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Land use planning in Ahar area (Iran) using MicroLEIS DSS

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A b s t r a c t. The decision support system, MicroLEIS DSS, was applied to evaluate the land use planning in Ahar area, East Azarbaijan. In this way 6 agro-ecological land evaluation models constituents of this DSS software were selected in order to make strategies related to land evaluation at a regional level, such as segregation of agricultural lands, restoration of marginal areas, diversification of crop rotation, and identification of vulnerability areas. Results obtained from each evaluation models are presented and discussed in this research work. Soil morphological and analytical data were collected from 44 soil profiles representative of the study area and stored in SDBm plus database. Three control sections: 0-50, 25-50, and 0-100 cm were calculated by 'soil layer generator' to apply and run the models. Results show that in Ahar area, 45% of the total extension was classified as good capability land for agricultural uses. However, almost 12% of total area must be reforested by suitable shrub species, and not dedicated to agriculture, to minimize the land degradation. Additionally, soils with vertic properties used to present an excellent capability for most of the traditional crops. Wheat-alfalfa-soybean was selected as the best crop rotation. In summary, MicroLEIS DSS tool appears to be useful in semi-arid regions, such as East Azarbaijan (Iran), to formulate sustaining agro-ecological systems.

K e y w o r d s: decision support tools, MicroLEIS DSS; SDBm plus, semi-arid, sustainable use

INTRODUCTION

Agro-ecological innovations are necessary to develop a new and truly sustainable agriculture that reverses environmental deterioration at the same time augmenting the supply of food (Uphoff, 2002). This strategy of future agricultural development is based on similar scientific principles considered by FAO in its Agro-ecological Zoning Project (FAO, 1978) which was a milestone in the history of land evaluation. Technical guides for implementing agro-ecological approaches must be prepared in considerable detail, and localized so that they apply specifically to the geographic site for which they are intended. In this way, research information produced by academic, government, and private organizations must be consistently compiled, evaluated, and formatted for use by specialists and lay people (Arnold, 2004).

A specific agricultural use and management system on land that is most suitable according to agro-ecological potentialities and limitations is the best way to achieve sustainability (FAO, 1978). For example, the Norwegian Soil Information System is being used as a basic instrument for the elaboration of soil tillage maps to reduce soil erosion (Arnoldussen, 2003). The new concept of soil quality as the capacity of a specific kind of soil to function with its surroundings, sustain plant and animal productivity, maintain or enhance soil, water and air quality and support human health and habitation (Karlen *et al*., 1997), based on data collected in standard soil surveys, appears to be the most appropriate framework. The soil physical, chemical, and biological quality is of manifest importance in achieving sustainable agricultural systems, which balance productivity and environmental protection.

Emerging technology in data and knowledge engineering provides excellent possibilities in land evaluation analysis. Such analysis involves the development and linkage of integrated databases, biophysical models, computer programs,

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and optimization and spatialization tools, which constitute the innovative decision support systems (DSS). DSS are computerized technology that can be used to support complex decision-making and problem-solving (Shim *et al*., 2002).

MicroLEIS DSS application in Pampean region of Argentine with special reference to humid or semihumid subtropical climate showed that a conversion of grassland into cropland is the major land-cover process during the last 10 years, accounting for about 28% of increase of cultivated land area (Moscatelli and Sobral, 2005). Also this DSS was applied in Egypt, Africa, for 30 soil units of Newly Reclaimed areas. Taking these results into account, caused to applying an agro-ecological land evaluation decision support system MicroLEIS DSS (De la Rosa *et al.*, 2004) in a new semi-arid region located in Ahar province, NE Iran.

The paper is intended to show the possibilities of using an agro-ecological land evaluation decision support system. The main aim is to point out the best agricultural lands, restoration of marginal areas, diversification of crop rotation and prediction of productivity of area for some selected soils. Soil erosion risk and economical conditions were not considered in this research work.

Combining MicroLEIS DSS results with Geographic Information System (GIS) helps to extract information from the evaluation models (MicroLEIS DSS) to be used and displayed as thematic geo-referenced maps. This level of assessment is where policy decision is usually required (Davidson *et al*., 1994).

In a more operational sense, suitability expresses how well the biophysical potentialities and limitations of the land unit math the requirements of the land use type. Therefore, new investigations must obviously be based on a solid understanding of past studies (De la Rosa and Sobral, 2007).

MATERIALS AND METHODS

This study was performed in Ahar province of East Azarbaijan, Iran, (Fig. 1) which has different kind of land use associated with different parent material such as limestone, old alluvium and volcano-sedimentary rocks. It is about 9000 ha and is located between 47°00′00′′ to 47°07′30′′ E and 38°24′00′′ to 38°28′30′′N. Its slopes range from < 2 to 30%, and the elevation is from 1300 to 1600 m a.s.l. Flat, alluvial plain, hillside and mountain are the main physiographical units in the study area.

