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Potential land use planning and assessment in the west part of the Büyük Menderes basin by ILSEN Model

Mustafa Bolca *, Fulsen Özen, Yusuf Kurucu, Ünal Altınbaş
Burçin Çokuysal, Sezai Delibacak

Ege University Faculty of Agriculture, Department of Soil Science and Plant Nutrition, 35100, İzmir, Turkey

Abstract

This research was planned to investigate the structural properties and soil mapping capability according to rules of the 7. Approximation Soil Taxonomic System of the region western part of the Büyük Menderes Basin by using Landsat satellite images in remote sensing technique. The data gathered from field observation about some soil properties and land requirements of different land use types were correlated and as a result of that the boundaries of land use patterns were carried out. Land use patterns were detected according to suitable land use classes for soil mapping units and potential land use map were done.

Land use assessment is likely to be the prediction of land potential for productive land use types. This case is great important in guiding decisions on land uses in terms of potential and conserving natural resources for future generations. The main objective of this study was to determine land resources and to assess potential land use in the west part of the Büyük Menderes Basin of Aegean region. The study area covers about 24.300 km^2 and formed on alluvial material deposited by Büyük Menders River. Using Landsat 5 TM satellite images, which cover back and foot slope of mountain and alluvial plains of the western part of Menderes Basin, and taking physiographic units of the region as basis, detailed soil series and phases were determined. Soils of the region were classified as Entisol, Inceptisol as 2 orders, 4 suborders, 4 great groups and 6 sub groups, and 10 series. Twenty-five different land utilization types grouped into 4 major land use groups were evaluated for the studied area's soils. ILSEN computer model was used to determined potential land use groups and suitable classes for agricultural uses.

In addition, ArcGIS software was used to generate their maps and database. Suitability map for agricultural uses results showed that, distributions of the best, relatively good, problematic and restricted agricultural lands were 31,68%, 22,63%, 22,16% and 23,53% respectively. Only 31,68% of the study area has the best land for agricultural uses. The main plant growth limitation soil factors are shallow soil depth, high slope, subsurface stoniness, poor drainage, heavy and coarse sub surface soil texture and low water retention capacity.

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Introduction

The main objective of this research was to determine potential land use in Büyük Menderes Basin of Agean region ILSEN model and GIS technique. Improvement of the agricultural product, which is necessary for human life, is related to use of agricultural area in a well design land use planning or managing system.

* Corresponding author.
Ege University, Faculty of Agriculture, Department of Soil Science and Plant Nutrition, 35100 Bornova, İzmir, Turkey
Tel.: +902323112686 Fax: +902323889203 E-mail address: mustafa.bolca@ege.edu.tr
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Basically, a detailed soil map is necessary for a well-designed land use plan. Many of methods have being used for carrying out the soil properties and drawing boundary of soil groups.

Özcan (2006) stated that all lands can be used for almost all purpose if sufficient inputs are supplied and illustrate land evaluation is a process of matching based on a series of selected land qualities and comparison of them with land use requirements.

The land resources regeneration is very slow while the population growth is very fast, leading to an unbalance. Potential land use assessment is likely to be the prediction of land potential for productive land use types. This case is great important in guiding decisions on land uses in terms of potential and conserving natural resources for future generations. Therefore, careful planning of the use of land resources is based on land evaluation, which is the process of assessing the suitability of land for alternative land uses (Fresco et al, 1994).

Land evaluation is concerned with the assessment of land performance when used for a specified purpose (FAO, 1977). In other words, land evaluation is likely to be the prediction of land potential for productive land use types, and then generally a comparison or match of the requirements of each potential land use with the characteristics of each kind of land. Şenol et al. (1996) prepared a database for the Agricultural Research and Implementation Farm of Çukurova University, using geographic information systems (GIS), and evaluated the land use by means of the ILSEN computer model. In addition, Ali and Sato (2001) also stated that GIS and RS may play a vital role at the stages of exploration and analysis of local resources, planning and evaluation. Başayiğit and Şenol (2001) used the Şenol land evaluation method and the ILSEN computer model to evaluate Türkgeldi state farm soils agricultural and nonagricultural uses. The detailed soil survey maps and report on the Türkgeldi state farm was interpreted and eight different land characteristics and 30 different sub-level land utilization types were used in the research. In appropriate land uses were observed, and the importance of land use planning was emphasized. Besides, Dengiz et al. (2003) were carried out an investigation in Baypazarı area soils using ILSEN and GIS techniques to determine land resources and to evaluate land utilization types and their suitability. According to their results, the suitability map for agricultural uses results showed that 42.8% of the study area soils were not suitable for agricultural use and that 90.4% of these soils are classified as lithic xerorthents. Only 12.7% of the study area soils were found to be highly suitable for agricultural uses.

