ECOLOGICAL SENSITIVITY AND RISK ASSESSMENT IN THE KIZILIRMAK DELTA

Article *in* Fresenius Environmental Bulletin · January 2018

CITATIONS
4

READS
422

2 authors:

Kemal Ersayin
Gaziosmanpasa University
1 PUBLICATION **4** CITATIONS
SEE PROFILE

Sermin Tagil
Balikesir University
30 PUBLICATIONS **463** CITATIONS
SEE PROFILE

© by PSP Volume 26 – No. 11/2017 pages 6508-6516 Fresenius Environmental Bulletin

ECOLOGICAL SENSITIVITY AND RISK ASSESSMENT IN THE KIZILIRMAK DELTA

Kemal Ersayin[1], Sermin Tagil[2,*]

[1]Gaziosmanpasa University, Faculty of Arts and Sciences, Tokat, Turkey
[2]Balikesir University, Faculty of Arts and Sciences, Balikesir, Turkey

ABSTRACT

The purpose of this study is to present the ecosystems where ecological sensitivity is high due to anthropogenic and natural influences and which are under risk, and to make recommendations concerning the sustainable use of these areas. Firstly, the factors having an impact on the ecological sensitivity in the delta site were identified by making different literature reviews. The factors considered in this study consist of elevation, land use, soil, water systems, population density, settlements and roads. The weights of these factors in the multi-parameter model were specified by using the method Analytic Hierarchy Process (AHP). Ecological sensitivity and risk zones were revealed by classifying the obtained sensitivity and risk values as extremely sensitivity and risk, high sensitivity and risk, moderate sensitivity and risk, light sensitivity and risk and no sensitivity and risk. The factors leading to risk and sensitivity to be high were examined in the observations made during field works. The results obtained from the study show that especially the eastern side of the delta, the surroundings of the lagoons and the lowlands around the coastal dunes are areas with high sensitivity and risk. This knowledge is qualified as a base for the local authorities and decision-makers.

KEYWORDS:
Ecological sensitivity, ecological risk, Analytic hierarchy process, geographic information systems, Kizilirmak river delta

INTRODUCTION

Created by the developing humankind, the "Era of Science and Technology" is based on the notion that the nature is perceived as an unlimited treasure. This pragmatic view advocates the unlimited human domination over natural resources, i.e. an anthropocentric understanding of environment [1]. In 1970s, the environmental problems caused by the anthropocentric view of environment and the ecological crises gave rise to a view of environment advocating avoidance of any human behaviour that may damage the nature [2, 3]. This eco-centric approach highlights preservation of nature. Accordingly, the need for preserving the nature led the way to detailed examinations concerning the irregularities in the nature and the reasons for its non-functionality or deterioration [4]. The path for understanding the nature goes through the discipline of ecology.

The ecological thought serves as a bridge between natural sciences and social sciences. The scope of ecology was extended by this functioning, and it gained an interdisciplinary form and had many sub-branches [5]. Examining and studying the principles for the operation of the natural resources without disturbing the natural balance, applied ecology is a sub-branch of the discipline of ecology, and its purpose is to ensure that necessary methods to solve the ecological problems [1]. The scope of this study significantly overlaps that of the applied ecology. The "ecological sensitivity and risk" comprising both the main topic and the method of the study reflects the degree of sensitivity of the ecological system, ecological imbalances and the ecological environmental problems or their possibility as caused by human activities [6]. The purpose of this study is to present the ecosystems where ecological sensitivity is high due to anthropogenic and natural influences and which are under risk, and to make recommendations for the sustainable use of these areas.

MATERIAL AND METHOD

Study area. The study site covers the delta plain and the total area is 52.779 ha (Figure 1). The coexistence of the habitats of various ecological characters such as sea, river, lake, reed, swamp, meadow, pasture, forest, dune and agricultural areas in Kizilirmak River Delta, its richness in nutrients and suitable climate conditions have enabled the delta site to harbours a very rich biodiversity [7]. Due to its value, a lot of study has been done in delta, river and coastal of Black Sea [8-13]. Kizilirmak River Delta is an important area both at national level and at international level. It was declared to be one of the 122 important plant sites of Turkey due to the rare plant species contained. Kizilirmak River Delta is also internationally important owing to its fauna which is particularly rich in ornithological aspect. It is used by more than 320 bird species (75% of all

known bird species in Turkey) for breeding, wintering and migration [14]. Due to this richness, different parts of the delta are preserved under 3 different statuses (Ramsar, Natural Site Area and Wildlife Improvement Area).

FIGURE 1
Location of study area.

