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Multifactor sensitivity assessment for spatial planning in Izmir, Turkey

Sensitivity assessment produces data to guide spatial planning by determining areas that need to be protected. Izmir, the study area of this article, is a city with rich ecological values but rapidly changing spatiality. This study determines ecologically sensitive areas of Izmir and reveals the relationship between ecologically sensitive areas and spatial planning decisions. To achieve this goal, ecologically sensitive areas are defined by the Analytical Hierarchy Process (AHP) and overlapped with planning decisions. The study evaluates ecological factors and processes using nine main parameters and twenty-one sub-parameters. Each of the parameters selected was divided into ecological sensitivity levels. The result of the analysis found 16.8% of the area to have very high sensitivity, 18.5% high sensitivity, 22.7% average sensitivity, 28.5% low sensitivity, and 13.5% very low sensitivity. A comparison of these areas with the 1:100,000 Environmental Regulation Plan decisions showed that the planning decisions are not compatible with the ecological sensitivities of the study area. As a result, the study provides an ecological sensitivity assessment model that can contribute to improving decision-making processes in urban plans.

Keywords: ecological sensitivity assessment, analytic hierarchy process, GIS, spatial planning, Izmir

1 Introduction

Today, the exploitation of resources and uncontrolled human activities are causing the rapid transformation or disappearance of ecologically sensitive areas (IPBES, 2019; Powers & Jetz, 2019; Almond et al., 2020). This destruction is leading to the loss of habitats and a decrease in biological diversity, also causing the loss of ecosystems, which are essential for human life (McPhearson et al., 2015; Ritchie & Roser, 2021). To prevent these losses, it is necessary to integrate decision-making processes with ecological sensitivities in the planning process. Many different assessment tools and methodologies have been developed that integrate decision-making processes with environmentally sound perspectives (Singh et al., 2012; Dizdaroglu & Yiğitcanlar, 2016). In this context, ecological sensitivity assessment is a tool for obtaining reliable information about the area from an ecological point of view and making appropriate planning decisions (Dai et al., 2012; Liang & Li, 2012; Xie et al., 2015; Leman et al., 2016; Niu et al., 2020).

Ecologically sensitive areas are areas that contain various ecosystems that are necessary for the long-term management of soil, water, and other natural resources, especially biodiversity. They include forests, wetlands, steep slopes, and agricultural land (Ndubisi et al., 1995; Steiner et al., 2000). Although there are many studies that define ecologically sensitive areas using different approaches (Jennings & Reganold, 1991; Steiner et al., 2000; Hong et al., 2017), ecologically sensitive areas are generally defined as the level of response and/or adaptability of an area to environmental changes caused by internal and external factors (Mingwu et al., 2010; Liang & Li, 2012). In particular, external interventions cause natural areas to undergo spatial change processes, such as perforation, dissection, fragmentation, shrinkage, or attrition (Forman, 1995). One of the main reasons for these changes is due to the development of spatially inappropriate land-use decisions (Dai et al., 2012). In the last three decades, ecological sensitivity analysis has become a cutting-edge field of research, especially in ecological and environmental assessment, in terms of evaluating and defining ecologically sensitive areas to help guide spatial planning (Liang & Li, 2012).

Many approaches and methods are used in ecological sensitivity analysis (Steiner et al., 2000; Xie et al., 2015; Leman et al., 2016). Whereas early studies focused more on the environmental problems of a single species or event (Liang & Li, 2012), later research focused on specific issues, such as erosion susceptibility, desertification, and soil salinization (Leman et al., 2016). In recent years, the scope of the subject has been expanded, and studies that deal with multiple factors at the same time have used different spatial scales. Some of these studies focus on a specific area, such as wetlands and river basins (Steiner et al., 2000; Mingwu et al., 2010; Butt et al., 2019; Chi et al., 2019), or nature reserves (Liang & Li, 2012; Düzgüneş & Demirel, 2016) and parklands (Deng & Hu, 2012), and other studies on spatial scales have been expanded with evaluations made at the urban (Zhang et al., 2011; Pan et al., 2012; Niu et al., 2020; Yilmaz et al., 2020) and regional scale (Dai et al., 2012; Xie et al., 2015; Leman et al., 2016; Hong et al., 2017; Tsou et al., 2017).

These studies, which aim to identify ecologically sensitive areas, are generally carried out using geographic information systems (GIS) and remote sensing techniques. Integrated methods offered by GIS, such as analysis, synthesis, spatial query, quantitative measurements, and data management, are used to identify sensitive areas. Among these integrated methods, there are studies using the Analytical Hierarchy Process (Huang et al., 2010; Mingwu et al., 2010; Leman et al., 2016), the Fuzzy Logic method (Zhang et al., 2011), and the weighting method with various approaches (Hong et al., 2017; Butt et al., 2019), and studies using a combination of some of these methods (Niu et al.; 2020). In particular, these methods evaluate the sensitivity of areas through parameters such as soil conditions, atmospheric conditions, biodiversity, and hydrological structure, and the study area is levelled within the determined parameters (Xie et al., 2015). In most studies, ecological sensitivity is addressed at four or five levels on a scale from extreme to non-sensitive (Zhang et al., 2011; Dai et al., 2012; Liang & Li, 2012; Pan et al., 2012; Niu et al., 2020).

It has been emphasized by many studies that inappropriate decisions about land use damage the functionality of ecologically sensitive areas (Su et al., 2011; Dai et al., 2012; Butt et al., 2019; Niu et al., 2020). Nowadays, spatial planning is expected to include new approaches presented by ecological sensitivity analysis to reduce the destructive effect of human activities (Steiner et al., 2000; Liang & Li, 2012; Leman et al., 2016). However, as a result of neoliberal policies, the real estate and construction sectors have become one of the critical sectors behind economic growth since the 2000s in Turkey (Balaban, 2012). As a result, the planning process has become one of the most critical tools that guide the public sector to implement this growth model in cities (Öktem Ünsal, 2023). In this respect, the planning system in Turkey has established a balance between the market and the public interest (Salata et al., 2022). Nevertheless, this growth model – which is supported by planning as well as other factors, such as authority confusion in planning and plan revisions – has given rise to urban sprawl and environmental degradation, and it has ignored areas with ecological sensitivity in cities.