Tunçay et al. (2011) aim to determine the suitability and land use variations of the fields considering the characteristics of the soils in Kirşehir Çiçekdağ-State Farm. In the study, ILSEN computer model was used for the determination of the potential groups of land use and agricultural land suitability, as well. According to the data of the land use suitability maps, 4.16% of the soils were classified as the best agricultural lands, 9.46% highly good, 42.51% problematic, and 38.27% suitable only for limited use and 5.60% unsuitable for agricultural use.

Wahba et al. (2007) This study is qualitative evaluation for the actual soil parameters to realize a precise and objective interpretation for the area under consideration and its suitability for a wide range of crops. It can be concluded that the most effective soil parameters that influence the suitability classification in the studied area are soil texture, drainage condition and sodium saturation. Their crops suitability calculated on the basis of the proposed computer program "MicroLEIS" and presented as planning agricultural soil suitability maps. Twenty-eight soil profiles have been selected to represent the variation in the soils of the studied area. According to the morphological description, climatic conditions, physical & chemical properties and USDA Soil Taxonomy, the soil can be classified as the following: *Typic Calcigypsids*, *Calcic Aquisalids, Gypsic* and *Calcic Aquisalida*, *Typic Torripsaments* and *Typic Quartzipsamments.* The obtained results reveal that the evaluated crops could be determined and arranged according to their soil suitability classes as follows: olives < peach < sunflower, melon and corn.

Material and Methods

Field description

This study was carried out in the west part of the Büyük Menderes Basin of Agean region. With an area of 24.300 km^2 in the west part of the Büyük Menderes basin in the Aegean Region, between 37^{o} 20'-37^{0} 56', North latitudes, 27^{0} 6'-28^{0} 24' East longitudes. It has an appearance of a graben plain formed as a result of tectonic events. (Fig. 1). Its lies at an elevation from sea level 0-350 m.

