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Dursun Zafer Şeker[1,*], Ayşegül Tanık[2], Ercan Citil[3], İzzet Öztürk[2], Süleyman Övez[2], and Tuzin Baycan Levent[4]

[1] ITÜ, Civil Engineering Faculty, Department of Geomatic Engineering, 34469 Maslak İstanbul TR
[2] ITÜ, Civil Engineering Faculty, Department of Environment Engineering, 34469 Maslak İstanbul TR
[3] ITÜ, Civil Engineering Faculty, ITUNOVA TTO, 34469 Maslak İstanbul TR
[4] ITÜ, Faculty of Architecture, Department of Regional and Urban Planning, 34437, Taksim Istanbul, TR

Corresponding author. Tel: ++90 285 3755
E-mail: seker@itu.edu.tr

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Abstract

Functional zoning of Akcakoca District located along the Western Black Sea Coast of Turkey is achieved by implementing the 'Methodology for Spatial Planning for the Coastal Zone' developed by European Union for coastal areas. The aim of applying the methodology was to realize functional zoning of the district that will eventually lead to spatial planning. In this technique, a typical base map at an appropriate scale and thematic layers are prepared for each of the environmental components for further analyses. The possibility to overlap different layers according to a specified procedure and to realize new theme mapping is a considerable factor while using GIS for the functional zoning. Identical grading system has been applied to each layer formed in order to achieve the overall importance and vulnerability maps of especially the natural components of the district. Functional zoning map is further developed through comparing different layers and current land-use information obtained from satellite imagery coupled with the findings of both the importance and vulnerability analyses. This attempt of applying such a methodology was a significant study as it addressed the decision makers on the multi criteria analyses through the visualized maps of different layers.

Keywords: Geographical Information Systems (GIS), functional zoning, importance, vulnerability.

Introduction

Functional zoning and land-use planning is based on an integrated assessment of the conditions and the potential of natural components, natural factors and anthropogenic impact on the environment as well as on the alternatives of nature management and socioeconomic conditions (Taussik, 2007). Its goal is selection and introduction of such types of nature management which meet the population's requirements for socioeconomic sustainability together with the international requirements for resources conservation to fulfil the demand of future generations. Implementation of functional zoning, which in turn, lead to spatial planning may be realized at three main levels: national, regional and local. Different kinds of decisions may be taken at each level, wherein the methods of planning and kinds of plan differ (Mc Kenna et al., 2008). For example, the coordinated planning and management of marine and terrestrial sides of a coastal zone are of priority issues. It should develop a global vision of the coast, land and river management. This study can be evaluated as a precursor of this objective.

In spite of many international and national efforts to ensure sustainable management of coastal areas especially after 2000s throughout various seas, the coastal countries still face severe pressures and problems which threaten coastal resources (Vivero and Mateos, 2005; Brennan, 2007; Shipman and Stojanovic, 2007; Burak et al., 2004, Xu et al., 2009; Stuart, 2010; Musaoğlu et al., 2015). The importance of such areas is widely recognized, since anthropogenic pressures are becoming more and more intense like tendency to settle on the shores, changing agricultural production systems, industrial

Methodology used for functional zoning

The methodology set by EuropeAid-TACIS projects (1998-2003) consists of the following steps;

- Development of a GIS data base,
- Displaying environmental, land-use, and socioeconomic data on maps using GIS thematic layers,
- Identifying conflicting uses and presentation of these uses via GIS layers,
- Development of prioritizing uses, based on analysis of natural and economic resources and land-use features,
- Development of spatial plans (functional land-use zones), using primary information and evaluation of conflicting land-uses, and display via GIS layers, and
- Incorporating opinion of stakeholders in iterative series of refinements to land-use plans.