Material. The parameters influencing the sensitivity and risk were identified at first. Literature was taken into consideration while identifying the parameters; however, field surveys were also not ignored as they control the sensitivity on-site. As stated by Zhang et al. [15], various factors cause regional, ecological and environmental problems and these factors vary in each region. Field surveys were conducted in April and August 2015. In addition to the observations made within this period of time spent on field, both the academics and volunteers studying on field and the local people were interviewed, and information was collected on the area through open-ended questions. As a result, seven parameters with an impact on ecological sensitivity at delta site were determined (Table 1).

Ecological sensitivity is the reaction level of the environmental change caused by internal and external factors [16]. As understood from the definition, existence of two main elements draws the attention in the development on ecological sensitivity. First, the risk resulting from ecosystem change due to human activities. The other is the sensitivity caused by ecosystem's own processes or natural processes. If we are to explain these two different ways leading to ecological sensitivity over Kizilirmak River Delta, the roads, settlements and river canals on the site are the sensitivity and risk resulting from human activities. The presence of wetlands as well as soil and rivers constitute the sensitivity zones developed by natural processes. Ecological sensitivity and risk analyses show the on-site status of these two different elements, and additionally, they are important as they reflect the high sensitivity and risk created by their coexistence at the same area.

TABLE 1
Data sources and features.

Parameters	Source	Features
Elevation	Military	1/25.000 scale digital topography map
Land Use	Bafra-Forest Management Institution, 2005 Landsat ETM+	Land use map was produced with forest management map. Verification was made from satellite images.
Soil	Ministry of Food, Agriculture and Livestock	1/25.000 scale soil map. Major soil groups were considered.
Water surfaces	Bafra-Forest Management Institution, 2005 Landsat ETM+, Esri Basemap	Stream network, channels and lakes data were collected and corrected from different sources.
Population density Settlements	TUİK, Esri Basemap, Google Earth vb.	The amount of population was obtained from Turkish Stastical Institute. According to the function, settlements divided into rural and urban areas.
Transportation density	Bafra-Forest Management Institution, Esri Basemap	Road data was obtained from forest management map. Also deficiencies of this map was fixed using Esri Basemap. Classified as asphalt, soil and stabilized.

Methods. After specify the parameters, determination of factor weights, the second phase in ecological sensitivity and risk assessment, is a difficult task because there are complicated relations between the factors, and their importance are not same everywhere. Each parameter class must be assigned a different weight according to its importance. Accuracy of the assigned weights is important for the accuracy of the results [17, 18]. Analytic Hierarchy Process (AHP), one of the "Multi Criteria Decision Making" methods, was used as the most suitable way for clearing this obstacle [19, 20]. In this context, the factor weights (assessment index) obtained with AHP and presented in Table 2.

Although AHP has a specific advantage in assessing many factors or criteria, it cannot reveal the spatial distribution of these factors or criteria. In the second step, this deficiency of AHP was covered by the strong spatial analysis function of GIS. The spatial distribution of the sensitivity was determined by applying the weighed superposition method to the factors already classified and weighed with GIS support. The following formula was used during ecological sensitivity assessment:

$$S_{ij} = \sum_{k=1}^{n} W(k) C_{ij}(k) \quad (1)$$

In the formula (1), S_{ij} reflects the ecological sensitivity value in each cell. k=1, 2, ..., n are the

TABLE 2
Classes and weights of assessment parameters

No	Para meters	Classes of parameters		Weights of classes		Weight of Parameters
1	Elevation (m)	0-3		0,51		0,34
		3-5		0,29		
		5-10		0,11		
		10-15		0,06		
		>15		0,03		
2	Land Use	Swamp		0,39		0,16
		Coastal dune		0,23		
		Stream bed		0,15		
		Bare land		0,07		
		Forest		0,11		
		Agricultural		0,03		
		Settlement		0,02		
3	Soil	Hydromorphic		0,64		0,24
		Coastal dune		0,28		
		Alluvium		0,08		
4	Water surfaces	Rivers and channels (m)	< 50	0,64	0,40	0,11
			50-100	0,26		
			100-200	0,11		
			>200	0,00		
		Lake (m)	< 50	0,64	0,60	
			50-100	0,26		
			100-200	0,11		
			>200	0,00		
5	Population density (person/km^2)	0		0,51		0,07
		0-40		0,26		
		40-70		0,13		
		70-120		0,07		
		> 120		0,03		
6	Settlements	Urban (m)	< 250	0,56	0,70	0,05
			250-500	0,26		
			500-1000	0,12		
			1000-2000	0,06		
			> 2000	0,00		
		Rural (m)	< 250	0,56	0,30	
			250-500	0,26		
			500-1000	0,12		
			1000-2000	0,06		
			> 2000	0,00		
7	Transportation density	Soil and stabilized road (m)	< 200	0,57	0,30	0,03
			200-600	0,28		
			600-1200	0,11		
			1200-2000	0,04		
			> 2000	0,00		
		Asphalt road (m)	< 200	0,57	0,70	
			200-600	0,28		
			600-1200	0,11		
			1200-2000	0,04		
			> 2000	0,00		

factors with an effect on the ecological sensitivity. W(k) is the importance weight of the ecological factor. $C_{ij}(k)$ corresponds to the sensitivity level in each cell of the factors [20-22]. The weight values provided in Table 2 are used in this formula.

