fig 3 shows correlation between stimated yield and observed yield in GIS method. Also are shown, correlation coefficient between the mentioned parameters was R=0.758.

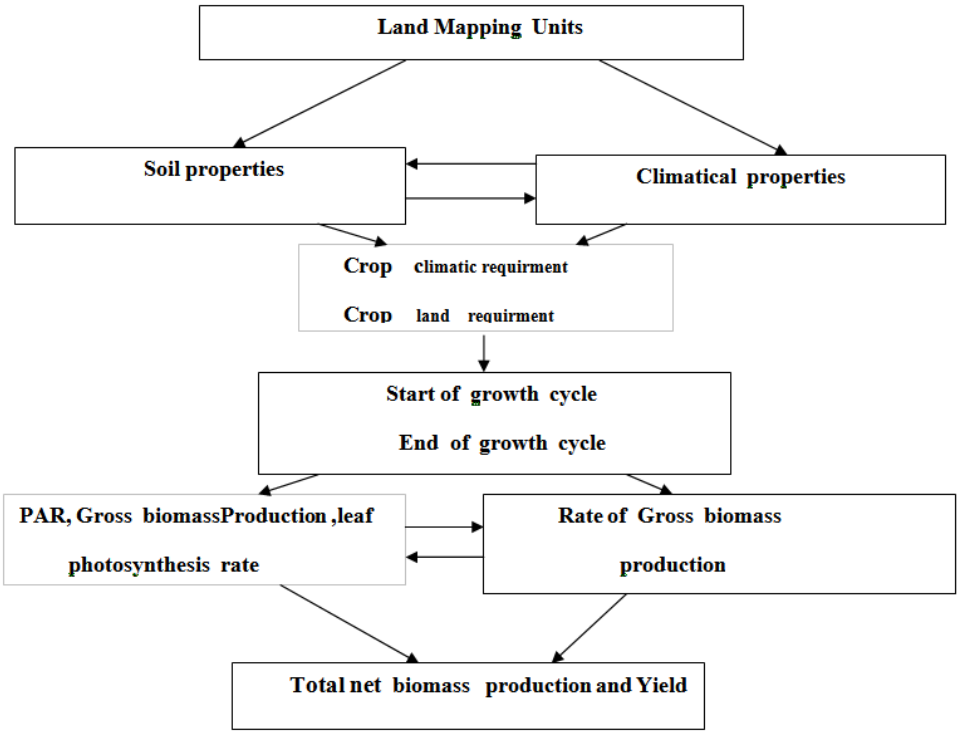

Fig. 1: Diagram of the flow and integration of information in the production potential estimation.

Table 1: The Determine of Rating and weight for each factor.

Ceriteria	Lime	Gypsum	Fertility (ph)	EC(Salinity)	ESP(Alkalinity)	Rainfall	Temperature
Weight	0.118	0.01	0.06	0.33	0.12	0.13	0.03
Rating	1.5,7,9	1.5,7,9	1.5,7,9	1.5,7,9	1.5,7,9	1.5,7,9	1.5,7,9

Ceriteria	Slop	Dranage	Soil physics	Surface Stoniness	Gravel	Soil depth
Weight	0.002	0.04	0.1	0.02	0.02	0.02
Rating	1.5,7,9	1.5,7,9	1.5,7,9	1.5,7,9	1.5,7,9	1.5,7,9

Table 2: Results of the qualitative suitability evaluation of different land units for wheat, using GIS methods.

NO	2	3	10	4	8	1	9	5	11	7	6
Land unit	1.1.1	1. 1.2	1. 2	1.3	2.1.1	2.1.2	2.2	2.3	3.1	3.2	3.3
Land class	S3	S3	S3	N1	N2	N2	N2	N2	N2	N2	N2
Observed yield	4500	4500	5100	1470	1380	1380	2560	4550	0.00	0.00	0.00
Estimated yield	3400	3400	4000	1150	998	998	1010	1080	38	130	155

Table 3: Results of the statistics analysis Observed yield with land index and estimated yield for wheat,using GIS methods.