GIS based data analysis and integration is preferred as useful tools to identify spatial connections between different information layers (Rodriguez et al. 2009). Similar approach has been developed, tested and put into operation to support management decisions related to land-use planning, functional zoning and utilization of natural resources in a sustainable manner during the application of the methodology to Akcakoca district in Turkey. The database provides support for better and sustainable management of the district. During the development of the database, spatial data and attributes collected were initially entered to the system. Data used has been supplied from various sources. Soil map scaled 1:25.000 and Standard Topographic Maps (STM) scaled 1:25.000 were obtained in digital form from General Directorate of Rural Affairs and General Command of Mapping respectively. All different map data were transferred to the same coordinate system. The GIS database contains several layers such as administrative boundaries, sub-watershed boundaries, topography, soil characteristics, land-use/cover, transportation network, water resources and streams, soil map, dump site, wastewater treatment plants, etc. Moreover, a Digital Elevation Model (DEM) of the study area was produced from STM for better expressing the land surface.

Overlay analysis by which multiple theme maps are used to spatially analyze environmental components, to derive new parameters, or to select least impact alternatives is especially useful in resource conservation and management programs. In this technique, a typical base map is prepared at an appropriate scale and overlay maps are prepared for each of the environmental components or attributes to be further analyzed. The possibility to overlap different layers according to a specified procedure and to realize new theme mapping is a considerable factor during functional zoning.

Figure 2 illustrates the flowchart of the overall methodology used for functional zoning. According to this methodology, the database comprises of three main groups of layers; natural components, social and demographic components, and geographical components. The flowchart also covers the ecological components; however, as there were almost no data on the spatial and temporal distribution of the ecological values of the district, this component is excluded in the applied methodology. For each of the layers, importance and vulnerability assessments are conducted and by the help of the grading system used during this analysis, the necessary information and related maps are produced. In this study, emphasis will be given to the importance and vulnerability analyses of the natural components that form part of the overall methodology.

Prior to importance and vulnerability analyses, data collection, generation of GIS-based digital maps, processing of environmental, socioeconomic and land-use information, determination of sectoral conflicts and displaying the current land-use distribution in the form of maps were realized. Details of conflict analyses are explained in Tanık et al. (2008). All these efforts aimed to put forth priority uses of land resources of the district. The outputs of these studies basically aimed to submit the findings to the decision makers for future planning approaches. During the implementation of the methodology for spatial planning of Akcakoca District, 3 field trips to the area had been organized with the aim of gathering available data and information, realizing visits to different parts of the district,

Table 2. Importance and vulnerability values for different GIS layers.

Layer	Criteria	Area (km^2)	%	Importance	Vulnerability
Slope	0-2 %	169,74	48,39	3	1
	3-6 %	24,21	6,90	3	1
	7-12 %	42,18	12,03	3	2
	13-20 %	68,20	19,44	2	2
	21-30 %	40,82	11,64	1	3
	above 30 %	5,59	1,59	1	3
Current Land-Use	No data	6,32	1,80		
	Horticulture (dry)	3,69	1,05	2	2
	Horticulture (wet)	2,63	0,75	3	3
	Dry agriculture	11,44	3,26	2	2
	Meadows and pasture	0,45	0,13	3	2
	Dry agriculture (without	0,30	0,09	2	2
	Wet agriculture	1,41	0,40	3	3
	Hazelnut cultivation	160,12	45,65	1	1
Land-Use Capability Classification	No data	4,74	1,35		
	I	6,73	1,92	3	2
	II	1,38	0,39	3	1
	III	5,13	1,46	3	1
	IV	50,34	14,35	2	2
	V	0	0	2	2
	VI	117,14	33,40	1	3
	VII	165,26	47,12	1	3
	VIII	0,03	0,01	3	3
Degree of Erosion	No data	4,87	1,39		
	None or slight	222,45	63,46	3	1
	Medium	115,51	32,95	2	2
	High	7,72	2,20	1	3
Land-Use Capability Sub-Classification	No data	15,54	4,43		
	Slope and erosion	65,01	18,54	1	3
	Erosion and soil	269,10	76,72	1	3
	Soil insufficiency	0,47	0,13	1	2
	Soil insufficiency and	0,63	0,18	1	3
Surface Waters	Wet streams			3	3
	Dry streams			2	2
Forests	No data	0,34	0,21		
	Preserved forests	47,57	28,94	3	3
	Production forests	60,99	37,10	3	2
	Private forests	0,11	0,07	2	2
	Hazelnut cultivation-	55,37	33,69	1	1

Table 3. Scoring of vulnerability and importance of current land-use layer.