Fig. 1. Localization of the study area (East Azarbaijan, IRAN).

Climate data such as mean average maximum and minimum temperatures for each month and total annual precipitation for last 20 consecutive years (1986-2006) were collected from Ahar meteorological station (Table 1). Data were integrated in the CDBm program (De la Rosa *et al*., 1986).

Graphical representation of results for Ahar station using CDBm (Monthly Climate Database) program of MicroLEIS is shown in Fig. 2.

Soil data were extracted from 44 soil profiles representative of Ahar zone. These sample points were identificated applying an exhaustive grid survey method based on geology and slope (Fig. 3).

The multilingual soil database SDBm plus (De la Rosa *et al*., 2003) was used to store and manipulate the large amount of soil data. In this way, it was stored the following input data: field site descriptions and soil profile characteristics; standard soil analytical data and soluble salts data; and soil physical analytical data, especially with reference to infiltration and water retention. Major facilities of the SDBm plus include input, edit, print, selection, and file generation. The 'soil layer generator' option represents a useful interface between the SDBm plus and the land evaluation and geographical information systems. The control section data for applying the models were: 0-50, 0-100, and 25-50 cm.

Following USDA Soil Taxonomy (USDA, 2006) and FAO Soil classifications (FAO, 1976) the dominant soils are classified as Inceptisols (Cambisols), Entisols (Regosols) and Alfisols (Luvisols). Additionally, were obtained 10 soil subgroups. Typic Calcixerepts (Calcaric Cambisols) is the most considerable subgroup (> 53% area).

The applied land use planning decision support system (MicroLEIS DSS; De la Rosa *et al*., 2004), through its 6 land evaluation models, analyses the influence of selected soil indicators on critical soil functions referred to land productivity, agricultural and forest soil suitability, crop growth, and natural fertility.

These empirical-based models were basically developed as sophisticated tools based on artificial intelligence techniques, using soil information and knowledge of the Mediterranean region. Input variables are physical/chemical soil parameters *eg* useful depth, stoniness, texture, water retention, reaction, carbonate content, salinity, or cation exchange capacity collected in standard soil surveys, monthly agro-climatic parameters for long-term period, and agricultural crop and management characteristics. Since the late 1980s, MicroLEIS DSS has evolved significantly towards a user-friendly agro-ecological decision support system for environmentally sustainable soil use and management. The design philosophy is a toolkit approach, integrating many software instruments: databases, statistics, expert systems, neural net-

T a b l e 1. CDBm results, Ahar synoptic station data (1986-2006)

Months	*Tmean* (°C)	*Tmax* (°C)	*Tmin* (°C)	*P* (mm)	ETo(T)	Hui	Ari	GS	Mfi	Aki
January	0.1	4.1	-4.0	18.6	0.1	-	-	-	-	-
February	0	3.3	-5.2	18.0	0	-	-	-	-	-
March	3.0	7.9	-1.9	25.4	9.3	-	-	-	-	-
April	8.3	14.2	2.6	38.2	35.5	-	-	-	-	-
May	12.9	18.9	6.9	58.9	68.2	-	-	-	-	-
June	17.8	24.7	10.9	27.1	102.2	-	-	-	-	-
July	21.0	27.3	14.6	11.5	126.4	-	-	-	-	-
August	22.3	28.6	15.9	8.9	127.7	-	-	-	-	-
September	19.3	25.9	12.8	9.3	95.2	-	-	-	-	-
October	14.5	20.9	8.2	23.7	61.7	-	-	-	-	-
November	8.3	13.3	3.2	34.6	26.8	-	-	-	-	-
December	2.9	7.2	-1.3	20.2	7.3	-	-	-	-	-
Annual	10.8	16.3	5.3	294.4	660.3	0.45	6	8	32	76.1

Tm – mean temperature, *Tmax* – maximum temperature, *Tmin* – minimum temperature, *P* – precipitation, ETo(T) – evapotranspiration calculated by Thornthwaite method, Hui – Humidity index, Ari – Aridity index, GS– growing season, Mfi – Modified Fournier index, Aki – Arkley index.

