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Investigation of suitable land use potential for industrial sites: the case of Kemalpaşa

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Abstract Kemalpaşa district (İzmir/Turkey), a significant area in terms of its natural and cultural characteristics alongside with its agricultural production, was selected as the specific site for the study at hand as its natural resources were endangered as a result of unplanned industrial settlement and development in the area. Therefore, the aim of the study was to ascertain the most suitable industrial sites for the area by taking natural factors into consideration, while excluding the economic ones. Within the scope of the study, a total of 13 criteria were set including wildlife development areas, protected areas, forest lands, olive groves, pastures, agricultural lands, water surfaces, streams, land capability areas, distance to residential areas, transportation (distance to roads), slopes, and erosion. Seventeen maps were created based on these 13 criteria and were used to select the suitable sites. The inquiries were conducted through the weighted linear combination technique and the analytic hierarchy process method utilizing the geographical information system software ArcGIS 10.2.1. The land use of Kemalpaşa is classified under five classes indicating different suitability values for industrial use and evaluating the land from "not suitable" (0) to "most suitable" (4). The results of the study revealed that 98.64% of Kemalpaşa district was "not suitable" (0) for industrial land use. The results further indicated that only 0.50% of the district was "suitable" (3) for industrial use, while 0.86% was found to be "most suitable" (4) to that end. Three alternative sites designated by the study and current industrial sites were evaluated based on protection criteria and planning proposals were suggested.

Keywords Industrial site selection · Weighted linear combination technique · Analytic hierarchy process · Geographical information system

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Introduction

While the selection of industrial sites highly affects an area and its surroundings in terms of sustainability (Puente et al. 2007), it proves to be a fundamental decision that ascertains the future balance between industrial activity and the environment (Fernandez and Ruiz 2009). Moreover, it has also been stated that its economic and environmental outcomes were key factors in regional planning and management (Sobhanardakani et al. 2013). Suitability standards should be set by taking scientific and legal criteria into consideration in site selection studies (Almodaresi et al. 2012). The goal within this framework should be to create a healthy and clean environment through planned industrialization (Veral 2008).

Industrial pollution is generally brought about by shortcomings in investment planning and site selection rather than sizable investments (Tanrıvermiş and Mülayim 1999). Economic, social, technological, etc. development endeavors mostly give way to disregarding environmental values as well. Yet, the ecological system should also be protected and sustained in order to render economic development persistent (Tıraş 2012). Changes in land use, developments in urbanization, and infrastructure cause divisions among natural habitats and endanger bio-diversity (Gontier et al. 2010). Land use differentiates while the increase in the use of natural resources moves to the disadvantage of natural balance depending on the increase in population and the diversified needs of human beings (Küçükali and Atabay 2013).

The primary goal of planning is to decide on the use of such resources (Marsh 2010). Planning reduces the negative effects of environmental conditions, while it improves the quality of life for human beings and spaces (Çetinkaya and Uzun 2014). Urban planning plays a key role in large-scale decision-making and management tasks (Ziaei et al. 2012). Urban planning is the procedure of sorting out suitable sites for various uses in line with social needs (Bhanderi et al. 2012). The significant aspect of land suitability analyses is not only their repeatability in the specified study area but also their applicability in, or at least their adaptability to other sites (Steiner et al. 2000). The selection of suitable sites necessitates taking the related factors into consideration in a comprehensive manner within a designated area and ascertaining its suitability by balancing out various goals for the determined type of land use (Jun 2000). Site suitability is not only dependent on physical aspects but also on economic factors as well (Bhanderi et al. 2012). The scope of suitability analyses, which can be applied to different sites and has to consider an ample number of opportunities and limitations for various types of land use within a logical framework, is predominantly based on existing data (Steiner et al. 2000).

The complicated process of site selection also involves physical, economic, social, environmental, and political necessities that may be at variance with one another (Jun 2000; Eldrandaly et al. 2003; Nair and Gupta 2010). A balance should be maintained between economic development and environmental protection (Çinier 1991). One of the recent issues considered in the selection of industrial sites has been the prevention of possible environmental problems and the proper utilization of all resources (Ziaei et al. 2012). This selection should be carried out in such a structure that necessitates a multi-criteria analysis involving economic, environmental, and social factors (Ohri et al. 2010).