Layer	Categories	Importance	Explanation of Scoring	Vulnerability	Explanation of scoring
CURRENT LAND-USE	Horticulture (without irrigation)	3	These lands have an importance because of their economical values although they are limited in abundance.	2	They form a semi-vulnerable structure since monotype usage of pesticides and fertilizers depending on the crop type may affect the soil fertility.
	Horticulture (with irrigation)	3	These lands are highly important regarding the soil properties and water accessibility.	3	The effect of human activities and meteorological-based disasters rapidly observed. Moreover, irrigation poses the risk of pollution transportation and thus, it may lead to negative impacts on the other natural ecosystems.
	Non-irrigated agriculture (not fallowed)	2	Both lands (non-irrigated with or without fallow) include similar compliances. They may have different important aspects in different years in terms of human activities depending on meteorological conditions.	2	Vulnerability value in these lands can be more sensitive according to no alternation in crop type, application of monotype system of pesticides and fertilizers and amount of precipitation.
	Pasture	3	Pastures are not only lands used as agricultural lands, but also they are important environments for robustness of the biogeochemical cycles and ecosystems. They are critical places for biological diversity as well. These lands usually situated among the medium- sloped areas forming a buffer zone between agricultural land and forests. The land cover in such areas is highly important for preventing	2	Pastures may have vulnerable characteristics in case of inappropriate pasture management (determination of seasonal breeding stocks) and / or misusage of pastures (e.g. housing in pastures).

			erosion.		
	Irrigated agriculture	3	Lands of irrigated agriculture usually are high productive fields in absolute agricultural zones with high soil capability and no irrigation problems.	3	A change in the water regulation in irrigated agricultural lands affects the whole system including many habitats, wildlife and other life forms. Moreover, a change in these lands could have negative impacts on agricultural productivity. Inappropriate soil tillage or misuse of pesticides or fertilizers can cause erosion, water pollution and eutrophication.
	Hazelnut cultivation	3	This crop is very important in terms of human activities in a settlement like Akcakoca which its main economical building block is mostly dependent on only one type of product.	1	Hazelnut is very enduring crop which is not easily affected by many factors such as soil type, land class, slope status, elevation, etc. However, it is vulnerable to meteorological based natural disasters.

In this study, the scoring range is selected as 3. In other words, the criteria regarding vulnerability and importance scores varied from 1 to 3 for each of the natural components (Score 1 – low, 2 – average, 3 – high). It is important that one must be sure about the reliability of the data gathered, measured and/or agreed by all in order to reach satisfactory conclusions by the criteria selected. Thus, a narrower range was selected for this study to compare the findings more roughly rather than more sensitively. The below principles are taken into account;

- Each vulnerability item is scored independently since vulnerability scoring should not take into account any interaction with other vulnerabilities.
- Only the direct impact to the target host is considered during scoring vulnerability.

The importance and vulnerability scores given for each natural component based on various layers is shown in Table 2. In this table, areal values are shown for each sub-layer. Descending scores represent comparatively decreasing importance and vulnerability. In order to demonstrate an example on how the scores given are explained, the land-use layer is selected and shown in Table 3.

Criteria for each of the natural layers of the district were determined and consequently vulnerability and importance maps were generated for each of the layers. Maps shown in Figure 3 (a, b, c, d, e, f) are generated by taking into account the scores given for each of the layers.

Figure 3. Importance and vulnerability analyses on (a) current land-use layer, (b) sub-soil group's layer, (c) land-use capability layer, (d) forests layer, (e) slope layer, (f) erosion layer

According to the evaluation of the importance and vulnerability analyses and functional zoning Figure 4 has been consequently produced by overlaying the individually scored GIS layers of concern. The maps in this figure present the finalized forms of both importance (a) and vulnerability (b) analysis results.