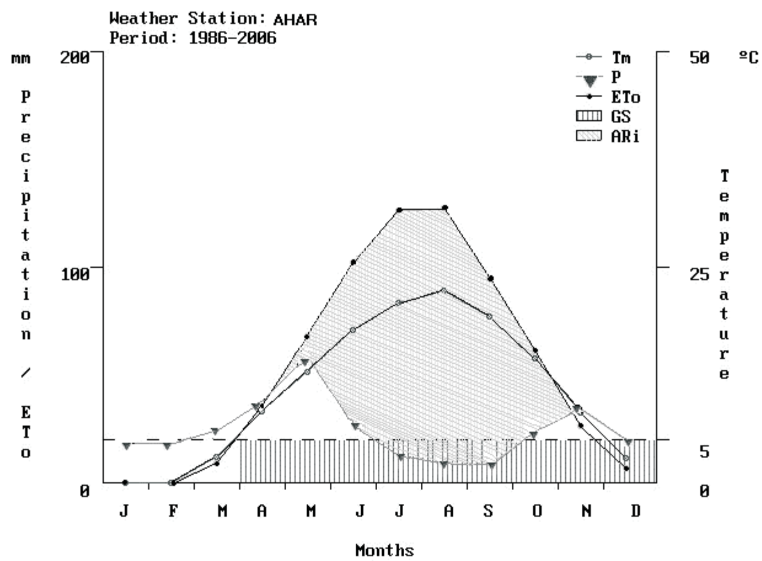

Fig. 2. Climate graphical representation of the study area (current situation). Explanations as in Table 1.

works, Web and GIS applications, and other information technologies. Input data warehousing, land evaluation modeling, model application software and output result presentation are the main development modules of this system.

All the information needed to select the suitable land use and management can be entered separately, hence it is possible to establish the exact soil, climate, and farming conditions.

The MicroLEIS DSS models are described in detail by De la Rosa (1979) and De la Rosa *et al*. (1981, 1992, 1993, 1999), Farroni *et al*. (2002), Horn *et al*. (2002) and Sanchez *et al*. (1982). All the components are available free and ready-for-use from the following Internet site address: www.microleis.com (De la Rosa, 2008).

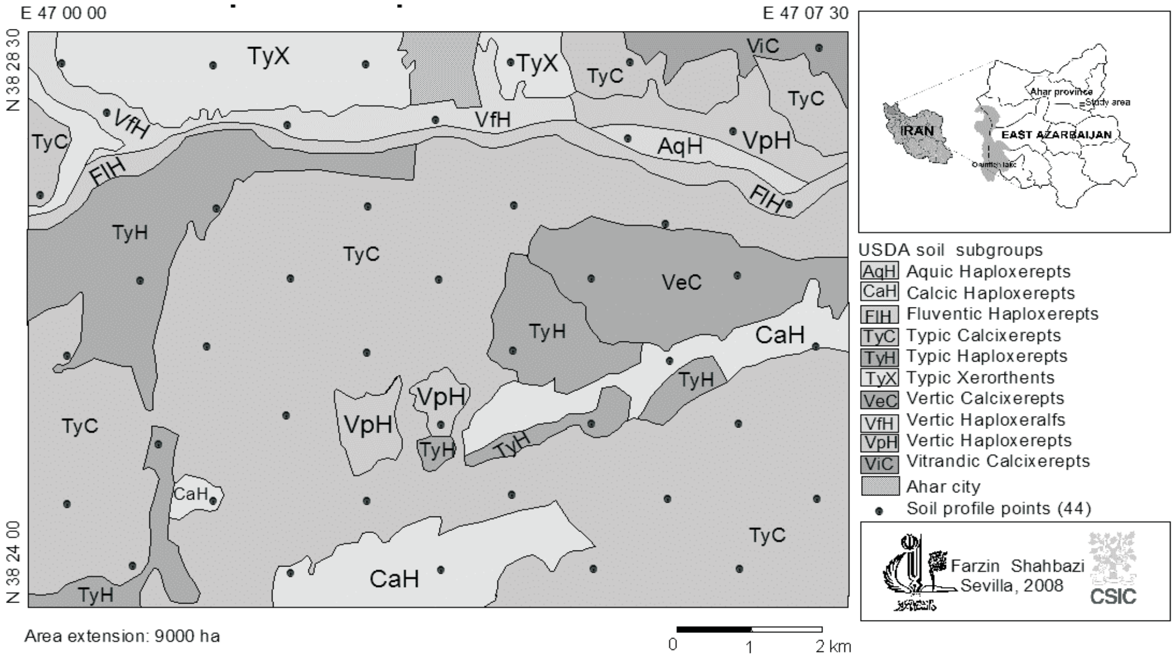

Fig. 3. USDA soil subgroups map of study area.