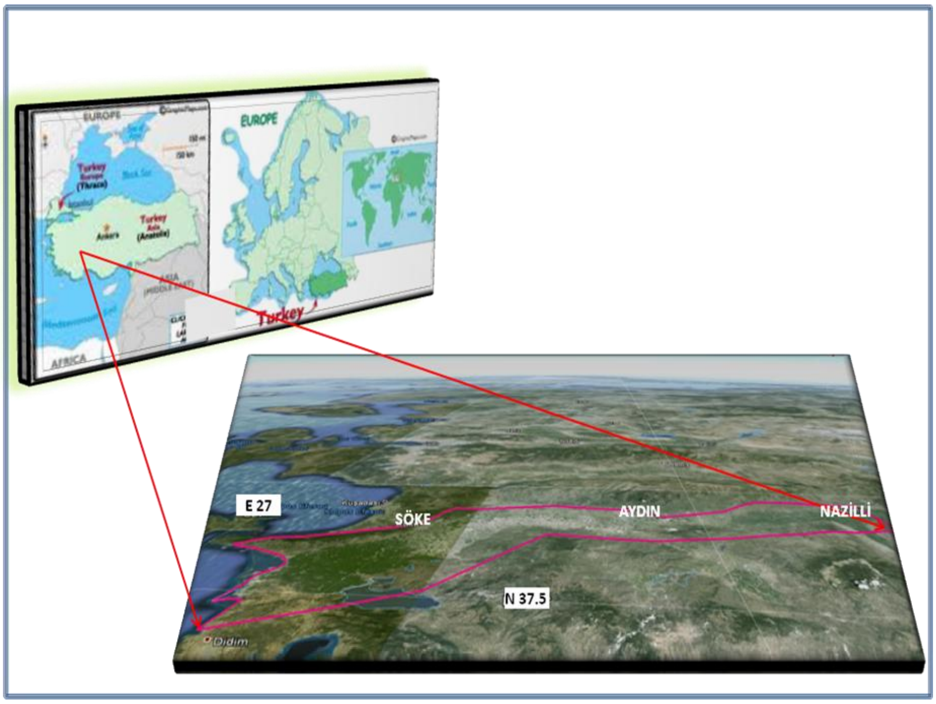

Figure 1. Location map of the study area

Research area is located in south of Izmir in the west side of Turkey, which has semiarid climatic condition and Xeric soil moisture regime. According to last 30 years meteorological data total amount of rain (average) per year 701mm/m^2, temperatures are 7.6 ^{o}C in January, 25.9 ^{o}C in June and evapotranspiration 7.1mm in June. In this context, on the land which our study covers, types of land such as mountainous, valley and piedmont, slope, basin, alluvial fan, low glacie, over flow montle and such as levee physiographic units were determined in Soil Taxonomy (1999). Flat land of the study area has been under intensive agricultural activities. Cotton, wheat, sunflower, strawberry, maize, pepper, watermelon, cucumber and tomato, citrus, olive, clover, cabbage and leek have been produced in the study area. The main water resource to this area is Büyük Menderes River. The study area has been commonly used for irrigated agriculture. Presently, the irrigation systems used by farmlands are furrow, drip and sprinkler irrigation systems

Method

Soil and land classification process, soil and environmental features are classified according to Soil Survey Manuel (U.S.D.A., 1981) principles. Land evaluation was made according to features which lands have and according to rules of FAO(1977), (Şenol, 1995) (Table 1).

Table 1. Distribution of land mapping units (LMUs) and soil series of the study area

Type of Land	**Physiographic Unit**	**Parent Material**	**Soil Series**	**Soil Taxonomic Unit**	**Land Mapping Units**
Mountainous	Slope	Micaschist	Yazırlı	Lithic Xerorthent	DYY
		Regolith	Moralı	Typic Xerorthent	DYM
Piedmont	Low glasi	Kolluvium	Aslanlı	Typic Xerorthent	PGA
	Alluvial fan	Alluvium	Bağarası	Typic Xerorthent	PFB
Valley	Basin	Alluvium	Yenipazar	Typic Xerofluvent	VBY
			Karahayıt	Aquic Xerofluvent	VBK
			Dereköy	Vertic Fluvaquent	VBD
	Over flow montle	Alluvium	Köşk	Typic Xerofluvent	VTK
			Balat	Typic Halaquept	VTB
	Levee	Alluvium	Menderes	Typic Xerofluvent	VSM

Land evaluation system developed in the light of the FAO's (1977) principles by Senol (1994) and a PC-compatible ILSEN package program developed by Şenol and Tekes (1995) were used in the quantitative assessment of the agro-ecological evaluation in the study area for the land use types (LUTs) of horticultural lands (for fruit and vegetable), field crop land, and non-agricultural area. A digital soil database was prepared by entering the diagnostic characteristics (depth, texture, available water capacity, slope, erosion, calcium carbonate, stoniness, organic matter, pH, EC,) for each land-mapping units (LMUs). Total 14 LMUs were determined from digital soil database. In addition, a total of 30 different LUTs were distinguished and their land use requirements (LURs) were determined by using related information and available digital soil data (Table 1, Fig. 2).