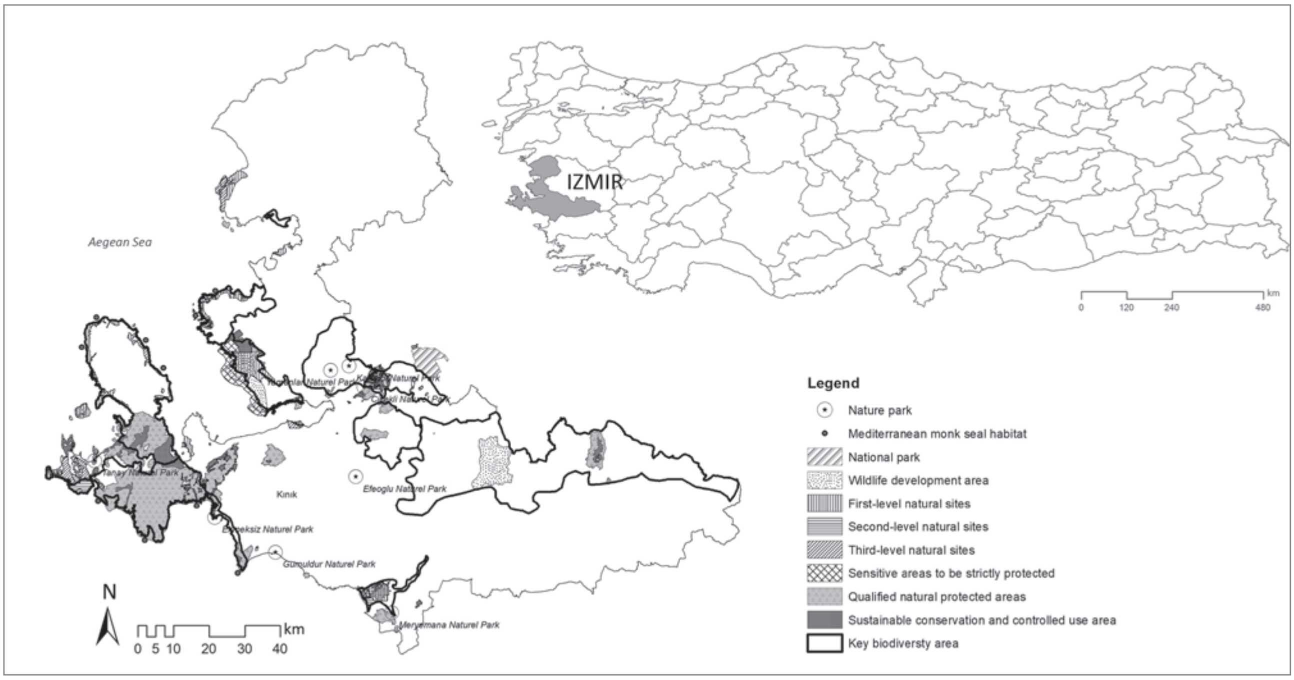

Figure 1: Location of the study area, regulated nature conservation areas, and key biodiversity areas (illustration: author).

This study determines areas of ecological sensitivity and compares them with the Environmental Regulation Plan (ERP) to reveal contradictions between planning decisions and ecological sensitivity, and to offer an ecological sensitivity analysis model that can assist decision-making processes for planning.

2 Materials and methods

2.1 Description of the study area

Izmir, which is the third-largest city in Turkey by population and urbanization rate, was examined as the study area (Figure 1). The morphological structure of the city, which covers 12,012 km^2, plays an important role in the formation of the natural and built environment.

The area has many different ecosystems, including terrestrial and aquatic ecosystems. However, Izmir has been affected by the migration waves experienced in Turkey since the 1950s, and it began to urbanize rapidly in the 1960s, which has led to increased pressures, especially on its ecosystems. Due to the wide ecological diversity of Izmir, conservation areas with various statuses (wildlife development areas, nature parks, natural monuments, Ramsar areas, special environmental protection areas, and natural protected areas of different levels) were created within the legal administrative framework. In addition, these areas are evaluated within the scope of the plans implemented in Turkey.

In Turkey, there are plans at different scales and scopes in the planning hierarchy. National development plans at the highest scale are followed by the national spatial strategy plan and ERP at scales of 1:100,000 or 1:25,000 prepared by the Ministry of Climate Change, Environment, and Urbanism. In addition, metropolitan municipalities prepare 1:25,000 and 1:5,000 master development plans, and district municipalities prepare 1:1,000 implementation plans. With regard to the plans and decisions guiding the spatial development of the city, many different plans were produced soon after 1923, but the 1:25,000 master plan for Izmir was approved in 1973. In this planning period, which was in force between 1973 and 2002, many different revisions of planning decisions at the 1:5,000 and 1:1,000 scales were also implemented. In 2007, the 1:100,000 ERP, which included the Izmir, Manisa, and Kütahya regions and was prepared by the central government, remained in effect until it was cancelled in 2011. In 2012, Izmir was designated a metropolitan municipality by law no. 6360, and in 2014 the entire provincial area became a metropolitan municipality. In 2013, the Metropolitan Municipality of Izmir implemented the 1:25,000 Izmir Metropolitan Whole Environmental Regulation Plan.

The new ERP, which covers the Izmir and Manisa regions, was prepared and implemented in 2014, and it is still in effect with revisions made at various dates. It received criticism from the public because this plan was not prepared using the current data for the area, and the process of creating the plan was also criticized (TMMOB, 2020; Salata et al., 2022). This plan is at the top of the planning hierarchy. Ignoring ecological sensitivities is one of the most significant problems of the plan.

2.2 Methods

2.2.1 Establishment of ecological sensitivity evaluation units

The method used in this study consists of five stages. In the first stage, the research area was divided into ecological units in accordance with the evaluation level of the inventory data. In the literature research, two different techniques are used for ecological units. The first of these is based on overlapping areas within the scope of each specified parameter according to the evaluation scale, and it is a technique in which vector data are mainly used (Mingwu et al., 2010; Zhang et al., 2011; Yilmaz et al., 2020). The second is the division of the area into cell units of certain sizes. This technique is mostly used in studies in which raster data alone are used, or raster data and vector data are used together (Dai et al., 2012; Leman et al., 2016; Hong et al., 2017; Butt et al., 2019; Niu et al., 2020). Within this study, the cell unit technique was used and all of Izmir was divided into a 500 × 500 m grid system, after which evaluations were made. The main reason for choosing this technique in this study was to obtain a data set that is compatible with the scale of the plan to be compared.