RESULTS AND DISCUSSION

Land use planning decisions are supported essentially by land capability and land suitability models. Land use planning is generally aimed at a regional level. It can be supported by the application of the following evaluation models of MicroLEIS DSS: Terraza, Cervatana, Sierra, Almagra, Albero, Raizal and Marisma (Table 2), in order to implement strategies for segregation of arable land surfaces, restoration of semi-natural habitats, diversification of crop rotation, and identification of risk areas. But, in this research work soil erosion risk was not evaluated (Raizal model).

For detailed study of soil *eg* this research work, application of MicroLEIS models can be reflected the land properties of the whole natural region of Ahar Province. Therefore, the results of this benchmark sampling points analysis of land use and management can be extrapolated to large geographical areas associated with additional spatialization studies.

Any kind of agricultural management system will have a negative environmental impact when applied on land with very low suitability for agricultural uses.

Results of applying Terraza (bioclimatic deficiency) model and Cervatana (land capability) model in the selected 10 benchmark soil subgroups are shown in Table 3, where dominant classes were presented in each soil.

Eight application soil subgroups are classified as arable or best agricultural lands, and another two as marginal lands. Typic Calcixerepts, Typic Haploxerepts, Vertic Calcixerepts, Vertic Haploxeralfs, Calcic Gaploxerepts and Vertic Haploxerepts present the highest capability for most agricultural crops (S1 class) in 22.8, 7, 5.6, 3.1, 1.83 and 1.43%, respectively. Soil and topography limitation factors are two basic agents to classify Fluventic-Haploxerepts and Vitrandic Calcixerepts subgroups and part of Typic Calcixerepts (2.42%) and Typic Xerorthents (4.84%). 11.75% of the area was distinguished as a marginal lands, that are currently dedicated to agricultural use. Changes in the unusable soil subgroups from natural habitat to intensively tilled agricultural cultivation are one of the primary reasons for soil degradation. Optimum land use will be taken when consider the moderate arable lands as a natural habitat cultivation area. Also, 45% of the study area, was classified as a good capability lands with soil limitation factor. General capability map of study area is shown by Fig. 4.

Several current land uses are entirely wrong with respect to agro-ecological potentialities and limitations. Deforestation for agricultural needs and overgrazing has led to severe erosion in the past. Usually, increasing agricultural land capability correlates with a decrease in the soil erosion process. In summary, a positive correlation between current land use and potential land capability would be necessary (De la Rosa and Van Diepen, 2002).

Results of applying Sierra (forestry land suitability) model in the 2 benchmark soil subgroups previously classified as unsuitable lands, were obtained any forest species communities suitable for the study area. High basic reaction was the major limitation factor. According to these results, it is clear that in many of the marginal agricultural lands, it can be necessary to change the land use system fundamentally – for example, by conversion from arable to forest or pasture. For this, the viability of converting set-aside lands into semi-natural habitats must be evaluated. Therefore, within the framework of the land evaluation decision support system MicroLEIS, a data processing tool (Sierra 2 model)

T a b l e 2. MicroLEIS land evaluation models according to the soil function evaluated and the concrete strategy supported for land use planning

Constituent model	Land evaluation issue (Modelling approach)	Specific strategy supported
Terraza	Bioclimatic deficiency (Parametric)	Quantification of crop water supply and frost risk limitation
Cervatana	General land capability (Qualitative)	Segregation of best agricultural and marginal agricultural lands
Sierra	Forestry land suitability (Qualitative/Neural network)	Restoration of semi-natural habitats in marginal agricultural lands: selection of forest species (61)
Almagra	Agricultural soil suitability (Qualitative)	Diversification of crop rotation in best agricultural lands: for traditional crops (12)
Albero	Agricultural soil productivity (Statistical)	Quantification of crop yield: for wheat, maize, and cotton
Marisma	Natural soil fertility (Qualitative)	Identification of areas with soil fertility problems and accommodation of fertilizer needs

T a b l e 3. Land capability evaluation results from point application of the Terraza and Cervatana qualitative models (De la Rosa *et al*., 1992)

USDA soil subgroups	Approx. extension (ha)	Land capability classes	
		Best agricultural land	Marginal agricultural land
Aquic Haploxerepts	89.1	S2l [a]	
Calcic Haploxerepts	669.8	S2l	
Fluventic Haploxerepts	262.0		S3l
Typic Calcixerepts	4793.5	S2l	
Typic Haploxerepts	1131.4	S1	
Vertic Calcixerepts	504.2	S1	
Vertic Haploxeralfs	278.5	S1	
Vertic Haploxerepts	326.5	S2l	
Vitrandic Calcixerepts	141.7		S3t
Typic Xerorthents	693.0	S2lr	

[a]Land capability classes: S1 – Excellent; S2 – Good; S3 – Moderate; N – Not suitable.
Limitation factors: t – topography: slope type and slope gradient; l – soil: useful depth, texture, stoniness/rockiness, drainage, and salinity; r – erosion risk: soil erodibility, slope, vegetation cover, and rainfall erosivity; b – bioclimatic deficiency (GPL) without considering the frost risk.

was developed for evaluating the relative suitability species. In this way, the input variables considered for modeling and application analyses can be grouped in three categories: soil, climate and site data (Heredia, 2007). Sierra 2 model application results are summarized by Table 4.