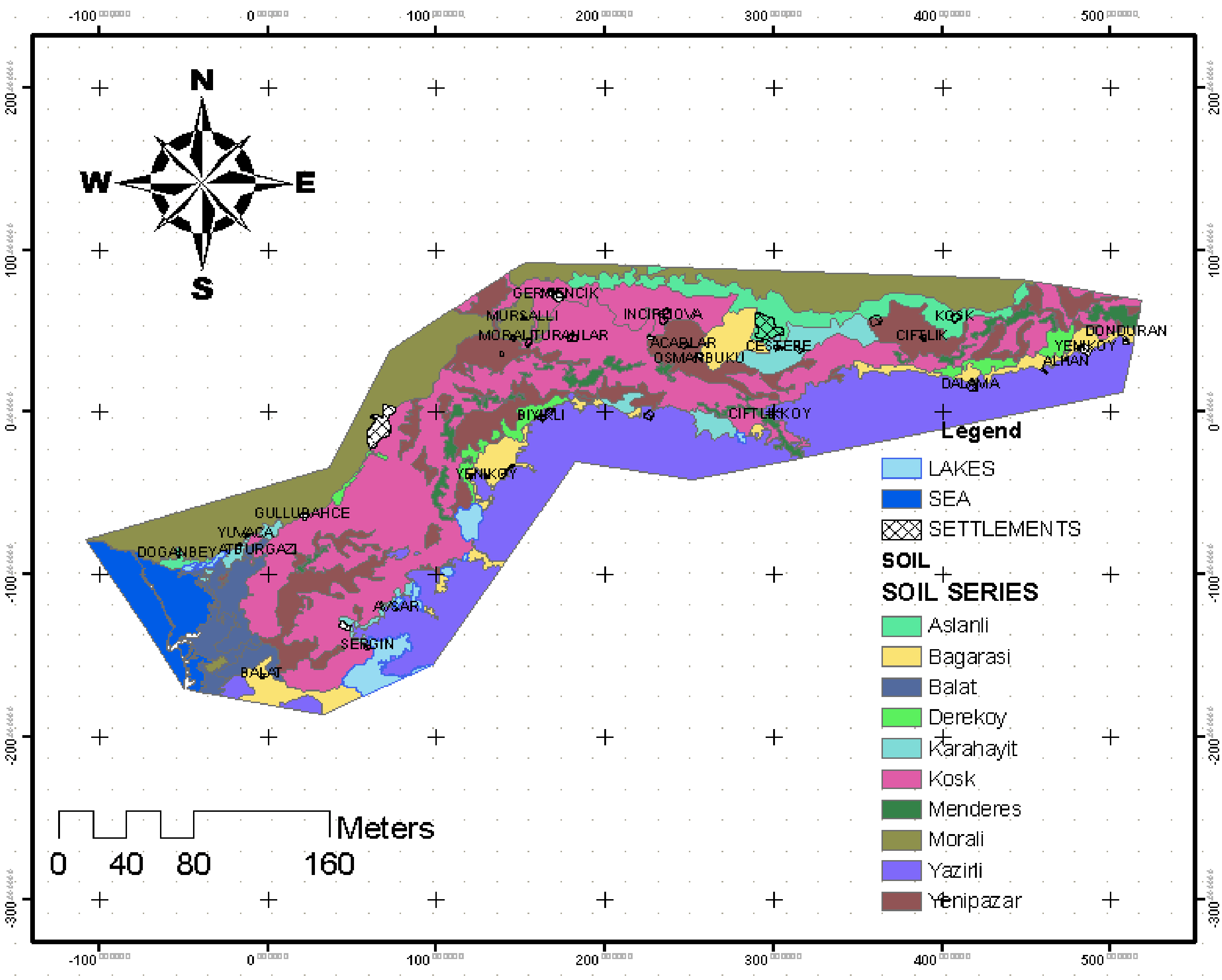

Figure 2. Distribution of land mapping units (LMUs) and soil series of the study area

Land suitability (LS) is a function of a set of LURs determined for LUTs ($LURs_{LUTs}$) and a set of land characteristics (LCs) measured for LMUs (LCs_{LMUs}) as flows: $LS_{LMUs\ for\ LUTs} = f\ \{LCs_{LMUs}, LURs_{LUTs}\}$. The land suitability index (LSI) of the LMUs for each LUT was calculated using the multiplicative combination of suitability rating index (SRI) as flows;

$$LSI_{LMUx\_LUTy} = \prod_{i=1}^{n} SRI_{LCi\_LMUx\_LUTy},\ LCi \in [\,0....1]$$

where; LSI values show the degree to which the requirements of the LUTs matched each LMU. LSI values were also expressed rating scale of suitability classification for each LUT. At the same time, all LCs were standardized according to the common scale [0....1]; the least beneficial value of LC is 0, and the most beneficial value of LC is 1. In other words, the limiting nature of each LCs is taken into account by its effect in reducing productivity. During agronomic analysis, the higher SRI values represented the greater suitability of LMUs for each LUT, namely, the suitability of each identified LMU and LUT was assessed using ILSEN computer model to generate Land Suitability Index (LSI) and suitability class for LUTs presented in Table 2.

Table 2. Land Suitability Index (LSI) and Suitability Class for LUTs.

LSI	Symbol	Suitability classes
1.00-0.90	S1	Highly suitable
0.89-0.75	S2	Moderately suitable
0.74-0.50	S3	Marginally suitable
0.49-0.25	N1	Currently not suitable
0.24-0.00	N2	Permanently not suitable

Furthermore, digital soil map databases which were examined for input data using ILSEN software for suitability ratings for agricultural uses (Table 3)

Table 3. Suitability class for agricultural use

Relative LMU index	Symbol	Classes
1.00-0.90	C1	Best
0.89-0.75	C2	Relatively good
0.74-0.50	C3	Problematic
0.49-0.20	C4	Restricted
0.19-0.00	C5	Non-agricultural

In the final process of the land evaluation, using the ILSEN computer model, a suitability map for agricultural use was obtained. The results, obtained from the ILSEN computer model, were added to the soil database for each LMU. These values were used to generate a potential land use groups map and a suitability map for agricultural use using GIS.

