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Agro-Ecological Zoning by GIS: A Case Study of the Bafra and Carsamba Plains in Turkey

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This study introduce a pilot agro-ecological zoning exercise for areas of the Carsamba and Bafra plains near Samsun, Turkey, using geographical information systems (GIS). The various information layers such as soil, topography and climate dataset and models were used to determine agro-ecological zones. Weighted factor analyses were used to evaluate and analyze the data layers and the resulting maps were produced for the two plains. The results obtained are presented as a thematic map for practical use.

Key Words: Geographical information systems, Bafra, Agro ecological zone and Carsamba plains.

INTRODUCTION

An agro-ecological zone (AEZ) is a crop production area which is homogeneous with respect to climate, soil and environmental conditions[1]. Zoning maps are essential components of zoning plans. Many zoning plans and maps continue to be produced and reviewed manually. The expected potential of geographical information systems (GIS) technology in the improvement of the quality of zoning map production and review is well known. By GIS technology, useful information can be derived from the preliminary data and elaborate and re-organized information flow can be effectively practiced to significantly improve work quality[2].

Zone planning is a process to produce zoning plans, involves many fields, including design art, engineering and sciences[3,4]. The main purpose of zone planning is to recognize potential lands for increasing farmlands. This work can be applied as a special programme for particular fields.

AEZ can derive by two approaches; in the first approach is expected planning crop production and agroecological zoning work focused to planning crops[5-12]. The second approach considers land classification[13-18].

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The main object of this work is to evaluate with in a GIS environment, the relevant variables of climate, soil and topography at different spatial and temporal resolutions, in order to identify the agro-ecological zone for general crop production on the Carsamba and Bafra Plains, in Samsun, Turkey.

EXPERIMENTAL

The Carsamba and Bafra plains were chosen as the research areas; because these plains have high potential as agricultural lands. The geographical situations of Carsamba and Bafra plains are depicted in Fig. 1. Carsamba and Bafra plains are located between 41º 03'-41º 24' and 41º 24'-41º 46' north latitudes, and between 36º 23'-37º 12' and 35º 30'-36º 12' east, respectively. The total area of Carsamba plain is 112,790 hectares and Bafra plain is 75,800 hectares with elevation ranging between 0.0-80.0 meters from the Black Sea coast. The plains have serious shallow water table problems that create drainage and salinity. Existing agricultural practices are concentrated on a mixture of field crops, horticulture, poultry and fishery.