Geographical information systems and multi-criteria decision-making techniques are commonly used together in site selection studies (Jiang 2007; Rikalovic et al. 2014). While spatial suitability is determined for the localization of industrial sites through the multi-criteria analysis method in which the process is accelerated by the utilization of analyses in geographical information system (Rachdawong and Apawootichai 2002), it has been stated that the method could also be used to assess existing industrial sites (Puente et al. 2007).

Material and method

Material

The principal material of the study is the study site (Fig. 1). The study site is limited to the administrative borders of Kemalpaşa district in İzmir (Turkey). The natural and cultural characteristics of the district influenced the selection of the study site. Kemalpaşa district in İzmir is 29 km away from the city center and is located on the eastern border of the city. The study site is formed by the district's administrative borders at 38° 34′ 0.2″ northern latitude and 27° 15′ 31.1″ eastern longitude with 38° 17′ 34.5″ northern latitude and 27° 43′ 27.5″ eastern longitude. The study site has about 730.35 km^2 of surface area.

The history of the district dates back to the Late Neolithic-Early Bronze Age (Kayan 1999). The district's basic means of livelihood are agriculture, stockbreeding, and industry (Kemalpaşa Municipality 2014). The total population of Kemalpaşa is 99,626 according to the data provided by the "address-based population registration system of 2014" (TUIK 2015). The district proves to be one of the significant districts of İzmir because of its proximity to the city center, its fertile lands, agricultural production, industry, nature, history, and touristic value. The unplanned settlement and development of industry in Kemalpaşa affected the district in economic, ecological, and cultural ways. The current industrial sites in the district had been built on fertile agricultural lands. The population rapidly went up as a result of the increase in the number of industrial plants and of the impact brought about by the influx of immigrants to the district. The district has experienced and is still going through a rapid development and urbanization process by virtue of all these factors.

Fig. 1 The geographical location of the study site (the map was created by combining data offered by Google Earth 2018; General Command of Mapping 2018 and Anonymous 2012)

The most significant factors that enabled the settlement and development of industry in the Kemalpaşa Plain were geographical location, proximity to İzmir, suitable topographical structure, available labor force and market opportunities, and rich water sources (Gül 2005).

The criteria and data sources investigated within the framework of the study are presented in Table 1.

Method

The research method is comprised of five parts in accordance with the goals and targets of the study. These are as follows (Fig. 2):

(1) Determination of criteria and limiting criteria, (2) Preparation of data layers for the criteria, (3) Determination of suitability values for the criteria,

Table 1 The criteria and data resources utilized in the study

No	Criteria title	Data type and source
1	Wild life development	Digital, (State Hydraulic Works, Region II, Region II, 2012)
2	Protected areas	Digital, (Directorate of the Regional Board of Cultural Heritage Preservation in İzmir No 2, 2012)
3	Vegetation (forest border)	1/25000 scale, (Anonymous 2012)
4	Olive groves	1/25000 scale, (Anonymous 2012)
5	Pastures	1/25000 scale, (Anonymous 2012)
6	Agricultural lands	1/25000 scale, (Anonymous 2012)
7	Water surfaces	Digital, (State Hydraulic Works, Region II, 2012)
8	Streams	Digital, (State Hydraulic Works, Region II, Region II, 2012)
9	Land capability class	1/25000 scale, (Anonymous 2012)
10	Settlement	1/35000 scale aerial photograph, (General Command of Mapping 1976; 1977)
11	Transportation	1/25000 scale, (Anonymous 2012)
12	Slope	1/25000 scale, standard topographical map (General Command of Mapping 2000)
13	Erosion	1/25000 scale, (Anonymous 2012)