RESULTS AND DISCUSSION

Elevation change. Although there is no significant elevation change in Kizilirmak River Delta, small elevation changes cause impacts such as changing underground water level, limited drainage, injectability of the sea water, wetland formation, habitat change, etc. By means of using the conditions available in the study area and the literature, the delta was categorized (Figure 2a; Table 3). Sensitivity and risk decreases in parallel with the increasing elevation.

The most important thing leading to elevation dependent ecological sensitivity in Kizilirmak River Delta is the formation of wetlands. Recognized as world natural resource museums due to their biodiversity, the wetlands are one of the most important ecosystems of the earth with their natural functions, economic and cultural values [23, 24]. The underground water level was very high under two-meter level in Kizilirmak River Delta, and even, the underground water approached to the surface for up to one meter in rainy periods (November-April) [25]. This allows rare habitats to develop especially on lower sites of the area and increases the sensitivity. Halophytes that can survive and proliferate under high salt concentrations are common at the lower parts of Kizilirmak River Delta. These plants constitute only

1% of the world's flora [26]. The fact that this rare flora observed on the lowest parts (0-3m) of the delta site increases the ecological value and sensitivity of these parts.

Land use. When the land, being sensitive to natural events and human activities, is used carelessly, it may deteriorate easily and lose its ecological and economic function. It causes the natural ecological systems to turn into human-led ecosystems. As a result, habitats become extinct or go through irremediable changes [27, 28]. Kizilirmak River Delta is a site which is under heavy pressure from human activities related to its economic attractions. This leads to the extinction of the habitats with the destruction of the natural system on the site. The fact that Kizilirmak River Delta is covered by agricultural areas by 65.1% and settlement areas by 8.9% clearly reveals the presence of human-led ecosystem in which naturalness has vanished (Table 3; Figure 2b). When assessed in terms of sensitivity, the swamp has the highest weight. Dunes has the second highest sensitivity weight and surround the delta site, particularly the lagoons, as a shield, and almost serve as a protection on the area.

Soil differentiation. Soil is the source of inorganic materials and considered as one of the lifeless elements of the ecosystem [5]. However, soil which accommodates thousands of living creatures is a very important part of the ecosystem. The entire study area has soils formed by the materials carried via water (Figure 2c).

When considered on study area scale, the alluvial lands where intensive farming is carried out heavily represent the class with the lowest sensitivity among the soil classes. Therefore, alluvial soils have the lowest class weight within the soil parameter (Table 3). Owing to the biodiversity, hydromorphic land in Kizilirmak River Delta has the highest sensitivity within the soil parameter. Dunes are very important for the continuity of the delta ecosystem. Along with the ecologically rare habitats they accommodated, these sites serving as a sort of guarantee for the wetlands located behind are rapidly affected by the external factors. So, dunes are considered as second sub-class with an impact on ecological sensitivity and risk in Kizilirmak River Delta.