Regarding on shrub species, Mastic tree (*Pistacia lentiscus* L.) is the most-viable species for reforestation, which appears in whole areas. It is interesting to note the different number of viable tree species in comparison with the number of viable shrub species predicted for whole soil subgroups, which appears to be due to the different influence of the soil factor useful depth and its humidity.

In order to adopt also agro-forestry strategies, the land evaluation results of Sierra model can be combined with those predicted by the Almagra model for selecting the best combination of trees and crops to produce maximum environmental benefits in each particular soil units.

Results of applying the Almagra (agricultural soil suitability) model in the 8 benchmark soil units previously classified as agricultural lands are shown in Table 5.

For this qualitative model, matching tables following the principle of maximum limitation for soil factors are used to express soil suitability classes for 12 Mediterranean crops. In this research work, only 7 typic and traditional crops were selected. The control or vertical section for measuring texture, carbonates, salinity and sodium character was established by adapting the criteria developed for the differentiation of Families and Series in the Soil Taxonomy. For annual crops, control section is between surface to 50 cm in depth, or between surface to the limit of useful depth when the latter is between surface and 50 cm. For semi-annual and perennial crops, control section range is between surface and 100 cm in depth.

Aquic Haploxerepts has high suitability for all of the selected crops except wheat. Carbonates and salinity are the major limitation factors in cultivation of maize and soybean. 48.89% of Typic Calcixerepts area has optimum soil suitability for cultivation of wheat, soybean and alfalfa. While, 10.83% of Calcic Haploxerepts area has had the same suitability. Generally, the excessive content of carbonates in soils is the limiting factor which more appears at the evaluation. Wheat (*Triticum aestivum*), soybean (*Glycine max*.) and alfalfa (*Medicago sativa*) are the most-suitable crops for most of the units. Wheat, maize and potato did not show any subclasses that it was affected by useful depth, drainage and profile development. While, in some part of study area the pointed factors are the main limitation factors in development of peach crop. So, in 30.62% of total area, cultivation of peach (perennial crop) can be recommended. Land suitability classification map of wheat, alfalfa and peach are represented in examples of annual, semi-annual and perennial respectively for the study area (Fig. 5).

Results from Almagra model were combined with GIS (ArcView 3.2). This shows that 26.43%, 55.78% and 5.04%

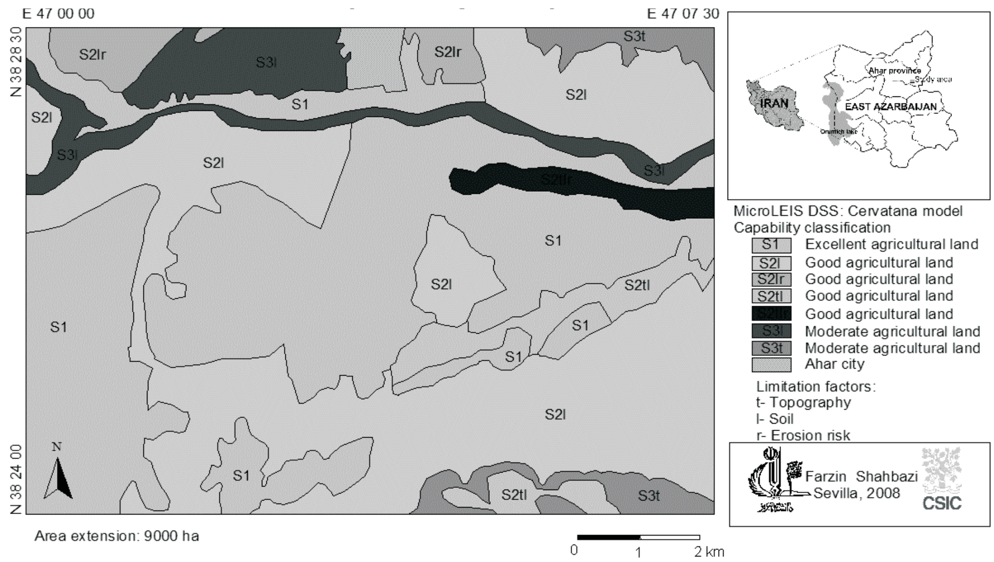

Fig. 4. General capability map of study area.