2.2.2 Selecting evaluation parameters

The second step is the selection of ecological sensitivity evaluation parameters. To objectively evaluate ecologically sensitive areas, the selection of appropriate evaluation parameters and determination of evaluation levels are of great importance for the accuracy of the study (Zhang et al., 2011; Leman et al., 2016). In addition, each parameter that plays a major role in determining ecological sensitivity should be selected based on the characteristics of the study area and the scale of the study (Hong et al., 2017).

Each parameter used for the research was determined to include ecological factors and processes, considering previous studies and the characteristics of the area (Table 1). Within the scope of the evaluation, two principal evaluation categories – ecological factors and processes – were applied to the study area. Ecological factors in the study are defined as features (topography, soil, microclimate, etc.) that determine the sensitivity of an area. In addition, the distance to industrial areas affects the ecological sensitivity of that area. Therefore, distance to industrial areas is considered a factor in this study. Ecological processes, which are not static, but instead have a dynamic structure, are defined as the ecological cycles that take place within an area. In addition, ecological processes are directly affected by the ecological characteristics of the area.

There are numerous processes in an area, including water infiltration into the soil, soil transport, and the carbon cycle. This study examines water infiltration and soil transport. In this context, the two evaluation categories were evaluated based on nine parameters and twenty-one sub-parameters. Five reference values were determined, ranging from 1 to 5 as follows: 1 = very low sensitivity, 2 = low, 3 = average, 4 = high, and 5 = very high. Reference values for all parameters were determined according to the relevant literature (Mingwu et al., 2010; Zhang et al., 2011; Dai et al., 2012; Deng & Hu, 2012; Pan et al., 2012; Düzgüneş & Demirel, 2016; Leman et al., 2016; Özhancı & Yılmaz, 2018; Alphan & Çoşkun Hepcan, 2019; Karadağ & Şenik, 2019; Niu et al., 2020; Yilmaz et al., 2020) and characteristics of the area.

The slope was the first sub-parameter analysed. The greater the slope, the less suitable an environment is for life. In particular, the slope degrees that make soil formation difficult adversely affect the growth of plant species. Aspect, as the second sub-parameter studied, impacts plant sensitivity, especially because it affects temperature and humidity. The northern sides of hills, which are shaded, have a denser plant texture and therefore are less ecologically sensitive due to the higher soil moisture content and higher organic matter content of the soil. On the other hand, the hotter and drier southern sides of hills lead to plants growing less frequently and therefore to being more sensitive against internal and external factors (Sternberg & Shoshany, 2001). In the elevation sub-parameter, the sensitivity levels especially for plants increase depending on the temperature as the elevation increases (Odum & Barrett, 2008). For the land capability sub-parameter, reference values are assigned according to the sensitivity levels of the land capability classification of the area. Class I–II soils are suitable for agriculture and have high sensitivity levels, whereas Class VII–VIII soils have low sensitivity levels. The soil groups sub-parameter was evaluated in terms of the properties of individual soil types and their sensitivity to internal and external factors.

To determine the ecological sensitivity of microclimate parameters, the data produced in the moderately optimistic climate scenarios (RCP 4.5) for Izmir in the book *A Framework for Climate Change Resistant Cities: A Green Oriented Adaptation Guide* are used (Alphan & Çoşkun Hepcan, 2019). The increase in the change in the average precipitation leads to an increase in the sensitivity. The average temperature sub-parameter was created according to the RCP 4.5 scenario, taking into account the geographical features of the areas where the annual average temperature changes decrease and increase.

Table 1: Evaluation parameters.

Parameter	Sub-parameter	Sensitivity				
		Very low	Low	Average	High	Very high
Factors						
Topography	Slope (%)	0–5	5–10	10–20	20–30	> 30
	Aspect	N	NE–NW	W–E	SE–SW	S
	Elevation (m)	0–100	100–200	200–500	500–1000	> 1,000
Soil	Land capability	VII–VIII	VI	V–IV	III	II–I
	Soil groups	—	Hydro-morphic soils, Regosols	Brown, chestnut, limeless brown forest, limeless brown, red Mediterranean, red brown Mediterranean, reddish chestnut, Rendzina, Vertisols	Brown forest, colluvial, reddish brown, organic soils	Alluvial soils
Microclimate	Avg. precipitation (mm)	—	—	50–150	150–200	> 200
	Avg. temperature	—	—	0.5 and 1	0.5 and –1	–2 and –1
Hydrology	Drinking water and basin conservation zone	—	Long-range	Medium-range	Short-range	Present and absolute
	Streams	—	—	—	—	Present
	Flood areas	—	—	—	—	Present
Habitat	Nature reserves (m)	—	—	500–1,000	500	Present
	NDVI	0.02 low	0.02–0.2	0.2–0.3	0.3–0.5	> 0.5
	Species diversity	—	—	—	—	Presence
	Forest canopy cover	Very low	Low	Average	High	Very high
Land use	Land cover	Urban-rural settlement	Arable land	Maquis, heather	Forest	Wetland
	Distance to city (m)	—	5,000	1,000–2,000	500–1,000	500
	Distance to village (m)	—	—	—	500–1,000	500
	Roads	—	—	—	—	Present
	Distance to cultural and archaeological site (m)	—	—	500–100	500	Present
Distance to industrial areas	Industrial zones	—	—	—	Small industrial and storage areas	Organized industry, waste-treatment facilities, mine sites, petrol stations
	Wind farms	—	—	—	—	Present
Processess						
Water infiltration		Very low	Low	Average	High	Very high
Soil protection		Very low	Low	Average	High	Very high

The drinking water conservation zone sub-parameter was evaluated in terms of the sensitivity level of the areas where dams and ponds are located, and their legal protection zones. Due to the study scale, the stream sub-parameter was evaluated only in the area where streams are located at the highest sensitivity level. With regard to the nature reserves sub-parameter, all the natural areas with legal protection status and the areas within 500- and 1,000-meter buffer zones were evaluated. The plant density of the area was determined by using the 2020 Landsat satellite image for the Normalized Difference Vegetation Index (NDVI) sub-parameter. As the value of the index becomes closer to 1, ecological sensitivity increases. One of the sub-evaluation criteria of the habitat parameter is species diversity. Within the study, only the species diversity data of the forest areas and key biodiversity areas (Eken et al., 2006) of Izmir were obtained. Because there are no data on the species diversity of the entire study area, only the regions where nature reserve areas are located were determined to be areas with very high sensitivity in the species diversity sub-parameter. In the forest canopy cover sub-parameter, the ecological sensitivity of the area was evaluated according to the extent of soil covered by crowns of trees. The land cover sub-parameter was determined within the scope of the use of the area.