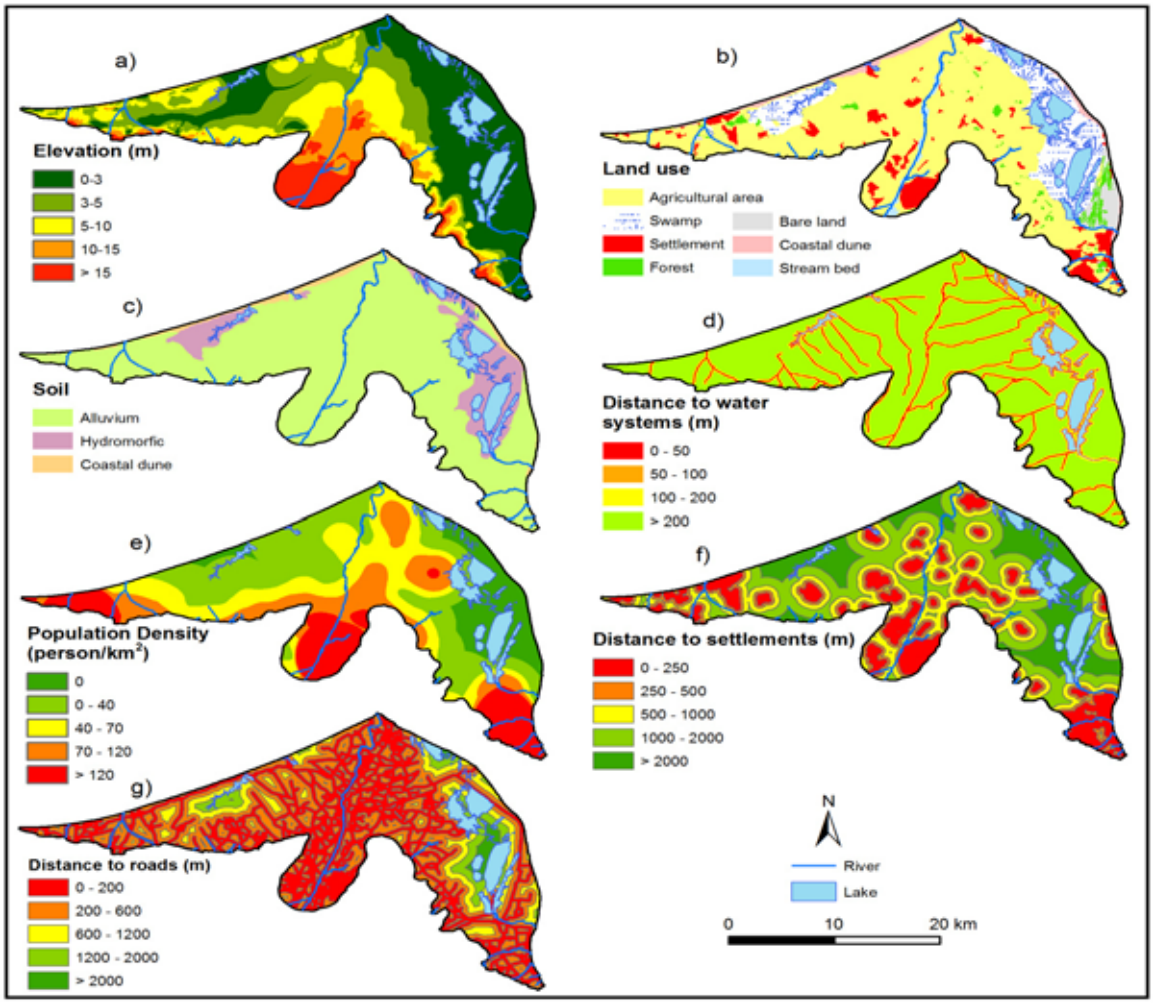

FIGURE 2
Ecological sensitivity and risk parameters.

TABLE 3
Spatial distribution of parameters and weights of classes.

Parameter classes	Area km²	Area %	Weight of Class	Parameter classes	Area km²	Area %	Weight of Class
Elevation (m)				**Population density (person/km²)**			
0-3	187,18	37,75	0,51	0	60,39	12,18	0,51
3-5	108,42	21,87	0,29	0 - 40	156,82	31,63	0,26
5-10	108,1	21,8	0,11	40 - 70	113,75	22,94	0,13
10-15	50,03	10,09	0,06	70 - 120	83,99	16,94	0,07
> 15	42,11	8,49	0,03	> 120	80,85	16,31	0,03
Rivers and channels (m)				**Lakes (m)**			
0-50	22,59	4,56	0,64	0-50	9,69	1,96	0,64
50-100	22,08	4,45	0,26	50-100	8,7	1,76	0,26
100-200	43,1	8,69	0,11	100-200	14,47	2,92	0,11
> 200	407,99	82,29	0	> 200	462,91	93,37	0
Urban settlements (m)				**Rural settlements (m)**			
0-250	33,04	6,66	0,56	0-250	69,41	14	0,56
250-500	7,35	1,48	0,26	250-500	52,58	10,61	0,26
500-1000	11	2,22	0,12	500-1000	110,6	22,31	0,12
1000-2000	23,48	4,74	0,06	1000-2000	145,59	29,37	0,06
> 2000	420,92	84,9	0	> 2000	117,61	23,72	0
Asphalt roads (m)				**Soil-Stabilized roads (m)**			
0 - 200	63,82	12,87	0,57	0 - 200	211,02	42,56	0,57
200 - 600	87,09	17,57	0,28	200 - 600	175,61	35,42	0,28
600 - 1200	88,82	17,92	0,11	600 - 1200	59,93	12,09	0,11
1200 - 2000	83,44	16,83	0,04	1200 - 2000	26,56	5,36	0,04
> 2000	172,62	34,82	0	> 2000	22,68	4,57	0
Land Use				**Soil**			
Agriculture	325,75	65,1	0,03	Alluvium	416,85	84,01	0,08
Swamp	78,74	15,7	0,39	Hydromorphic	60,85	12,26	0,64
Settlement	44,32	8,9	0,02	Coastal dune	18,48	3,73	0,28
Coastal dune	18,47	3,7	0,23				
Bare land	12,65	2,5	0,07				
Forest	12,02	2,4	0,11				
Stream bed	8,49	1,7	0,15				