Results and Discussion

Land evaluation is the process of predicting land performance over time according to specific types of uses. Baja et al. (2002) were determined a methodological framework of land resource assessment. The model developed uses two primary sub-models (modules): remote sensing based land use classification, and land suitability assessment. The first module uses Landsat 7 ETM+ images to produce a land use/land cover map of the study area. A **site-specific** framework was developed for use in thematic information extraction involving the use of visual analysis, spectral-based (automated) procedures, and ancillary information. The second sub-model implements a fuzzy set methodology, and uses soil landscape data sets and a Digital Elevation Model as evaluation criteria. A test case is presented to map the spatial distribution of runoff Curve Number (CN) using soil landscape data, which were also used for land suitability evaluation, along with existing land use/land cover information.

Recatala´ Boix and Zinc (2008) stated that their study proposes alternatives to the mono cropping of soybean with the aim to help farmers make adequate decisions on land use and management under deteriorating environmental conditions and for addressing the issue of competitive land uses in the context of land-use planning. Land suitability was assessed using the Food and Agriculture Organization (FAO) framework for a set of crops ecologically adapted to the area, including soybean, maize, wheat, sugarcane, citrus, and safflower. Major limitations for cropping are low annual rainfall and flooding in the east of the study area, and sloping topography and flooding in the west. Zhang et al. (2012) stated that this study centers around two important issues in land use planning: land use allocation and specific land use proposal deliberation. A Conflict Resolution Framework was proposed based on GIS and Multi-criteria Decision Analysis techniques. A Consensus Building Model was established to address the conflicts among different stakeholders with competing interests in the process of land use allocation. The both models were tested and evaluated in the context of Lantau, Island Hong Kong. Moreover, the challenges of this research and future work are also covered in this research. Akbulak (2010) also stated that, land suitability analysis of the upper basin of the Kara Menderes River was carried out, which drains the Biga Peninsula, west of the Marmara Region in Turkey, on the basis of geographical information systems and analytical hierarchy process, a technique used for multi-criteria decision making studies. After the determination of suitability in terms of the main three land use types, i.e. agriculture, meadow-pasture and forest, an optimal land use map was produced and results were compared to the present-day land use situation. Zengin and Yılmaz (2008) stated that optimal land-uses in convenience with the ecological structure in the close proximity of the river of Kura, Ardahan, which has diverse and untouched reserve values, were determined. In the study area, natural and cultural reserve values were studied in detail in the determination of the land-uses, and ecological suitability charts for seven different land uses including Agricultural, Rangeland, Pasture, Forest, Settlement, Tourism and Recreation and Conservation areas were prepared.

Land evaluation is the process of predicting land performance over time according to specific types of uses (Van Diepen et.al., 1991; Rossiter, 1996). Here, land evaluation is expected to be the prediction of land potential for productive LUTs, and generally the comparison or match of the requirements of each potential land use through the characteristics of each type of land. Therefore, it is necessary to evaluate the arable land in order to select or determine the best land use types. All of the LUTs were automatically spread to land use groups (Table 4) using the ILSEN model for each kind of LMU to determine Potential Land Use Groups (PLUG). The outputs results from ILSEN computer model added to the soil database. These values were used to generate PLUG map that was given in Table 5 and Figure 3 and Suitability Map for Agricultural Uses was given Table 6, Figure 4 and Figure 5. The distribution of irrigated agriculture suitability for vegetables results showed that 23,53% of the study area soils were not suitable for any type of irrigated agricultural applications (S0). These soils were classified as Lithic Xerorthent. 47,16% of the study area soils were suitable for all of the irrigated agriculture land use types (S6) (Table 5). In addition, The distribution of land use groups for field crops results showed that 23,53 % of the study area soils has not suitable into any of use type for this group (T0). As far field crops, All most half of the study area soil (48,81%) has suitable for field crops selected land use types (T5). These types of land uses have commonly been applied on Entisol.