The sub-parameters distance to a city, distance to a village, and distance to a cultural and archaeological site were evaluated in terms of distance to the built environment. Sensitivity of an area increases the closer it is to the built environment. Similarly for the road sub-parameter, the presence of roads increases ecological sensitivities in the area. The most important reason for this is that roads directly affect ecological flows. In the sub-parameter distance to an industrial area, the presence of industrial zones and wind farms was determined to be ecologically sensitive because it has a direct impact on the ecology. The sub-parameter water infiltration was evaluated in terms of the infiltration of water into the soil. Finally, in the soil conservation sub-parameter, places where erosion was high were determined to be ecologically sensitive areas. Based on the scoring system, the mapping process was carried out using the ArcGIS 10.4 program.

2.2.3 Weight scoring

The most commonly used method in determining weights is AHP (Dai et al., 2012; Liang & Li, 2012; Wang et al., 2014). AHP establishes a hierarchy based on a pairwise comparison between parameters by decision-makers or experts. The weight score of each parameter is obtained by determining the relative importance of the parameters evaluated with respect to each other (Saaty, 1990). A comparison is made according to the importance rating ranging from one to nine (1 = equally important, 9 = most important), and the score for the rating is taken as a basis. The weight coefficient of each parameter is calculated according to the number of parameters used. Accordingly, AHP was applied to determine the ecological sensitivity areas and to define weight scores for all parameters in this study. A pairwise comparison of the parameters was established by two expert decision-makers working on the Izmir Urban Transformation Roadmap Project. In this study, the WLC method, which is the most frequently used method in the literature, was used. This method weights the parameters and sums them according to the weighted average.

$$WLC = \sum_{i=1}^{n} w_i x_i$$

where WLC is the total sensitivity score, w_i is the weight score of parameter i, x_i is the score of parameter i, and n is the number of parameters.

2.2.4 Evaluation of integrated sensitivity areas

In the fourth stage of the study, the weight coefficients specified in Table 2 were used to obtain the integrated ecological sensitivity areas for Izmir.

2.2.5 Comparison of ecological sensitivity areas and the 1:100,000 ERP

The last methodological step in the study included a comparison of the integrated ecological sensitivity areas with the 1:100,000 ERP. Among the spatial decisions determined in the plan, six fundamental decisions that directly guide urban spatial development include housing development areas, industrial areas, organized industrial zones, logistics centre areas, public institution areas requiring a lot of space, and tourism areas. The data obtained were evaluated quantitatively on a provincial basis and then on a district basis. Although the legal boundaries do not overlap with the natural systems, the study compares the plan and ecological sensitivity area within the boundaries of a district to spatially evaluate the decisions. Areas with the highest conflict between the ecological sensitivity areas and the plan were determined at the district level. Based on these data, three regions with the highest conflict between ecological sensitivity and the plan (i.e., focus regions) were selected. In determining the focus regions, the geographical locations of the districts, their relations with the city centre, and the effect of planning decisions on spatial development dynamics were also taken into account. The focus regions are especially important because they make it possible to more effectively establish whether the plan decisions are appropriate in terms of the ecological sensitivity of space.

3 Results and discussion

3.1 Spatial distribution of Izmir's integrated ecological sensitivity areas

The study weighted the two main evaluation categories, ecological factors, and ecological processes, according to AHP. The consistency rate in the study for AHP carried out on ecological factors was determined to be 0.10, and this value meets the threshold consistency value determined by Saaty (1990).

Table 2: Weight coefficients of parameters used in the study.

Category, weight	Parameter	Weight	Sub-parameter	Weight
Ecological factors, 0.6	Topography	0.07	Slope	0.70
			Aspect	0.05
			Elevation	0.23
	Soil	0.15	Land capability	0.33
			Soil groups	0.66
	Microclimate	0.06	Avg. precipitation	0.50
			Avg. temperature	0.50
	Hydrology	0.26	Drinking water and basins	0.38
			Streams	0.44
			Flood areas	0.16
	Habitat	0.35	Nature reserves	0.46
			NDVI	0.14
			Species diversity	0.31
			Forest canopy cover	0.07
	Land use	0.04	Land cover	0.07
			Distance to city	0.50
			Distance to village	0.19
			Roads	0.50
			Distance to cultural and archaeological site	0.07
	Distance to industrial areas	0.01	Industrial zones	0.50
			Wind farms	0.50
Ecological processes, 0.4	Water infiltration	0.50		
	Soil conservation	0.50		