Distance to water systems. Adjacent areas of the aquatic environments which are ecologically important as to their own biodiversity are also sensitive areas because of the conditions they create on these areas. These areas should also be emphasized in terms of ecological integrity [29]. When Kizilirmak River Delta is taken into account, the fact that the topography created by river and rich habitats developing with presence of lakes reveals the importance of the water systems for the natural environment and ecology of the area. Based on the literature [17, 30], concerning both the land conditions and the sensitivity and risk assessment, 4 different zones were created around the river and lakes (Figure 2d). The subclasses, weights and coverage areas of these zones are given in Table 3.

The important functions of the areas surrounding the water systems include discharging the aquifers, sustaining the quality of surface and underground waters, preventing eutrophication in lakes and rivers by keeping the nutrients from the ambient and creating areas for several plant and animal species to meet their basic vital needs [31, 32]. Moreover, these areas serve as a corridor for the movement and migration of plant and animal species [33]. It is a fact that all of these matters are present in Kizilirmak River Delta and it is clear that these lead to an increase in ecological sensitivity.

Population density. Kizilirmak River Delta is an area under population pressure due to its attractions. This controls the ecological sensitivity and risk through accompanying environmental problems. The district centers located within Kizilirmak River Delta site (19 Mayis, Alacam, Bafra) and their surroundings are the places where the population pressure is highest (Figure 2e). The most negative effect of the high population density which is also present in Kizilirmak River Delta is the changing natural land cover [34]. The population trend in these areas, where biodiversity is also high, turns the ecosystems into human-led habitats where the species are under the risk of extinction [35]. Positive correlation values were found between the size of the human population and the extinction of species [36]. The increase in the population density makes the protection activities and strategies harder in these areas. Whereas, the most important purpose of creating protection areas is to minimize the human influence there [37]. Namely, population is one of the important reasons which are effective in the deterioration and annihilation of both the biodiversity and the protection efforts, and these matters are also observed in Kizilirmak River Delta. Furthermore, population causes a pressure on the natural environment in the delta due to their wastes, as well. Especially, the solid wastes around lagoons, dunes and water system pose an important environmental problem in Kizilirmak River Delta.

After calculating the distribution of population density in Kızılırmak River Delta by means of spatial statistics, population density classes were identified by considering the reflection of spatial difference in the study area (Table 2). As the areas with low population density are the areas where there is least deterioration in the natural environment, they comprise the areas with the highest ecological sensitivity. Classes were specified in a manner in which sensitivity would decrease in parallel with the increase in the population density. Regional distributions and weights of the population density classes are given in Table 3.

Settlement distribution. Human settlement occurs in two different ways in spatial terms, urban and rural. Urban areas are more active for the increase in the risk levels in the natural environment. Therefore, the weight of the urban settlements were taken into account more than the rural settlements in the study (Table 2). Settlements not only create ecological sensitivity and risk in the natural environment under their coverage but also consist a parameter affecting the surrounding sites [38], and this effect shows a decrease from residential areas towards the environment [39]. Considering this fact and the studies [17], buffer areas were created (Figure 2f). Class weights of the buffer areas were determined on the basis of the assumption that the closer to the settlements the area is, the more risk it creates ecologically. These class weights and spatial distributions are given in Table 3.

The settlements areas in Kizilirmak River Delta are generally accumulated in the surroundings of district centers as well as the site between lagoons and River Kizilirmak. In addition to the settlements established for economic reasons in Kizilirmak River Delta, there are secondary residence areas used as summer houses due to the natural beauties. The most important thing is that these types of residences are observed within the borders of protection areas. The second residence areas built in Ramsar site area and grade 1 natural site areas, i.e. areas absolutely prohibited to reside. Summer house areas rapidly increase around Derekoy, the easternmost part of the delta, and these areas continue to progress into the delta.