Table 4. Land use types of groups distributed by ILSEN program

1. Land Use Groups for (vegetables) Horticultural Crops (S)
S0: Does not suitable into any of use type for this group were taken into consideration (not suitable for this classification)
S1: Tomato, Spinach, Cabbage
S2: Peppers, tomatoes, beans, melons, cabbage, eggplant
S3: Peppers, Tomatoes, Beans, Melons, Spinach, Cucumber, Cabbage, Eggplant
S4: Peppers, Tomatoes, Beans, Melons, Spinach, Lettuce, Cabbage, Eggplant
S5: Peppers, Tomatoes, Beans, Melons, Spinach, Lettuce, Cucumber, Cabbage, Eggplant,
S6: Peppers, Tomatoes, Beans, Melons, Spinach, Lettuce, Cucumber, Cabbage, Eggplant, Strawberries
2. Land Use Groups for (fruit) Horticultural Crops (M)
M0: Does not suitable into any of use type for this group were taken into consideration (not suitable for this classification)
M1 :Olive
M2 :Olive, Fig
M3 : Olive, Apple, Plum, Almond, Fig
M4 : Olive, Citrus, Apple, Apricot, Plum, Almond
M5 : Olive, Citrus, Fig, Apple, Apricot, Plum, Almond
M6 : Olive, Citrus, Fig, Apple, Apricot, , Pear, Plum, Almond
M7 : Olive, Citrus, Fig, Apple, Apricot, , Pear, Plum, Almond, Walnuts,
M8 : Olive, Citrus, Fig, Apple, Apricot, Peaches, Pears, Cherries, Plums, Almonds, Walnuts,
3. Land Use Groups for Field Crops (T)
T0 : Does not suitable into any of use type for this group were taken into consideration (not suitable for this classification)
T1 : Wheat,
T2 : Wheat, Barley
T3 : Corn, Wheat, Corn, Barley
T4 : Cotton, Corn, Wheat, Clover, Peas, Barley
T5 : Cotton, Wheat, Tobacco, Corn, Clover, Peas, Barley
4. Land use Groups for Non-Agricultural (D)
D0 : Does not suitable into any of use type for this group were taken into consideration (not suitable for this classification)
D1 : Natural Life, Recreation, Pasture, Maki
D2 :Natural Life

Table 5. Distributions of the potential land use groups for each LMUs

LMUs	POTENTIAL USE GROUPS				AREA (ha / %)	
DYY	S0	M2	T0	D1	5416,88	23,53
DYM	S2	M8	T1	D1	35354,76	15,18
PGA	S3	M8	T2	D0	9556,68	4,10
PFB	S4	M8	T3	D0	11603,72	4,98
VBY	S6	M8	T5	D0	29341,68	12,60
VBK	S6	M4	T5	D0	6703,07	2,88
VBD	S5	M2	T5	D0	3849,79	1,65
VTK	S6	M8	T5	D0	68269,19	29,31
VTB	S2	M3	T4	D0	7921,93	3,40
VSM	S6	M8	T5	D0	5516,30	2,37

Twenty-five PLUGs (Potential Land Use Groups) were calculated with the ILSEN computer model. Distribution of the major potential land use groups is VTK-S6M8T5D0 (29,31%) and DYY-S0M2T0D1 (23,53%) respectively (Figure 3).