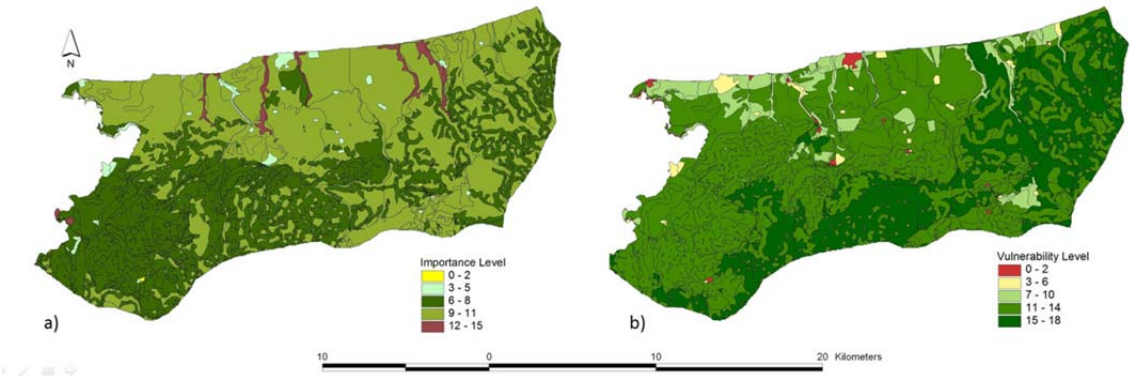

Figure 4. Importance and vulnerability maps of the study area.

The significant findings of the overall importance map are summarized below;

- Areas with the lowest scores of 0-3 are generally river mouths and alluvial areas that can be characterized as vulnerable ecosystems. However, they are not considered as suitable for human activities. The other regions with lowest scores apart from the river mouths are determined as residential sites which do not have sufficient available data to be better evaluated in terms of natural resources and features.
- Areas represented by scores 4-6 are generally highly sloped, not suitable for human activities in terms of land-use capability, and bear problems like erodibility and soil insufficiency.
- Lack of data seems to be the main reason of why the regions with scores 7-9 cover the majority of the district. Missing data on forestry and natural vegetation cover grouped as medium importance level do not allow further evaluation concerning human activities.
- Regions with scores 10-12 generally represent suitable areas for human activities pertaining to slope, land-use capability and erodibility. Agricultural activities prevail on such areas.
- Land with highest scores of 13-15 is extremely limited, and they do not propound assessable features because of the scale used.

The vulnerability of the natural environment of Akcakoca district against human activities is summarized below;

- Land with lowest scores of 0-2 represents areas with no vulnerability. These areas are rather residential sites in the district.
- Land with scores of 3-7 is highly rural areas with lack of sufficient data.
- Areas with scores of 8-12 characterize medium vulnerability level. Such an evaluation is derived as such areas with lower elevations and slope groups belong to lower sub-groups in terms of land-use capability.
- Regions with higher scores of 13-18 generally bear high and extremely high slopes, lower land-use capabilities and face various erosion and soil insufficiency problems.

Table 4 on the other hand summarizes the areal and percent distribution of the overall importance and vulnerability analyses. The layer of surface waters is considered in Table 2, but since their surface area is negligible comparing to others, no information exists in Table 4.

Table 4. Areal distribution of GIS layers for overall importance and vulnerability analysis.

	Level	Area (km^2)	%
Importance	0-2	0,43	0,12
	3-5	12,38	3,53
	6-8	148,68	42,39
	9-11	183,69	52,37
	12-15	5,56	1,59
Vulnerability	0-2	1,76	0,50
	3-6	4,70	1,34
	7-10	33,96	9,68
	11-14	217,28	61,95
	15-18	93,04	26,53

Functional zoning of the district is further achieved as presented in Figure 5. This map is developed as a consequence of comparing different layers and current land-use information obtained from current Landsat satellite imagery, coupled with the findings of both the importance and vulnerability analyses.