Distance to roads. Roads comprise an anthropogenic element which emerge with the presence of two above-mentioned parameters (population and settlement) and have a density and effective site varying by these two parameters. In ecological terms, roads can affect the natural environment with its results such as reduced plant and animal populations, limited movement of the species, creating avoidance behavior on the fauna, water system contamination, deterioration of erosion and sediment balance, chemical pollution in the atmosphere, deteriorated natural vegetation with the introduction of the exotic species, habitat degradation and fragmentation [40, 41]. Negative effects caused by the roads can reveal themselves within a distance from few meters to few kilometers within the ecosystem. The areas under this effect alongside the road are defined as " road-effect zone" [42]. Negative correlation was detected between the natural fauna and flora density and determined that this correlation change positively as moved away the road [43]. In this study, zones are detected with knowledge that ecological sensitivity and risk decreased with increase in distance from road (Figure 2g). Also similar studies taken into account [17]. Additionally, due to the information that increased technical quality of the roads would decrease the protection of the flora and fauna value at the area [44] and the roads with a larger traffic volume caused bigger habitat and population problems [42], 2 sub-classes as asphalt roads and stabilized/soil roads were created (Table 2). The ecological sensitivity and risk weights of these sub-classes and road-effect zone as well as their spatial distributions are given in Table 3.

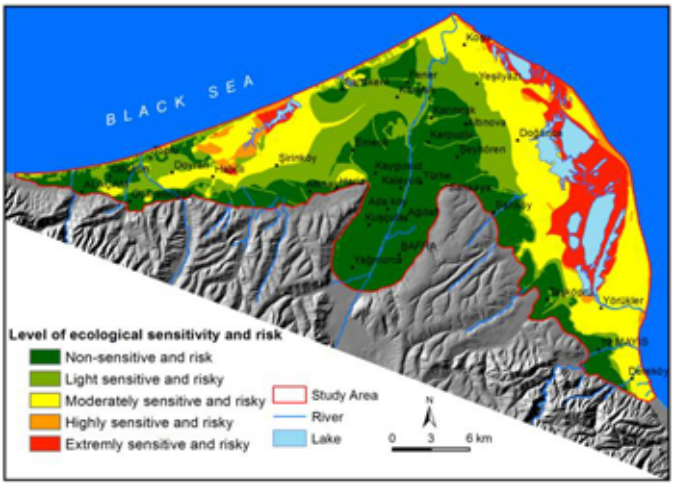

FIGURE 3
Ecological sensitivity and risk zones.

Enabling the human pressure to reach even the remotest areas, the roads are clearly an important spatial parameter in ecological sensitivity and risk assessment. The fact that roads spread over almost the whole site in Kizilirmak River Delta causes the ecological risk to increase. The total length of the roads within the delta is 783 km. These roads consists of 154 km asphalt, 203 km soil and 424 km stabilized roads. The road density is 1581 m/km^2.

Ecological sensitivity and risk zones. The sensitive and risky areas were determined as a result of the comprehensive ecological sensitivity and risk assessment made with seven above-mentioned parameters in Kizilirmak River Delta. In the determination of ecological sensitivity and risk zones, the parameters of elevation, soil and land use were more decisive than other parameters as they had a higher importance weight (Table 2). As a result, the eastern coasts of the delta were determined to have a higher level of sensitivity and risk (Figure 3). On western coasts, the relatively lower site around Lake Karabogaz was observed to have a higher ecological sensitivity and risk. Particularly, the lakes located close to the sea level and the soil formed around them as well as the type of land usage caused these zones to have a higher ecological sensitivity and risk in all delta areas.

The ecological sensitivity and risk were determined to be extremely at 44.83 km2 (%9) area mostly around lagoons in the delta area. At 16.99 km2' (%3.4) area corresponding mostly to the dunes around the delta area, a high level of sensitivity and risk were identified to spread. The high and extremely risk areas are surrounded by the moderate sensitivity and risk areas (141.75 km2) which are wider on eastern coasts, and they cover 29% of the total area. The areas with light (23%) and no (36%) sensitivity and risk zones which are mostly located in the south of the delta and emerged due to the human activities differentiated with the change in the parameters such as soil, land use and elevation.

CONCLUSION

The ecological sensitivity and risk assessments conducted on valuable coastal areas such as delta site constitute a new study area within sustainable development characterized as an early alert system for ecological safety and environmental management [45]. The study is an important example in this regard and to reveal the sensitivity and risk on Kizilirmak River Delta. Approximately 11% of the delta draws attention as a high sensitivity and risk zone. These zones must be taken into account by the local authorities and decision-makers. Thus, the habitats on the delta can maintain their functionality. Particularly, the eastern side of the delta has zones where the anthropogenic pressure must be taken under control.