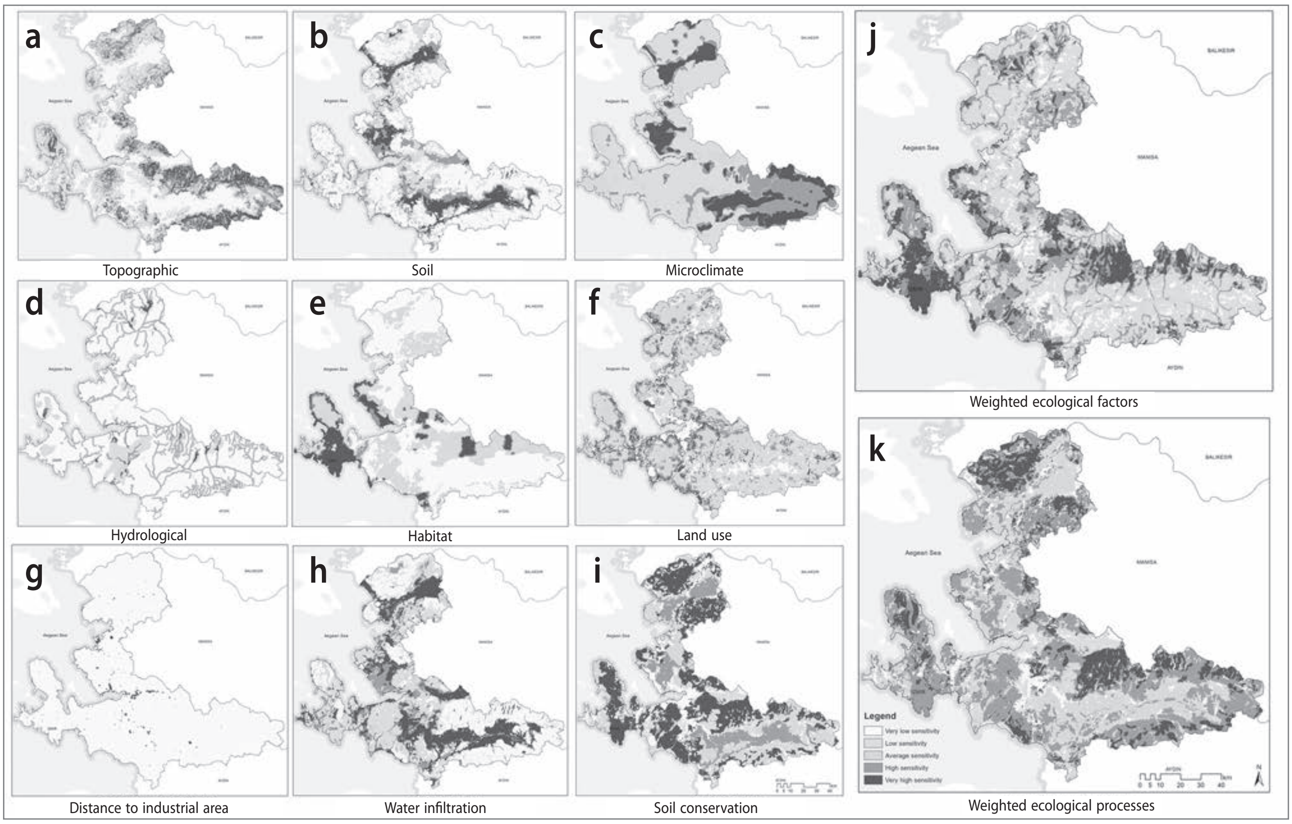

Figure 2: Ecological factors and process sensitivity: a) topography, b) soil, c) microclimate, d) hydrology, e) habitat, f) land use, g) distance to industrial area, h) water infiltration, i) soil conservation, j) weighted ecological factors, and k) weighted ecological processes (illustration: author).

Table 3: Ecological sensitivities of evaluation parameters by area (hectares) and percentage.

		Sensitivity									
Evaluation category	Parameter	Very low		Low		Average		High		Very high	
		Area	%	Area	%	Area	%	Area	%	Area	%
Ecological factors	Topography	362,070	30.4	299,400	25.1	199,100	16.7	227,175	19.1	103,550	8.7
	Soil	595,350	50.0	180,350	15.1	126,650	10.6	153,500	12.9	135,400	11.4
	Microclimate	642,650	53.9	127,000	10.7	87,725	7.4	193,825	16.3	140,100	11.8
	Hydrology	747,100	62.7	159,250	13.4	171,900	14.4	98,975	8.3	14,075	1.2
	Habitat	596,325	50.1	182,200	15.3	245,575	20.6	48,025	4.0	119,175	10.0
	Land use	136,350	11.4	309,650	26.0	460,525	38.7	216,650	18.2	68,125	5.7
	Distance to industrial area	1,181,050	99.1	—	—	—	—	1,125	0.1	9,125	0.8
Ecological processes	Water infiltration	355,714	29.9	295,073	24.8	140,162	11.8	130,862	11.0	267,806	22.5
	Soil conservation	170,706	14.3	150,088	12.6	272,559	22.9	164,309	13.8	433,566	36.4

Table 4: Levels of ecological sensitivity in Izmir Province by area (hectares) and percentage.

Sensitivity levels	Area	%
Very high	197,931	16.8
High	218,365	18.5
Average	268,310	22.7
Low	336,810	28.5
Very low	160,075	13.5

The parameters in the second evaluation category were determined based on the general characteristics of the study area and other studies in the literature (Dai et al., 2012; Deng & Hu, 2012; Leman et al., 2016; Mingwu et al., 2010; Niu et al., 2020). Using the method applied in the study, the areas that varied in ecological sensitivity for each parameter were determined and mapped (Figure 2, Table 3).

An integrated ecological sensitivity map was obtained after the weighted maps of the two main assessment categories were overlapped (Figure 3). The sensitivity levels established for all of Izmir Province are presented in Table 4. Examining the spatial distribution of the sensitivity levels on a district basis, the districts with very high sensitivity were Urla (62.2%), Çiğli (43.6%), and Bayındır (34.3%), and districts with high sensitivity included Karaburun (39.2%), Karabağlar (31.1%), and Çiğli (27.9%). Urla (74.6%), Çiğli (71.5%), and Karaburun (62.3%) districts stand out in terms of having very high and highly sensitive areas. Whereas some of these districts (Urla, Karaburun, Karabağlar, Çiğli) contain protected areas of various statuses, some of them (Bayındır) make significant contributions to the water cycle.

The size of areas with an average ecological sensitivity level in all of Izmir is 268,310 hectares, covering 22.7% of the entire province. Although the areas with this sensitivity level are distributed throughout the province, they are concentrated in the districts of Kınık (47.1%), Balçova (35.9%), and Menderes (33.3%). Areas with this level of sensitivity have average index values within the framework of the parameters selected due to a relatively uniform relationship between ecological values and environmental problems. However, the spatial decisions made in these areas (such as industrial areas, housing development areas, organized industrial zones, and tourism areas) have an effect on the sensitivity of the area. Accordingly, it is vital that the spatial decisions made in the future for these areas aim at nature conservation and that the principles of site selection be adopted by considering the balance of conservation and use.