The 'Functional Zoning of Akcakoca District' is introduced in the light of the general evaluations attained and by utilizing the available and useful data. The zones are symbolized by different letters and their share in total district area is given in parentheses.

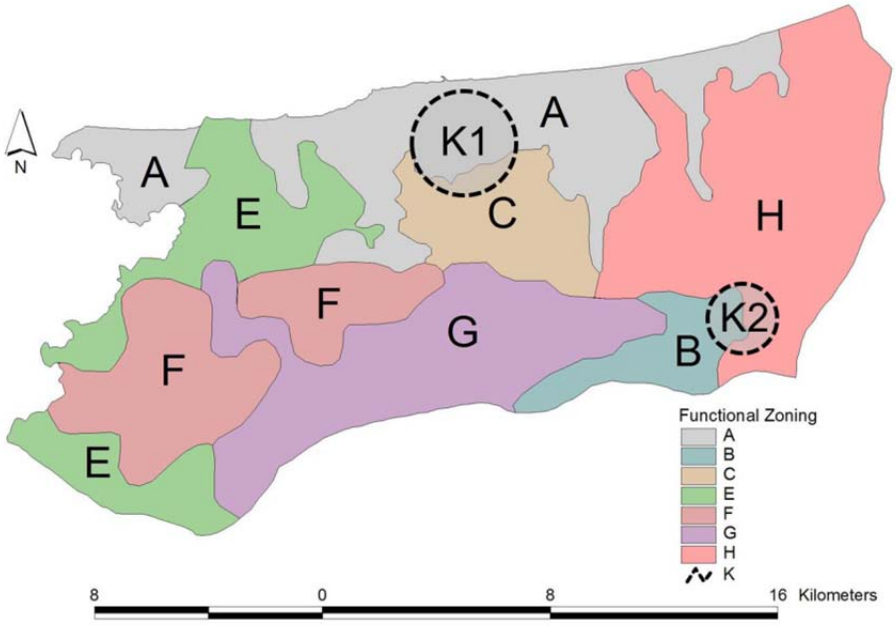

Figure 5. Functional zoning map of Akcakoca district.

The below referred comments are made on the functional zoning map;

K; This group identifies the urban development areas including the centre of Akcakoca and its vicinity. It identifies the intersectional zone of sectorial functions like urban planning, transportation, logistics, and forestry. There is a continuous interest among two residential sites (K1 and K2) reflected by the transportation network. K1 and K2 covers 10.34 and 3.73 km2

respectively. K group should not be considered as a separate zone since it overlaps with various other zones. It may be used by decision makers during future land-use planning. .

A; Dominating functions at the coastal area around the centre of the district are agriculture, forestry, recreation and tourism (21%).

B; This group covers the residential areas around which agriculture and forestry functions prevail (5%).

C; This group located at the south of Akcakoca centre that cover highly dense rural settlements, plantation and livestock breeding include functions of agriculture and nature tourism (7%).

D; Coastal area extending from the Centre of the district till the mouth of Melen River includes the major functions of coastal tourism and recreation together with agriculture, forestry and transportation.

E; This group includes agriculture and forestry functions and also describes the region where agricultural activities constrict forestry function (13%).

F; This group that is not suitable for the development of human activities defines areas where the functions of environmental protection and forestry have to be intensified (14%).

G; This group presenting both the highest elevations and the most highly sloped areas of the district basically includes forestry function (17%).

H; This group lying on the east of the district is recommended to be dominating with the forestry function as there is a necessity to improve the land's quality by environmental protection studies against the negative human effects encountered by agricultural activities, transportation, etc. (23%).

This specific effort on developing the functional zoning map of a coastal region is an essential step towards the generation of an efficient spatial plan of the area of concern. When the functional zoning map is coupled with national and regional legislation, and further enriched with the public hearings, spatial plan will be successfully put forth. Spatial plans are tools of land-use activities. Planning of land-use activities has become the most important issue in watershed management that covers the coastal zones as well. All sorts of environmental degradation and deterioration of water quality are due to wrong and illegal use of land resources. As such, functional zoning of land and spatial planning have become outstanding topics in sustainable management of natural resources that basically cover land and water resources. That is the main reason of why so many studies are being conducted in different parts of the world on coastal zone management as described in detail in the introduction part of this study.