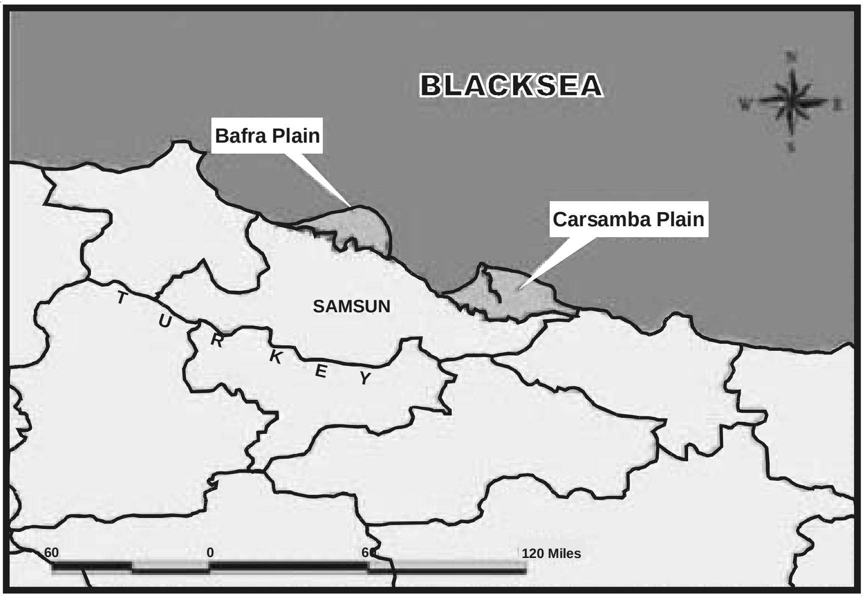

Fig.1 The location of Bafra and Carsamba plain study area

The layers of information or data relating to vegetation have been created or were mostly imported from an already existing GIS database, The Yesilirmak river Basin development project GIS infrastructure (YDPG)[1]. The YDPG aims to create a GIS database for five provinces in the Yesilirmak river watershed with multiple information layers such as the 3D-topography, soil and road maps, demographic information (urban centers, country boundaries, etc.), meteorological data, (temperature, precipitation, etc.), land cover and land use information, as well as the vegetation cover derived from recent satellite images. The information layers extracted from existing GIS for AEZ purposes were the following: (i) topography and 3D digital terrain model (DTM), (ii) soil information layer based on land and water works maps[19] and (iii) climatic information layer based on the climate atlas of Turkey[20].

Elevation, slope and aspect of the terrain derived from the DTM, the total annual precipitation, total summer precipitation, average annual temperature, cumulative effective temperature of summer months and vegetative period criteria were created by using the existing GIS database.

In the AEZ works ecological characteristics were determined for crop production. The data analyzed by weight factor[21]. All characters were taken from experts. First of all, the soil information model, the topographical model and the meteorological information model were created separately. Later, the three models were evaluated together and then the important agro-ecological zones for crop production were predicted. Data layers, soil class intervals, weight factors and predicted models are given in Table-1. Analyses and data production were done by using ArcView 3.2 software and GIS analysis functions[22].

RESULTS AND DISCUSSION

The factors for crop production evaluated for each zone, then all works evaluated with the Agro-ecological zoning (AEZ). Predicted models also evaluated together. Results are given in Fig. 2.

Soil information model: A collective analysis of the soil attributes, such as soil type, soil depth, drainage situation, state of erosion, land use capability classes, resulted in the final soil information model for the study area (Fig. 2a). The model shows that 77.9 % of Carsamba plain (88,408 ha) and 44.1 % of Bafra plain (33,557 ha) soil quality were classified very good. The east side of Yesilirmak river areas has 1,685 hectares drainage problems area in Carsamba plain. Those areas stands 5th zone and this particular area are described problem areas. The soil model shows that the Carsamba plain has high potential areas, with those areas in the 1st and 2nd zones totaling 105,407 hectares (92.9 %). However, the whole area has substantial water table and drainage problems.

On the Bafra plain, the 4th and 5th zones had lowest values for soil and crop production. These areas cover 7,865 and 694 hectares, respectively. Both zones were start from the Black sea coast. There is some salt water pressure from the sea. There is low elevation (0-2 meters) which produces

TABLE-1
DEGREE OF LIMITATION LEVELS AND WEIGHT FACTORS FOR SOIL, TOPOGRAPHICAL AND METEOROLOGICAL MODELS

(a) SOIL MODEL

Soil type	Limit. levels	Soil depth	Limit. levels	Soil drain.	Limit. levels	Erosion	Limit. levels	Land use capability	Limi. levels
Fine	100	>90	100	Bad Insufficient	-50	Other	-1	1. Class	100
Medium	90	90-50	80	Insufficient	-20	None or very little	-1	2. Class	85
Coarse	65	50-20	50	Good	-1	Medium High	-50	3. Class	65
Other	1	<20	30	Other	-1	High	-75	4. & 5. Class	50
		litozolilk	5			Very high	-100	6. & 7. Class	30
								8. Class	1
Weight factor = 2		Weight factor = 2		Weight factor = 3		Weight factor = 3		Weight factor = 4	

(b) TOPOGRAPHICAL MODEL

Elevation (m)	Limitation Levels	Surface Slope (%)	Limitation Levels	Azimuth (degree)	Limitation Levels
<2	95	<2	100	$(337.5^0$-$22.5^0)$N	40
2-10	100	2-5	90	$(292.5^0$-$337.5^0)$NW	50
10-20	80	5-8	70	$(22.5^0$-$67.5^0)$NE	55
20-30	70	8-15	50	$(247.5^0$-$292.5^0)$W	70
30-40	60	15-25	20	$(67.5^0$-$112.5^0)$E	75
40-50	50	25-50	10	$(202.5^0$-$247.5^0)$SW	80
50-60	40	>50	1	$(112.5^0$-$157.5^0)$SE	85
60-70	30			$(157.5^0$-$202.5^0)$S	90
70-80	20			Flat land	100
>80	10				
Weight factor = 3		Weight factor = 3		Weight factor = 0.5	