Areas with low sensitivity are concentrated in northern and southwestern Izmir. Low sensitivity levels are concentrated in the Dikili (47.9%) and Bergama (38.8%) districts in the north, and also in the Beydağ (54.7%) and Kiraz (41.4%) districts in the south. Most areas have very low soil and habitat sensitivity, and most have low and very low sensitivity levels in terms of ecological processes. This shows that the planning decisions in these areas should be regulated by considering the sensitivity

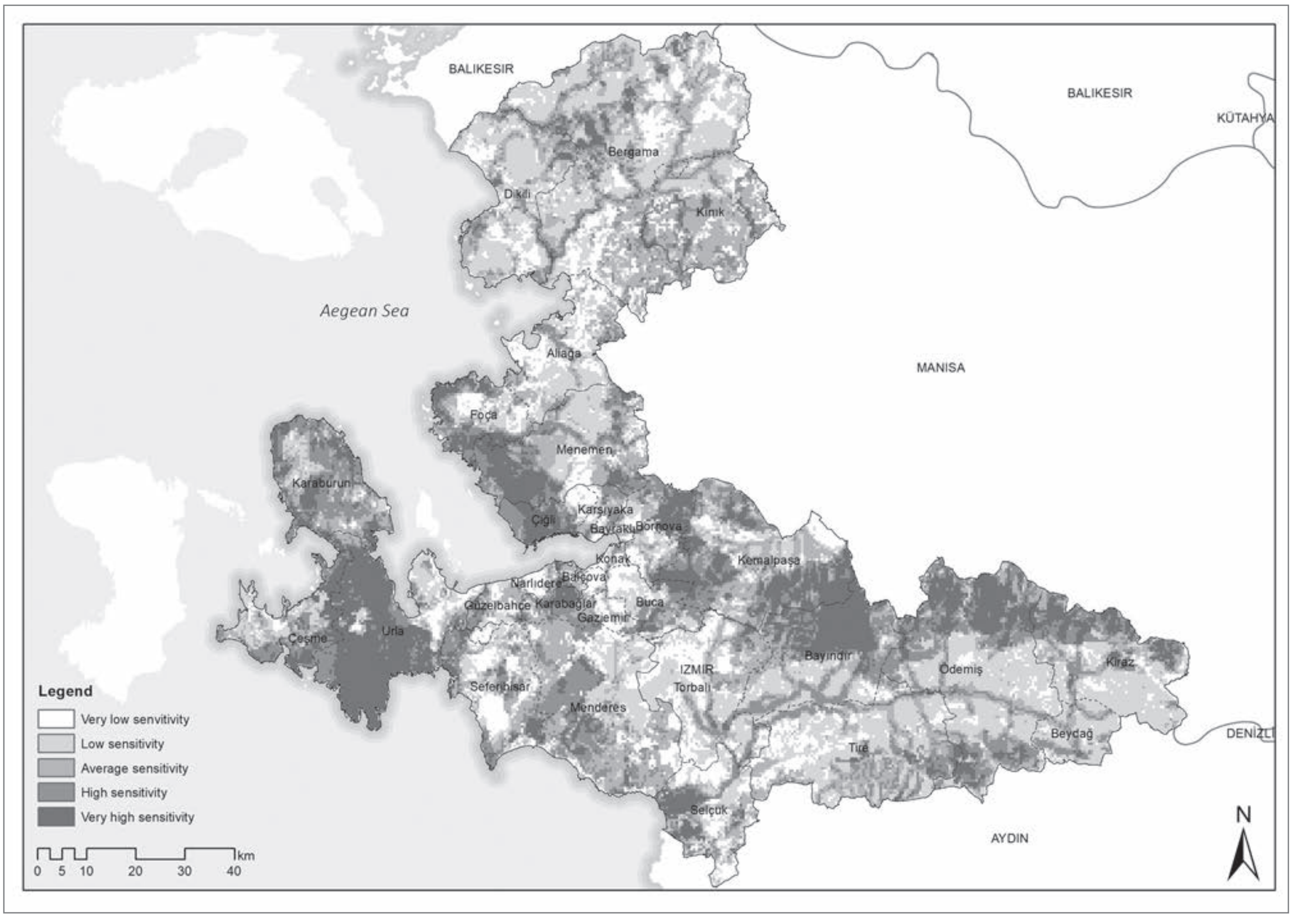

Figure 3: Integrated ecological sensitivity map of Izmir Province (illustration: author).

levels of the area. Accordingly, these areas should be studied in greater detail at sub-scales, and planning decisions should be made to improve their environmental characteristics.

The areas with very low ecological sensitivity in Izmir Province are concentrated in the Konak (45.4%), Narlıdere (44.3%), and Gaziemir (38.4%) districts. With regard to spatial distribution, these areas do not play a major role in terms of ecological processes and do not have legal protection status, especially in regions where the built environment predominates. Although these areas are suitable for construction, external interventions should be better managed by suitable spatial decisions and, due to the scale of this study, these areas require a more detailed analysis in terms of the parameters selected.

3.2 Comparison with the 1:100,000 ERP

The integrated ecological sensitivity map obtained in the study and the decisions determined in the 1:100,000 ERP were overlapped in the ArcGIS 10.4 program (Figure 4). Very high and high ecological sensitivity levels were compared against the 1:100,000 plan. It was determined that 69.6% of public institution areas requiring a lot of space, 10.3% of housing development areas, 48.6% of logistics centre areas, 19.6% of organized industrial zones, 8% of industrial areas, and 27.8% of tourism areas had a very high or high sensitivity level (Figure 5).

In this context, these values were reconsidered on a district basis. Accordingly, the districts that come to the fore in the entire province were evaluated in three focus regions within the scope of geographical location, relationship with the city centre, and the effect of planning decisions in terms of spatial development dynamics. The first focus region defined was the Northern Izmir focus region (covering the Aliağa and Menemen districts), the second was the Central Izmir focus region (covering the Çiğli district), and the third was the Peninsula focus region (covering the Çeşme, Karaburun, and Urla districts).

The Northern Izmir focus region has the most extensive industrial zone in Izmir Province. In the 1:100,000 plan, industrial area decisions were made by transferring the industrial areas from sub-scale plans (master and implementation zoning plan) to the plan. In addition, the surroundings of the existing industrial area have been expanded to serve industry. In this context, it is seen that the industrial site decisions in the area are made without paying attention to its ecological sensitivities. As a