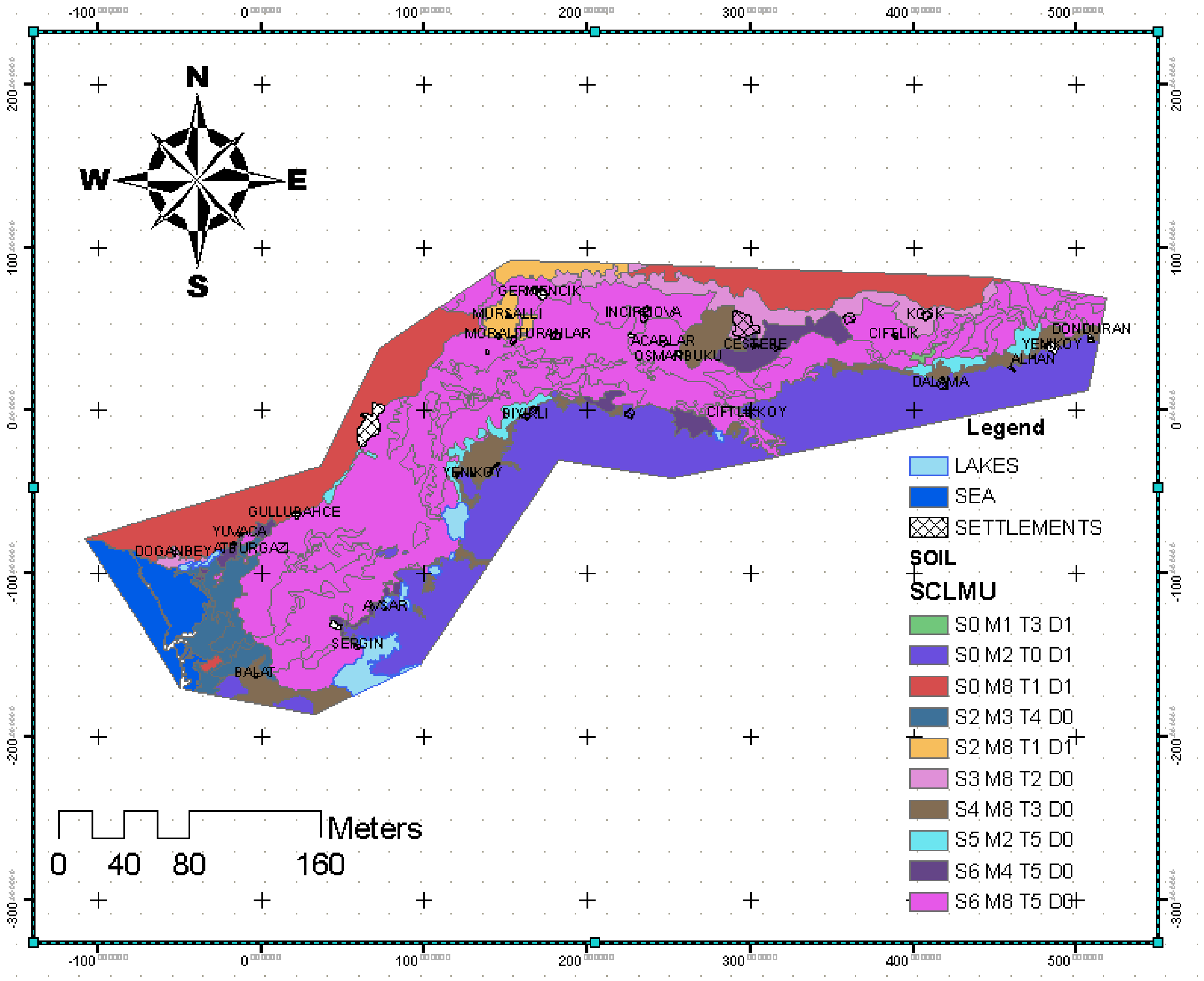

Figure 3 Potential Land Use Groups map of the study area

The distribution of land suitability for agricultural uses showed that 31,68% of the study area soils were classified as best (C1), (22,635) relatively good (C2) (Table 5). The distribution of the problematic (22,16%) (C3) and restricted (23,53%) (C4) . Finally, There is not appropriate for agriculture (C5) in the study area. , (Figure 5 and Figure 6).

Table 6. Distribution of the suitability classes for agricultural uses for each LMUs

LMU	Class		Area (ha)	Ratio (%)	LMU	Class		Area (ha)	Ratio (%)
DYY	0.048	C4	54816,88	23,53	VBK	0.687	C3	6703,07	2,88
DYM	0.674	C3	35354,76	15,18	VBD	0.757	C2	3849,79	1,65
PGA	0.726	C3	9556,68	4,10	VTK	0.916	C1	68269,19	29,31
PFB	0.879	C2	11603,72	4,98	VTB	0.773	C2	7921,93	3,40
VBY	0.881	C2	29341,68	12,60	VSM	0.945	C1	5516,30	2,37