T a b l e 4. Reforestation results from point application of the Sierra2 model to the marginal agricultural lands (Heredia, 2006)

Benchmark soil subgroups	Viable shrub species
Typic Xerorthents	Esparto (Stipa tenacissima), Broom-like-kindery-vetch (Anthyllis cytisoides), Dentate lavender (*Lavandula dentate* L.), Mastic tree (*Pistacia lentiscus* L.) Lygos (*Retama sphaerocarpa*), Rock rose (*Cistus albidus* L.)
Vitrandic Calcixerepts	Esparto (*Stipa tenacissima*), Broom-like-kindery-vetch (*Anthyllis cytisoides*), Dentate lavender (*Lavandula dentate* L.)
Fluventic Haploxerepts	Dentate lavender (*Lavandula dentate* L.)
Typic Calcixerepts	Esparto (*Stipa tenacissima*), Broom-like-kindery-vetch (*Anthyllis cytisoides*), Rock rose (*Cistus albidus* L.)

T a b l e 5. Soil suitability evaluation results from point application of the Almagra model to the best agricultural lands (De la Rosa *et al.*, 1992)

Benchmark soil subgroups	Soil suitability classes						
	Wheat	Maize	Potato	Soybean	Sugar beet	Alfalfa	Peach
Aquic Haploxerepts	S1b	S2c	S2tcs	S2s	S2a	S2sa	S2tdcsag
Calcic Haploxerepts	S2t	S2tc	S2tc	S1	S2t	S1	S2tdcg
Typic Calcixerepts	S2t	S2tc	S2tc	S2t	S2ta	S2t	S4t
Typic Haploxerepts	S2t	S2tc	S2tc	S2t	S2ta	S2t	S4t
Typic Xerorthents	S3t	S3t	S3t	S3t	S3t	S2c	S2pt
Vertic Calcixerepts	S2t	S2tc	S2tc	S2t	S2ta	S2t	S4t
Vertic Haploxeralfs	S2ta	S2tca	S2tsa	S2tsa	S2t	S2tsa	S4t
Vertic Haploxerepts	S2t	S2tc	S3t	S2ts	S2ta	S2tsa	S4t

Soil suitability classes: S1 – optimum, S2 – high, S3 – moderate, S4 – marginal, S5 – not suitable. Soil limitation factors: p – useful depth, t – texture, d – drainage, c – carbonate content, s – salinity, a – sodium saturation, g – profile development.

T a b l e 6. Summary of land suitability classification results (% of the total area) using Almagra model

Suitability classes*	Wheat	Maize	Potato	Soybean	Sugar beet	Alfalfa	Peach
S1	26.43	2.03	0	22.36	0	19.59	0
S2	55.78	80.18	66.71	59.85	84.21	62.36	31.61
S3	5.04	5.04	20.54	5.04	3.04	5.30	16.57
S4	0	0	0	0	0	0	37.85
S5	0	0	0	0	0	0	1.22

*Explanation as in Table 5. 1% of total area is occupied by Ahar city, 11.75% of total area is recommended for reforestation (see Table 4).

of the total area has optimum, high and moderate suitability respectively for cultivation of wheat. Soybean and alfalfa have very nearly suitability situations to wheat. Potato, Sugar beet and peach don't have any optimum suitability class. Therefore, the best crop rotation in the study area can be presented by wheat, soybean and alfalfa. Considering the maize suitability classification from Almagra model, this crop can be added to the crop rotation cycle. The final result of crop diversification is shown in Table 6.

Albero model deals with the characteristics of a quantitative system of evaluation of soil productivity, making use of computerized multiple regression techniques. It is a first approach to predicting productivity of the following crops: wheat, maize and cotton, based on a limited number of soil properties. But, in this research work, it was applied for wheat and maize. The productivity index calculated by application of the Albero (statistical regression model; Table 7) demonstrates the optimum soil physical/chemical quality of the Vertic Haploxeralfs and Vertic Haploxerepts (Vertic properties). While, Typic Xerorthents has had the less productivity index.

Table 8 shows the results of applying the Marisma (soil fertility capability) model in the 8 agricultural benchmark units. This model gives special emphasis to the soil chemical quality, but also considers several soil physical parameters related with the textural class.

Typic Calcixerepts has very variable fertility classes and some management practices such as protecting from loss of surface soil, flush of nitrogen at beginning of the rainy season, not to applying rock phosphate, *etc*.

4.93% of Typic Haploxerepts and 3.41% of Calcic Haploxerepts area present the greatest difficulties for management and to be care must be taken not to work when wet.