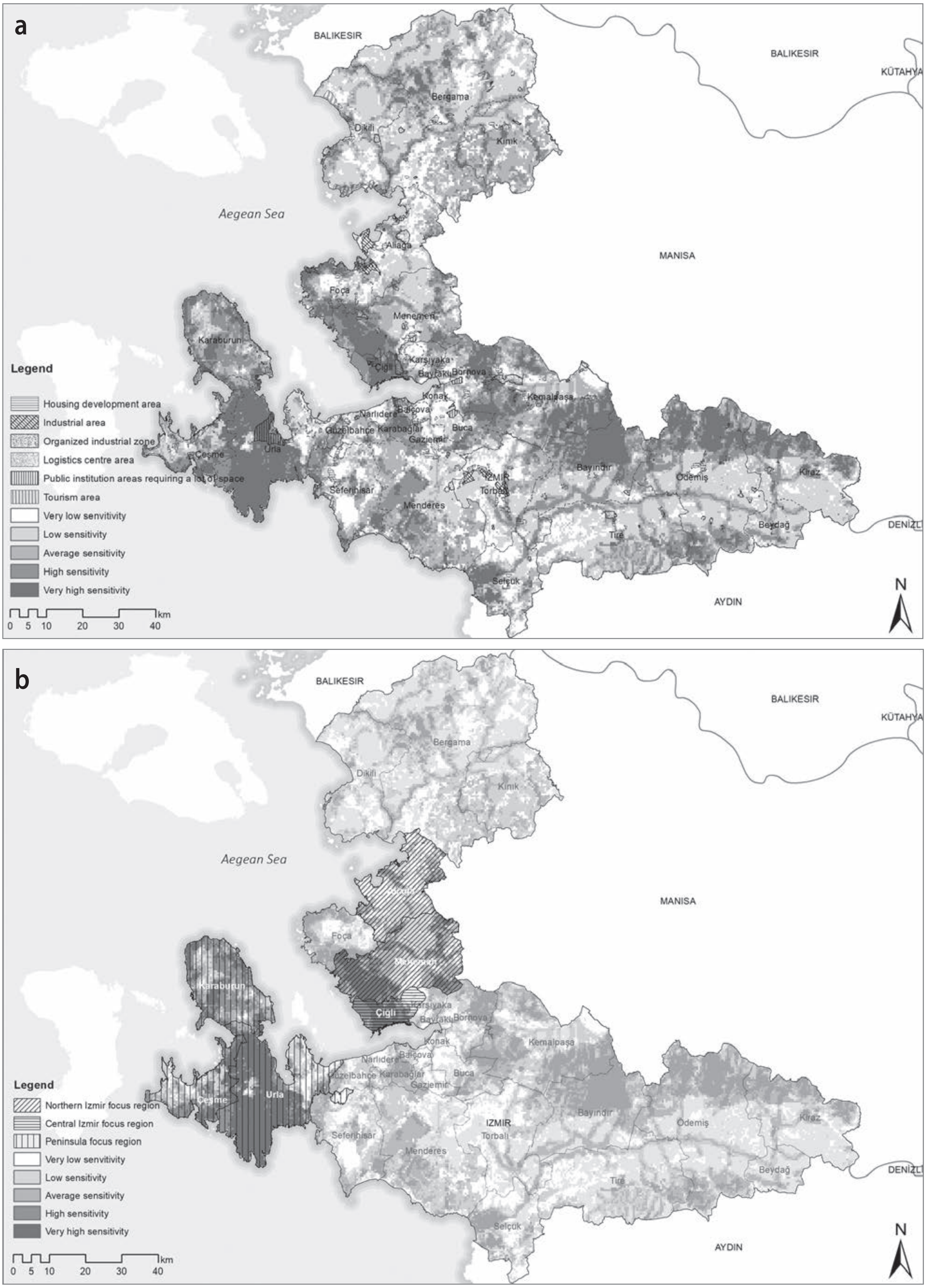

Figure 4: a) 1:100,000 planning decisions and ecological sensitivity map overlap, b) focus regions (illustration: author).