(C) METEOROLOGICAL MODEL

Plantation period (d)	Limitation levels	Annual precipitation (mm)	Limitation levels	Summer time precipitation (mm)	Limitation levels	Annual average temperature (deg)	Limitation levels
275-300	85	800	70	300-350	60	13-14	80
300-325	100	1000	85	350-400	70	14-15	100
		1250	100	400-450	80		
				450-500	90		
				500-550	100		
Weight factor = 3		Weight factor = 2		Weight factor = 3		Weight factor = 2	

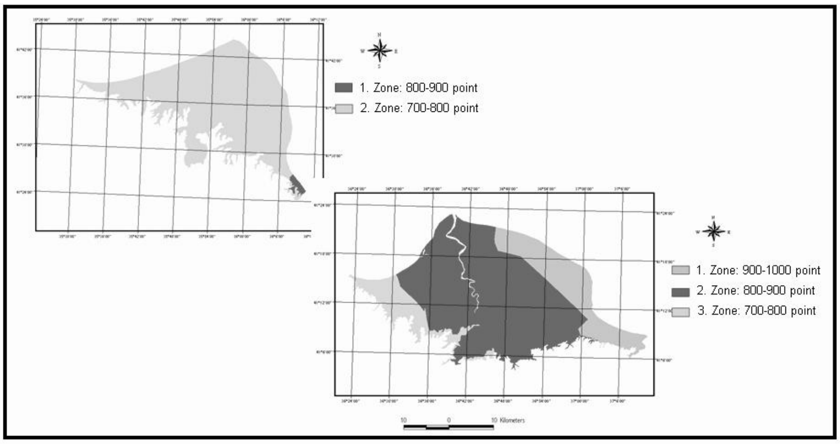

Fig. 2a. Developed models and zones for meteorological model by GIS

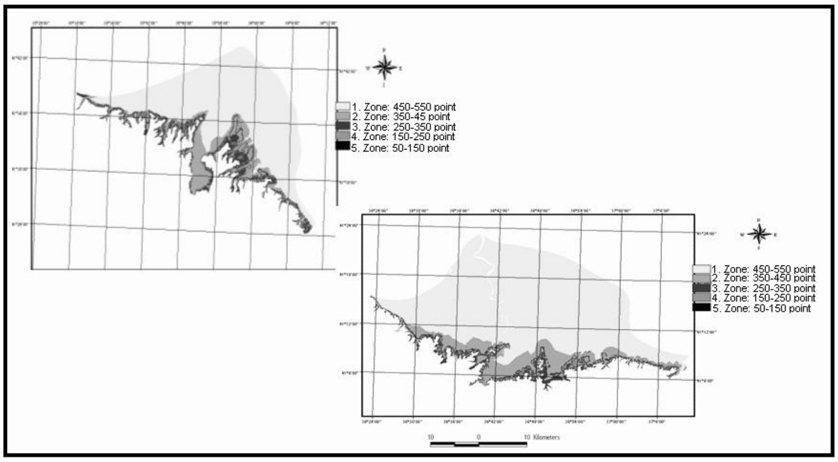

Fig. 2b. Developed models and zones for topographical model by GIS

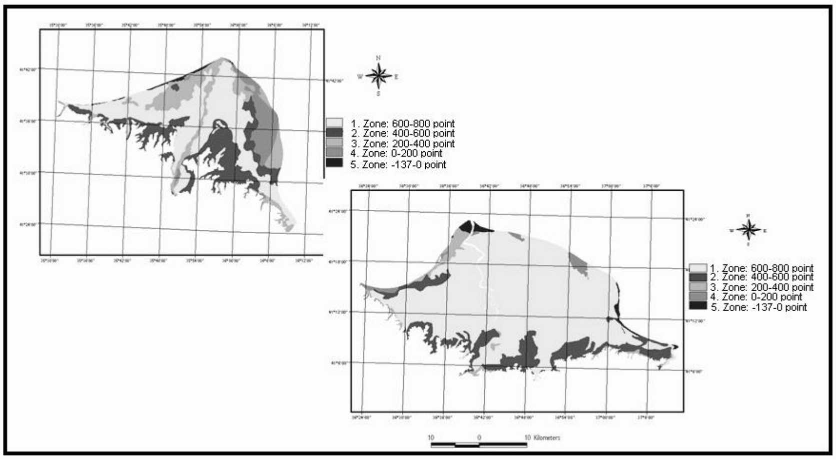

Fig. 2c. Developed models and zones for soil model by GIS

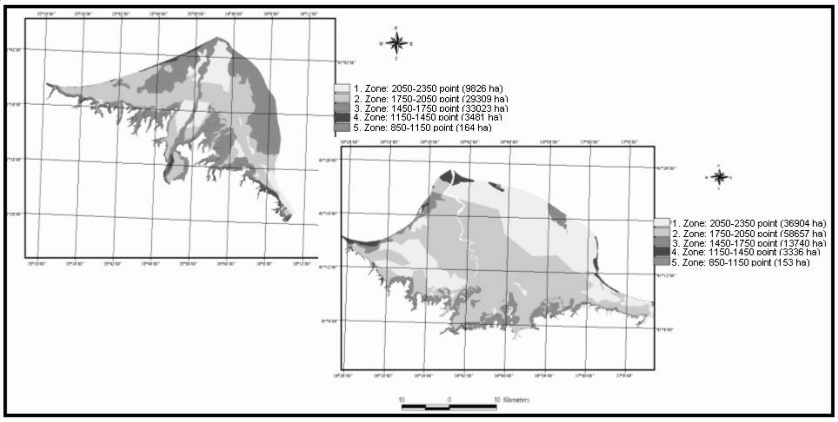

Fig. 2d. Developed models and zones for Agroecological Zones for Bafra and Carsamba Plains by GIS

a shallow and saline water table. In this area there are some lakes and wetlands. The soil model shows that the Bafra plain also has high potential areas, those areas ranged 1st and 2nd zones totally 39,135 hectares (51.6%). According to the results, the zones show that high potential because of soil depth, texture, land use classifications were good conditions and erosion hazard was low in this particular area. But all areas have saline water table and drainage problems, similar to Carsamba plain (Fig. 2a).

Topographical information model: The elevation, slope and aspect information layers were jointly analyzed to create the final topographic composite model, showing crop suitability from the topographical perspective. This shows that 79.1% of the Carsamba plain and 71.0% of the Bafra plains lands are topographically the most suitable for crop production. The lowest values 4th and 5th zones covered 2,084 hectares (1.8%) on the Carsamba plain and 2,427 hectares (3.1%) on the Bafra plain. As can be seen in Fig. 2b, topography is not a problem for crop production on the Carsamba and Bafra plains.