Method	Crop	Regression	R^2
GIS	wheat	Observed yield and estimated yield y = 0.614x + 67.27	0.758

Discussion:

With the aid of Geographic information system (GIS), agro-ecological cells can be defined in grid, which form the basic unit of analysis used in AEZ applications, and a program, which combining overlaid spatial information with the calculation of crop productivity, is developed. The land physical evaluation by GIS method emphasized that majority of map units had permanently unsuitable suitable(N2) for wheat cultivation. This can be related to wheat low resistance against environmental condition especially soil and water salinity tolerance. Findings showed that there were much differences between estimated yield in various areas. The considerable variability of soil characteristics over short distances will undoubtedly also lead to important local differences in wheat productivity. The results illustrated that the average farmers' yields was upper than the

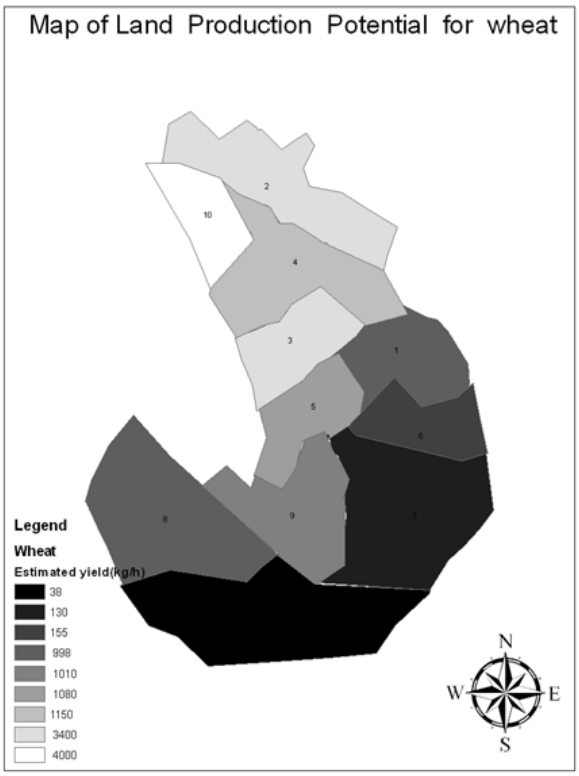

Fig. 2: Map of land Production Potential in Damghan plain for wheat.

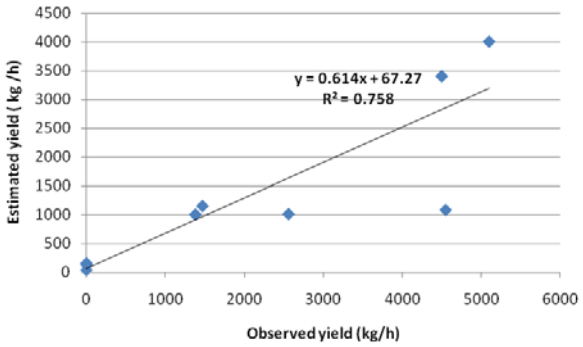

Fig. 3: The Correlation curve between observed yield and estimated yield for wheat, using GIS method

estimated LPP values (Fig 4) that can be caused calculating rating and weight of effective factors on wheat growth by expert. The GIS method need to calculate accurate of effective parameters on crops and or if many important factors are deleted the results may be inaccuray. The lowest LPP values was found in the map units 3.1 where soil conditions were unfavourable due to high salinity and alkalinity. The higher LPP values was found in northern areas (1.1 and 1.2), where soil physic-chemical peroperties were more suitable than other area.The partly good accordance between estimated yield potential and observed yield potential in GIS method approve that this method has suitable accuracy. One somewhat notable limitation of this method is that it requires a knowledgeable assessment of the relative importance of all factors. This can be carried out to some extent using the pairwise comparison method, but to rate the relative preferences level for two factors using the scale for pairwise comparison still needs priority-setting experience for the specific plant from senior researchers. To set the correct relative preference level without personal bias in this study required not only reliable soil theory information and the writer's experience, but also the experience of a number of senior researchers.

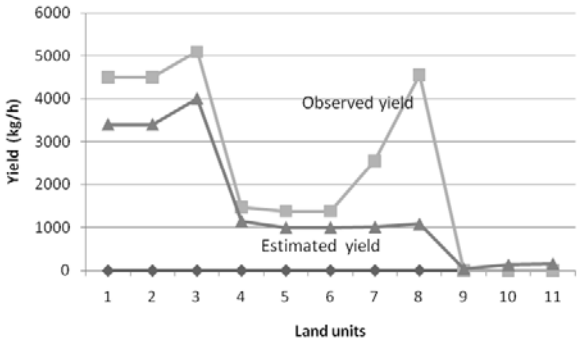

Fig. 4: The graph of observed yield and estimated yield for wheat in land units.

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