In 27.33% of area surface crusting if more than 30% silt; 19.95% protect from loss of surface soil; 23.69% alkali conditions, leach with Ca salts to prevent dispersion; and in whole of the soil units flush of nitrogen at beginning of the rainy season is necessary to achieve the best land use planning and finally sustainable agriculture. More details are shown in Fig. 6.

a

b

c

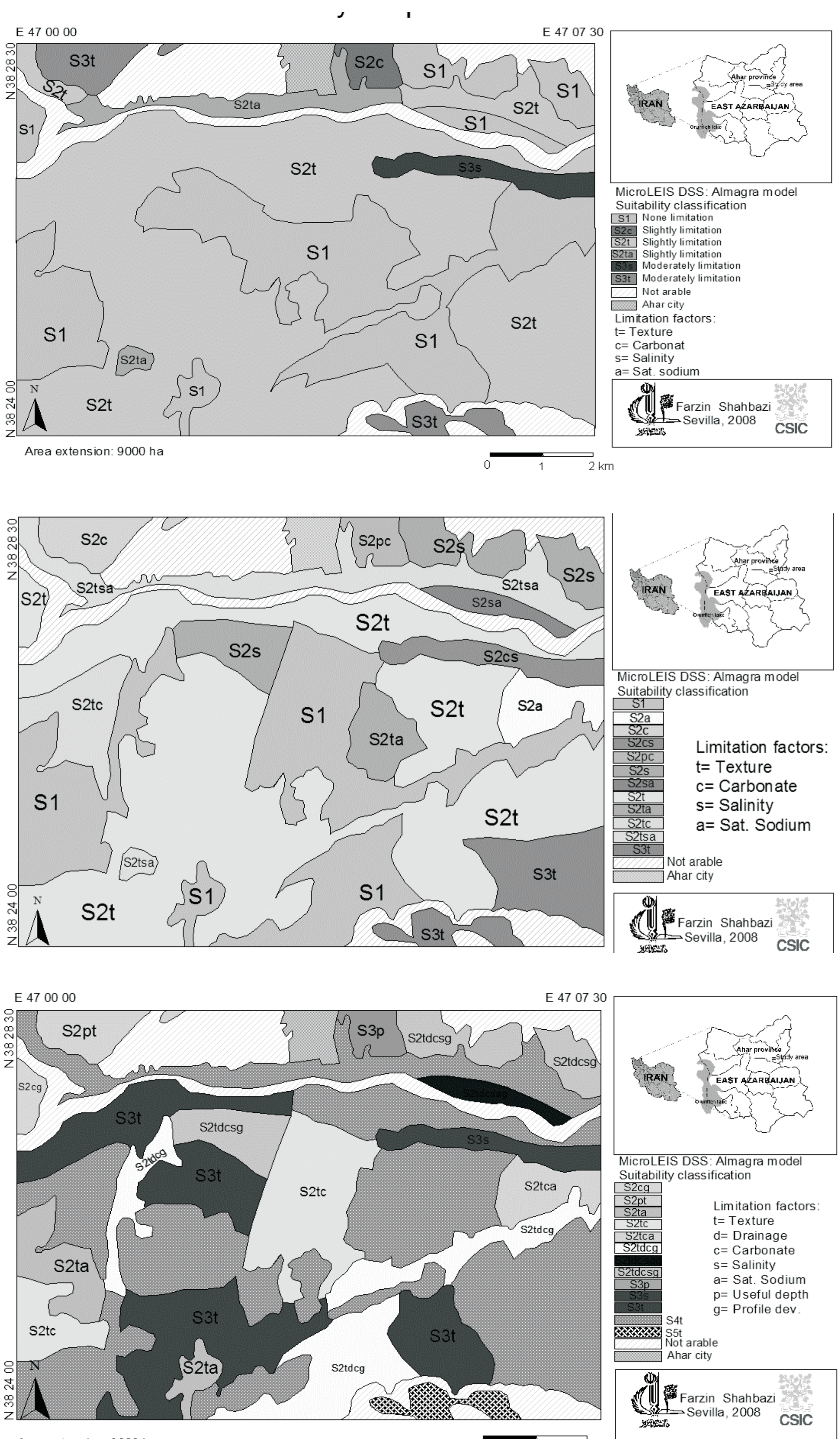

Fig. 5. Land suitability map of: a – wheat, b – alfalfa, and c – peach for Ahar province.