The methodology followed in this study covered three basic components; namely natural, socio-demographic and geographical components. However, the original methodology had four components, the last being the ecology component. Missing of this last component indicates the reality that insufficient ecological information existed on this component which led to ignoring it in the application of the methodology in Turkey. This fact once underlined the reality that ecological studies covering the in- depth surveys and analyses on both flora and fauna in different regions of the country are still lacking which would provide invaluable data to the ecology component of the methodology.

Vulnerability and importance analyses and their outcomes presented via mappings and illustrations are good examples that form integrity between the various components under inspection. The range of scoring selected in the study is within 1-3 for each of the vulnerability and importance analysis. The cardinal basis for the assignment of scores highly depends on the details and completeness of the input data used. Broader ranges mean that detailed and deepened information exist. In this study, the formed scale is considered to be satisfactory regarding the precision of the input data used and the target of the study which mainly attempts to make a descriptive presentation of various components that will form an initial database for a comprehensive assessment study.

It is important to note here that such studies covering multi criteria analyses coupled with scoring and illustrations must always be presented to the inhabitants of the region of concern to get feedback on what has been determined and put forth. Consultation with public is one of the most important steps in developing and improving sustainable management strategies. Otherwise, the analyses conducted and the assessments done would be meaningless and of no use.

Concluding Remarks

Functional zoning leading to spatial planning have become more popular in Turkey especially in the rapidly urbanizing coastal areas where tourism and fishery attracts both the domestic and foreign visitors. The lack of a national strategy and plan for coastal areas and the lack of a regional authority have hindered the realization of a sound management in Turkey representing a developing country. These facts have been the main limitations during the implementation of the methodology. The use, planning and management of coastal areas are mainly determined by local construction plans and this leads to fragmented planning applications. For an effective management system, the establishment of national and regional institutions as well as development of national and regional strategies and policies is advised. Another significant limitation experienced during the implementation of the methodology has been lack of available data utilizable by GIS. Ecological data covering flora and fauna distribution at both the land and marine sides of the district was accepted as the main weakness during the implementation of the methodology. Moreover, available data could be hardly gathered as they are scattered around at different institutes and state offices and have not been yet documented in a systematic database. In particular, insufficient data is of crucial importance, since it is one of the main components of coastal area management. In practice, no accepted definition exists of the "coastal area" in Turkey. Land-use planning deals with almost terrestrial area. Resources like soil, forests and alike, need to be presented at the country level, and then they have to be discussed at coastal regions and at provincial levels. Similar approach has to be followed for discussing coastal developments like tourism and urbanization.

Besides the limitations addressed, the practice of this methodology provided many benefits especially in increasing the awareness of the stakeholders including the inhabitants. Throughout the study, close contact with the Mayor of the district and his staff provided better explanation of the methodology to the inhabitants and other stakeholders of the district. Mutual discussions increased the interest to developing spatial plans under the light of functional zoning map by the decision makers. By this trial, the administrative staff of the district and the public became familiar with the advances of modern technology of GIS and RS used as tools to better visualize and present the outcomes of the methodology used, and to illustrate the results of multi criteria analyses covering importance and vulnerability grading and mapping. A classification needs to be established for the different types of coastlines in the regional seas according to their degree of vulnerability. Social, ecological, economic and cultural criteria need to be equally applied in order to assess interactions, enable a discussion of priorities among stakeholders and support the design of integrated implementation strategies for a more sustainable coastal development. The emphasis given to working with natural processes in the development and review of Shoreline Management Plans shows that this approach has become an accepted practice.

In conclusion, it is important to note that implementation of the outcomes of the study will be continuing in future as such efforts also need financial support from the administrative and other operational stakeholders. However, public participation during the implementation stage of the outcomes was remarkable.

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