The main problem encountered in the planning efforts made for protection purposes results from the lack of adequate, reliable and current information on the natural resources present in the planned region. This study also made an effort to produce more current and reliable data about Kizilirmak River Delta. We think that this data is important for serving as a basis for the local authorities and decision-makers.

ACKNOWLEDGEMENTS

This study was financially supported by the Scientific Research Unit of Balikesir University (Project no: 2015/155).

REFERENCES

[1] Nalbantoglu, G. (1982) Notes on the conceptualism of the environment and environment aesthetics. Mimar. Derg., 82, 23-25.
[2] Cimrin, F. (2014) Sociology and environment. Turkish Studies, 9, 1007-1020.
[3] Ozerkmen, N. (2002) From anthropocentric perspective to eco-centric perspective. Journal of DTCF, 2, 167-185.
[4] Cepel, N. (2006) Ecology, Nature Life Worlds and People. Palme Publishing, Ankara.
[5] Callenbach, E. (2012) Ecology: A Pocket Guide. Sinek Sekiz Publisher, Istanbul.
[6] Banai, R. (1993) Fuzziness in geographic information systems: Contributions from analytic hierarchy process. Int. J. Geogr. Inf. Syst., 7, 315-329.
[7] Yavuz, K.E. (2011) An important natural area: Kizilirmak Delta. Samsun Symposium
[8] Ozesmi, U. (2006) Ecosystems in the mind: Fuzzy cognitive maps of the Kizilirmak Delta wetlands in Turkey. arXiv preprint q-bio/0603022.
[9] Ozturk, D. and Sesli, A. (2015) Shoreline change analysis of the Kizilirmak Lagoonseries. Ocean Coas. Manag., 118, 290-308.
[10] Uzun, A. (2005) Anthropogenic changes in coastal of Samsun. Turkey Quaternary Symposium, Istanbul Technical University, Eurasia Institute of Earth Sciences.
[11] Yurtkuran, Z. and Saygi, Y. (2013) Assessment of pesticide residues in Karabogaz lake from Kizilirmak Delta, Turkey. Bull. Environ. Contam. Toxicol., 91, 165-170.
[12] Uncumusaoglu, A.A., Sengul, U. and Akkan, T. (2016) Environmental contamination of heavy metals in the Yaglidere stream (Giresun), Southeastern Black Sea. Fresen. Environ. Bull., 25, 5492-5498.