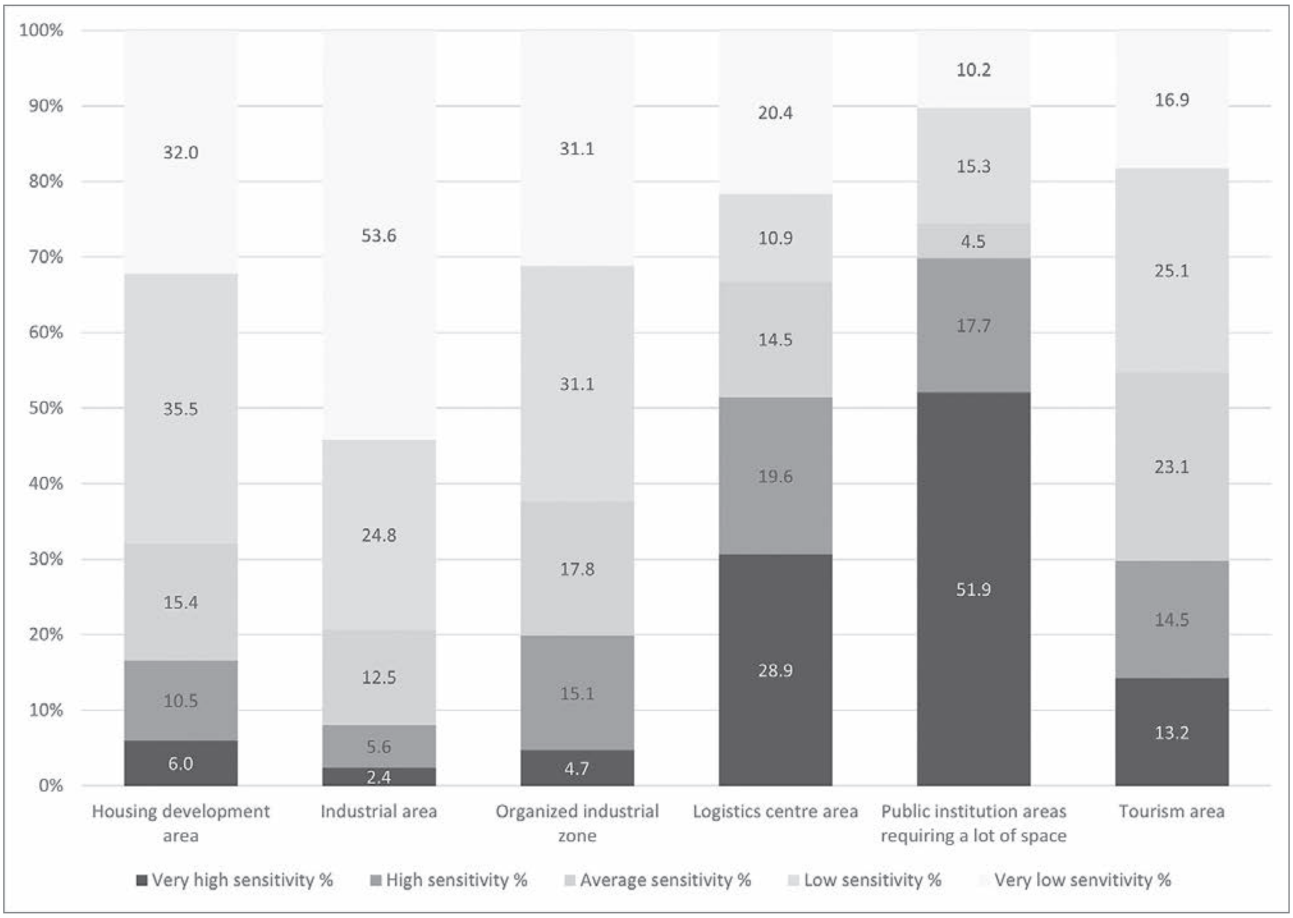

Figure 5: Comparison of 1:100,000 planning decisions with ecological sensitivity levels (illustration: author).

result, almost half of the industrial areas located in areas with very high and high sensitivity in Izmir are found in this region.

With regard to logistics centres, 48.6% of the logistics centre areas throughout the province are planned in areas with a very high or high level of sensitivity. Altogether, 27.2% of these are within the Northern Izmir focus region. Because this focus region is located particularly close to the city centre, many housing development areas and logistics centres are planned there. However, these planning decisions are not in conformity with the ecological sensitivity levels. This lack of conformity shows that the criteria prioritized by the plan do not follow an ecological point of view.

Housing development areas, logistics centre areas, organized industrial zones, and industrial areas come to the fore in terms of planning decisions in the Central Izmir focus region. The main reason for this is the aim of shifting the industrial and new residential areas to the north axis in the plan. Although this focus region, located just north of Izmir's city centre, covers the borders of a single district, many decisions that directly guide spatial development are made in a single district with an ecologically very high and high sensitivity level. Even though the region has important ecosystems and has a legal protection status, there is intense urbanization pressure on areas outside the region. The natural areas with legal protection status within this pressure area, which is also supported by the planning decisions, are under threat in terms of ecological functionality. The areas with very high or high ecological sensitivity are defined as housing development areas, logistics centre areas, organized industrial zones, and industrial areas in the ERP. This shows that areas with high ecological sensitivity outside the protected zones should be carefully planned and that the legal status of protected areas should not be changed in any way.

With regard to the planning decisions in the Peninsula focus region, tourism and public institution areas requiring a lot of space come to the fore. In particular, the location of public development projects that require a lot of space in areas with very high and high ecological sensitivity is a critical problem in terms of the ecological functionality of the region. Moreover, the Peninsula focus region has high ecological sensitivity, especially in areas without a conservation status that are under pressure from intense tourism and secondary housing development. This is particularly true for areas without a conservation status but with high ecological sensitivity that are defined as development areas in the 1:100,000 plan, and the changes made to the natural site levels within the scope of law no.

2863 are an indicator of the pressure of the construction sector in the area. In addition, the Culture and Tourism Protection and Development Region decision made for part of the area, apart from the ERP, similarly paves the way for construction even in the protected areas in the region.

In this context, it is necessary to protect areas with high ecological sensitivity to ensure the sustainability of such protected areas. In addition, planning is expected to direct development toward less sensitive areas. Accordingly, the level of sensitivity is critical, requiring planning decisions to be made correctly and effectively. If the ecological sensitivity map is used correctly, it can also provide an opportunity for development. Ecological sensitivities can be protected by detailing the planning decisions (such as tourism areas or housing development areas) in the planning notes. At this point, the ecological sensitivity map can be used to protect ecological sensitivities, as well as to produce planning decisions according to the ecological sensitivities defined. As a result, the planning decisions defined in the ERP should be revised for the three focus regions. For example, organized industrial zones and industrial areas should be planned in areas with low ecological sensitivity, and tourism and housing areas should be developed in line with their sensitivity levels.

Although currently only 10.95% of Izmir Province has legal conservation status, the share of areas with ecologically very high (16.8%) and high sensitivity (18.5%) was determined to be much higher than that. This includes natural areas protected by different legal statuses, as well as areas that are not protected by legal status but are of great importance in terms of ecological functionality. These areas with rich biological diversity are key in terms of ecological values and serve the system in terms of ecological functionality, but they are vulnerable to deterioration that may occur due to external interventions, especially human activities, and planning decisions that pose a threat to them. After the 1:100,000 ERP decisions were compared with the areas with ecologically very high and high sensitivity, it was determined that the plan's decisions are not suitable for the ecological characteristics of these areas. Moreover, the real sensitivities of the areas were not considered sufficiently during planning. It is therefore necessary to analyse multiple parameters with a holistic perspective on the study area to make planning decisions that take into account ecological sensitivities. The integrated ecological sensitivity map provides opportunities for revising the current 1:100,000 ERP and 1:25,000 Metropolitan Whole Environmental Regulation Plan.

4 Conclusion

This study examined the conflicts between the planning decisions made as part of the ERP and the sensitivities of ecosystems in the case of Izmir. A well-structured relationship between the plan content and real urban dynamics creates more sustainable living spaces. However, after the 2000s, neo-liberal policies in Turkey paved the way for a construction-oriented growth model. In addition, the ERP does not use the necessary methodological approaches to protect the environmental characteristics. The only limitation in the legislation is the legally determined conservation status. Nevertheless, in areas with high ecological sensitivity that are not protected, inappropriate spatial decisions can be regulated within the scope of the ERP. Considering the functions of ecological systems, grading in ecological sensitivity areas can be a tool to guide spatial development. This highlights the relationship between spatial development and ecological sensitivities while emphasizing the areas that need protection.

This study determined the sensitivity levels of the planning area and revealed the importance of making planning decisions according to these sensitivity levels. It shows that it is essential to adopt a more sustainable growth approach, such as green growth models, rather than construction-based growth models. In addition, the use of analysis for a holistic understanding of the ecological characteristics of an area, such as ecological sensitivity analysis, is another critical issue. Accordingly, an approach can be used for making planning decisions consistent with ecologically sensitive areas. In this respect, the research presents a new ecological sensitivity assessment model that will contribute to better decision-making in planning studies, especially in developing countries and distinct geographies.

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