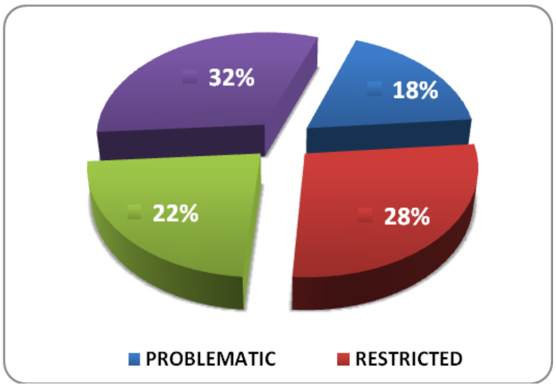

Figure 5. Distribution of suitability classes for agricultural uses

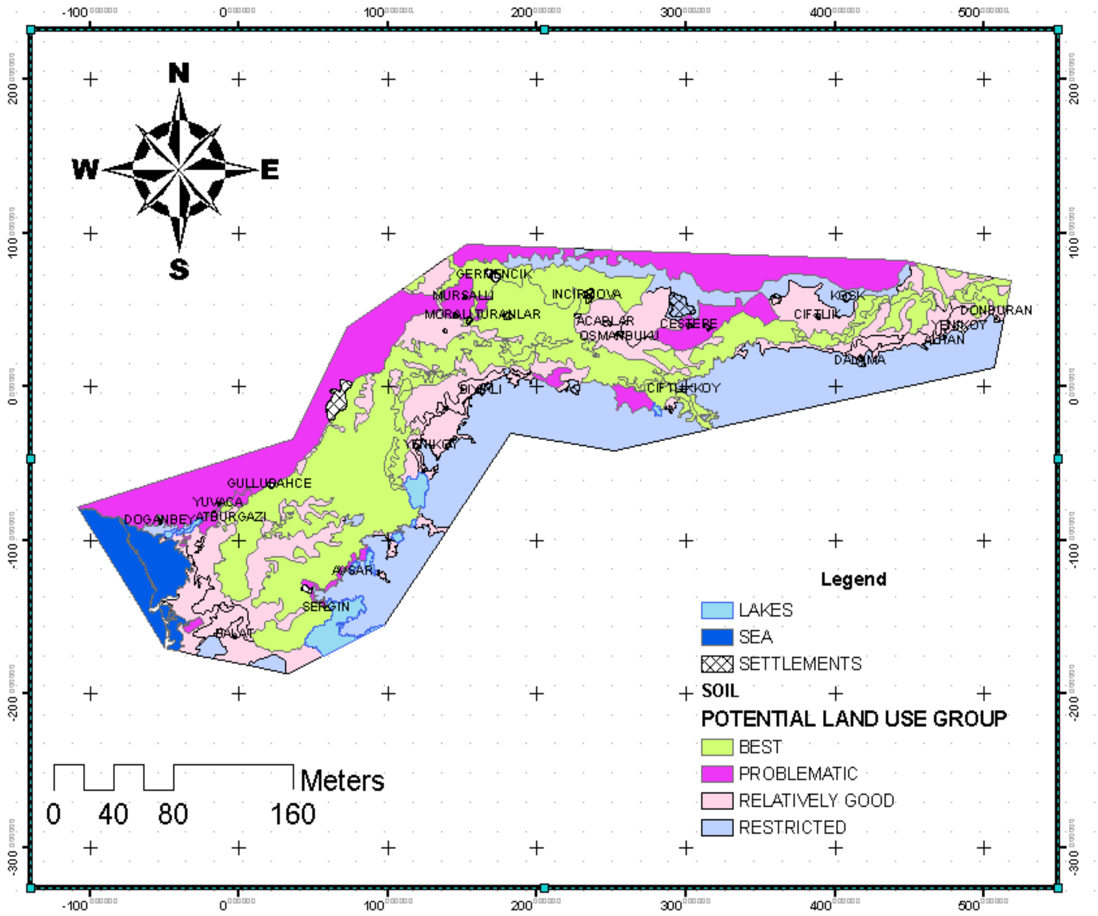

Figure 6. Suitability map for agricultural uses of the study area

Conclusion

The soils formed on the research area were classified in the term of Entisol, Inceptisol, as ordo level. 4 subordos and 4 great groups as Xerorthent, ,Xerofluvent, Fluvaquent, and Halaquept were delineated and grouped into 10 soil series. 7 horticultural (vegetables) uses (S), 6 field crops (T), 9 horticultural (fruit) uses

(M) , and 3 non agricultural (D) land use types (total 25) were determined with taking consider into the socio-economic condition of the region. As a result of the determination, potential land use map of the soils, which were classified according to result of the field observation, laboratory analysis and aerial photo interpretation were created. Land use types were grouped into 27 land use subclasses according to the physical mapping indexes of mapping units. Suitability classes for agricultural uses, between 1.- 5. Classes, and limit values of land rating, with respect to suitability classes, were determined. For that, the total mapping unit indexes which calculated between 1.00-0.00 for agricultural land use types were used. Establishing relationships between spatially variable attributes allows the development of understanding the variation of farming potentiality in the study area. The approach in this paper is based on intensive field information and logical reasoning using computer program called ILSEN and GIS techniques. Developments in GIS technologies process large amounts of spatial data and provide more accurate and more accessible information about soils. In this research these technologies were successfully used to generate soil map and land evaluation assessments. ILSEN is very useful software for land evaluation studies. However, ILSEN has to be developed and integrated with GIS to consider spatial variability. One of the main limitations of the ILSEN software is that input values of the physical mapping unit index depend heavily on the user.

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