[13] Yilmaz, F. (2006) Bioaccumulation of heavy metals in water, sediment, aquatic plants and tissues of Cyprinus carpia from Kizilirmak, Turkey. Fresen. Environ. Bull., 15, 362-371.
[14] Hustings, F. and Dijk, K. (1992) Bird census in the Kizilirmak Delta, Turkey, in spring 1992.
[15] Zhang, L., Liu, L.Q., Hu, H.B. and Dong, Y. W. (2009) Eco-sensitivity and countermeasures based on regional development - a case study of Qinzhou City. J. Ecol. Rural. Environ., 25, 16-20.
[16] Cao, J. (2011) Integrated GIS-based and analytic hierarchy process research on urban ecological sensitivity of Shanghai City, China. Geoinformatics, 2011 19th Int. Conf., 1-6.
[17] Wang, D., Wang, M. and Liu, J. (2011) Ecological sensitivity assessment in Taierzhaung based on '3S' technology. Remote Sensing, Environ. Transp. Eng. (RSETE), 2011 Int. Conf., 255-258.
[18] Liang, T., Cai, C.X., Liu, M. and Peng, X.L. (2007) Study on methodology of ecological suitability assessment of urban landscape, an example of Pingxiang. Geogr. Res., 27, 782-788.
[19] Cai, Z., Zhongi S., Jiang, W. and Lei, M. (2011) A schema of ecological environment sensitivity evaluation based on GIS. 2011 Int. Conf. Multimed. Technol., 5250-5255.
[20] Gao, C. and Zhang, J. (2011) Ecological sensitivity analysis in Wuhan city based on RS and GIS. 2011 Int. Conf. Remote Sensing. Environ. Transp. Eng., 251-254.
[21] Wang, K., Tian, G.H. and Cui, L. (2009) Ecological sensitivity analysis in Tongshan scenic spot based GIS and RS. J. Northeast For. Univ., 37, 200-203.
[22] Li, J., Hu, Y., Liu, Z. and Liu, M. (2010) Ecological suitability evaluation for eco- tourism in Qipanshan area. 2010 Int. Conf. Web Inf. Syst. Min., 112-119.
[23] Erdem, O. (2013) The Importance, Function and Value of Wetlands. In: Wetlands. Ministry of Forestry and Water Management, Ankara, 67-80.
[24] Karadeniz, N., Tiril, A. and Baylan, E. (2009) Wetland management in Turkey: Problems, achievements and perspectives. African J. Agric. Res, 4, 1106-1119.
[25] Arslan, H. (2007) Assessment of groundwater quality in Bafra plain for irrigation. Jour. of Tekirdag Agricultural Fac., 4, 219-226.
[26] Baldwin, A. H. and Mendelssohn, I. A. (1998) Effects of salinity and water level on coastal marshes: An experimental test of disturbance as a catalyst for vegetation change. Aquat. Bot., 61, 255-268.
[27] Maurer, B.A. (1993) Biological diversity, ecological integrity and neotrophical migrants: New perspectives for wildlife management. 24-31.
[28] Imeson, A. (2012) Desertification, Land Degradation and Sustainability. John Wiley and & Sons.
[29] Vaughan, I.P., Diamond, M., Gurnell, A.M., Hall, K.A., Jenkins, A., Milner, N.J., Naylor, L.A. Sear, D.A., Woodward, G. and Ormerod, S. J. (2009) Integrating ecology with hydromorphology: A priority for river science and management. Aquat. Conserv. Mar. Freshw. Ecosyst., 19, 113-125.
[30] Wu, X., Wang, Y. and Mao, W. (2013) GIS based construction land layout in ecological area. Int. J. Comput. Sci. Issues, 10, 25-30.
[31] Brionson, M.M., MacDonnell, L.J., Austen, D. J., Beschta, R.L., Dillaha, T.A., Donahue, D.L., Gregory, S.V., Harvey, J.W., Molles-Jr, M.C., Rogers, E.I. and Stanford, J.A. (2002) Riparian Areas: Functions and Strategies for Management, National Academy Press, Washington D. C.
[32] Wetzel, R., Adams, M., Almassy, A., Dinya, M., Eiseltove, M., Fustec, E. and Gibert, J. (1989) Nutrition, Energy and Water Flows Through Land-Water Ecotones. In: Role of Land/Inland Water Ecotones in Landscape Management and Restoration. UNESCO, 61-64.
[33] Periott, G. (1993) The importance of riparian vegetation to the health & stability of aquatic systems. 1-32.
[34] Meyer, W.B. and Turner, B.L. (1992) Human population growth and global land-use/cover change. Annu. Rev. Ecol. Syst, 23, 39-61.
[35] Cincontta, R.P. and Engelman, R. (2000) Human population in the biodiversity hotspots. Nature, 404, 990-992.
[36] Brashares, J.S. and Arcese, P. and Sam, M.K. (2001) Human demography and reserve size predict wildlife extinction in West Africa. Proc. Bio. Sc., 268, 2473-2478.
[37] Luck, G.W. (2007) A review of the relationships between human population density and biodiversity. Biol. Rev., 82, 607-645.
[38] Radeloff, V., Hammer, R.B., Stewart, S.I., Fried, J.S., Holcomb, S.S. and McKeefry, J.F. (2005) The wildland-urban interface in the United States. Ecol. Appl., 15, 799-805.
[39] Theobald, D.M., Miller, J.R. and Hobbs, N.T. (1997) Estimating and cumulative effects of development on wildlife habitat. Landsc. Urban Plan., 39, 25-36.
[40] Forman, R.T.T. and Alexander, L.E. (1998) Roads and their major ecological effects. Annu. Rev. Ecol. Syst., 29, 207-231.
[41] Develey, P.F., Stouffer, P.C. (2001) Effects of roads on movements by understory birds in mixed-species flocks in Central Amazonian Brazil. Conserv. Biol., 15, 1416-1422.
[42] Forman, R.T.T. (2000) Estimate of the area affected ecologically by the road system in the

United States. Conserv. Biol., 14, 31-35.
[43] Mech, D.L. (1989) Wolf population survial in an area of high road density. American Midland Naturalist, 121, 387-389.
[44] Eker, M., Acar, H.H. and Coban, O.H. (2010) The potential ecological impacts of forest roads. Turkish Jour. of Forestry, 1, 109-125.
[45] Pan, D., Jia, H. and Yuan, Y. (2014) A GIS-Based ecological safety assessment of Wushen Banner, China. Hum. Ecol. Risk. Assess.: An Int. Jour., 21, 297-306.

Received: **22.02.2017**
Accepted: **18.08.2017**

CORRESPONDING AUTHOR

Sermin Tagil
Balikesir University, Faculty of Arts and Sciences, Department of Geography, Cagis Campus, 10145, Balikesir/Turkey.

e-mail: stagil@balikesir.edu.tr