Meteorological information model: The composite meteorological model for the study areas was obtained by registration of total annual precipitation, annual average temperature, total temperature of summer months and crop plantation period coverage. As can be seen in Fig. 2c, there are no differences between the plains. On the Carsamba plain, three different regions resulted from the effect of precipitation and crop grown periods.

Agro-ecological zones of Bafra and Çarsamba plain: By joint analysis of the three main GIS layers which were created in this study (soil, topographical and meteorological models), agro-ecological zoning for the vegetation was obtained for the study area, as shown in Fig. 2d. A final layer of crop production suitability degrees in Çarsamba and Bafra plains was created as the end product of the agro-ecological zoning exercise. The zone 1 production area found on the Carsamba plain was 36,904 hectares and on the Bafra plain was 9,826 hectares. The areas in the 2nd zone on the Carsamba plain covered 58,657 hectares and Bafra plains 9,826 hectares. The lowest points were in the areas classified 3, 4 and 5th zones, whose land covered 17,229 hectares on the Carsamba plain and 36,670 hectares on the Bafra plain.

In summary, an agro-ecological zones study was done for Carsamba and Bafra plains in the middle Black sea region in Turkey. The study evaluated Carsamba and Bafra plains for agricultural land productivity levels. The results can be used for crop productivity planning for both the Carsamba and Bafra plains.

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