Table 7. Agricultural soil productivity evaluation results from point application of the Albero model to the best agricultural lands (De la Rosa *et al*., 1981)

Benchmark soil subgroups	Wheat		Maize	
	Predicted yield ($t\ ha^{-1}$)	Appr. extended area (ha)	Predicted yield ($t\ ha^{-1}$)	Appr. extended area (ha)
Aquic Haploxerepts	4 - 4.5	89.1	6.5 - 7	89.1
Calcic Haploxerepts	4.5 - 5	237.3	6.5 - 7	393.8
Typic Calcixerepts	3.5 - 4	3000	6.5 - 7	2058
Typic Haploxerepts	3.5 - 4	800	7 - 7.5	784
Typic Xerorthents	2.5 - 3	257	6 - 6.5	164
Vertic Calcixerepts	3.5 - 4	324.2	7.5 - 8	324
Vertic Haploxeralfs	4.5 - 5	280	8 - 8.5	280
Vertic Haploxerepts	5 - 5.5	198	7.5 - 8	198

Table 8. Soil fertility capability evaluation results from point application of the Marisma model to the best agricultural lands

Benchmark soil subgroups	FCC classes	Diagnostic report
Aquic Haploxerepts	LCdbn	Surface crusting risk; protect against soil loss; free carbonate material in soil surface; water deficit in the growing period
Calcic Haploxerepts	CCdbn	Care must be taken not to work when wet; Protect against soil loss; Possible flush of N; free carbonate material in soil surface; alkali conditions; leach with Ca salts to prevent dispersion.
Typic Calcixerepts	LLdb	Surface crusting risk; good subsoil texture; Possible flush of N; free carbonate material in soil surface
Typic Haploxerepts	LLdb	Surface crusting risk; good subsoil texture; Possible flush of N; free carbonate material in soil surface
Typic Xerorthents	SSdb	Surface leaching of nitrates; low subsoil water holding capacity; Possible flush of N; free carbonate material in soil
Vertic Calcixerepts	CCdbn	Care must be taken not to work when wet; Protect against soil loss; Possible flush of N; free carbonate material in soil surface; alkali conditions; leach with Ca salts to prevent dispersion
Vertic Haploxeralfs	CCdbn	Care must be taken not to work when wet; Protect against soil loss; Possible flush of N; free carbonate material in soil surface; alkali conditions; leach with Ca salts to prevent dispersion
Vertic Haploxerepts	SCdbsn	Surface leaching of nitrates; protect against soil loss; Possible flush of N; free carbonate material in soil; leach with Ca salts to prevent dispersion; leaching with drainage is recommended

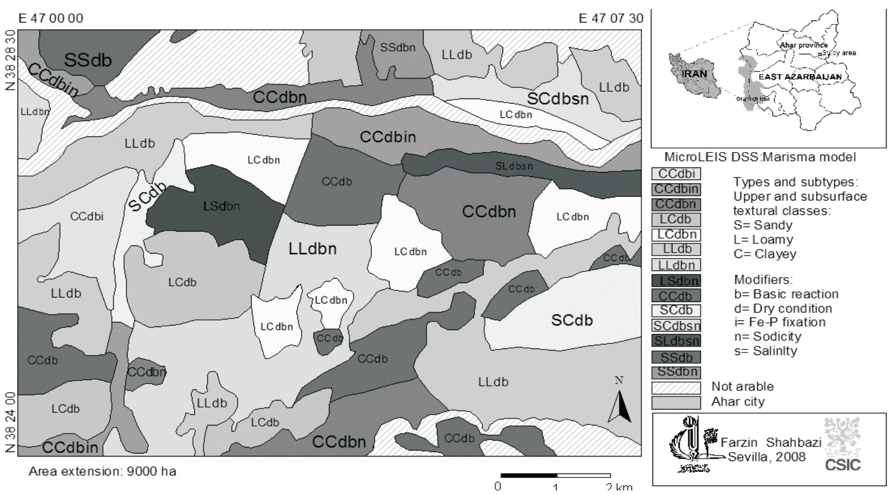

Fig. 6. Fertility capability classificatin map of Ahar province.

CONCLUSIONS

1. In Ahar area, 45% of the total extension was classified as good capability land for agricultural uses. However, almost 12% of total area must be reforested by suitable shrub species, and not dedicated to agriculture, to minimize the land degradation.

2. Soils with vertic properties used to present an excellent capability for most of the traditional crops. However, the maximum care must be taken to apply an appropriate agricultural management system in these soil types.

3. Wheat-alfalfa-soybean was selected as the best crop rotation. Also, maize can be added to this crop rotation.

4. Peach garden expanding as a perennial crop was recommended only in the 30% of the total area, being heavy texture the major limitation factor in this case.

5. Agricultural lands identification, according to its own ecological potentialities and limitations, is the first major objective of land use planning. At the same time, the second major objective is to predict the inherent suitability of each soil unit for supporting a specific crop over a long period of time. In a particular area, both complex tasks can be developed through agro-ecological land evaluation analysis such as by using MicroLEIS DSS.

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