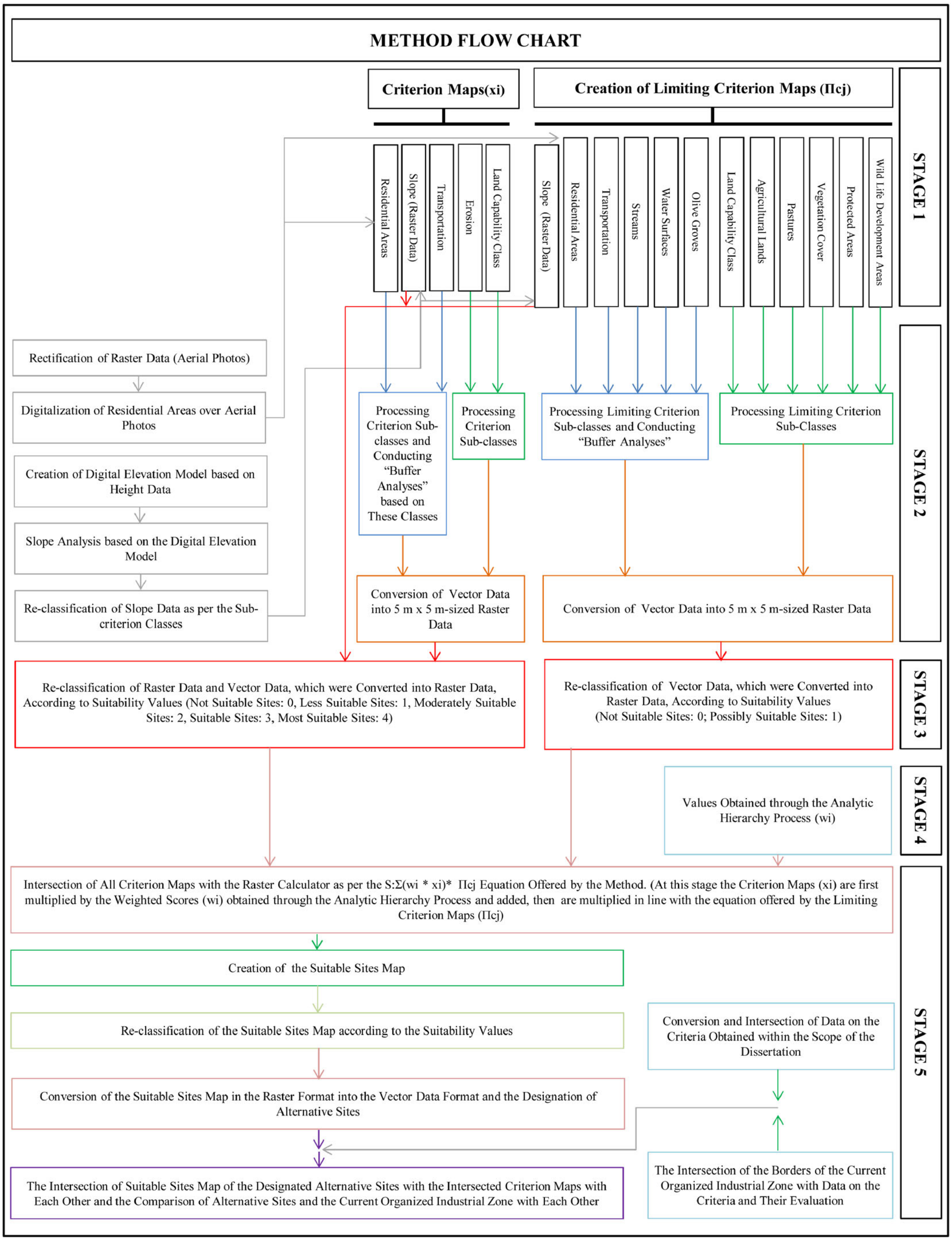

Fig. 2 Method flow chart

limiting criteria, and sub-criteria, (4) Determination of criteria weights through the analytic hierarchy process, (5) Creation of suitable lands map through the weighted linear combination technique.

Determination of criteria and limiting criteria

Expert evaluations, previous studies on the subject in literature, and the related legislation provisions concerning the study site have been taken into consideration when the "criteria" and "limiting criteria" on the selection of industrial sites were determined. The results of the evaluations revealed that wildlife development areas, protected areas, forest lands, olive groves, pastures, agricultural lands, water surfaces, streams, land capability areas, distance to residential areas, transportation, erosion, and slopes were to be set as "criteria and limiting criteria" within the scope of the study (Table 5).

Preparation of data layers for the criteria

ArcGIS 10.2.1 geographical information system software alongside with the 3D Analyst and the Spatial Analyst modules of the same software was used to prepare, process, and inquire data for the criteria set within the framework of the study. ED 1950 UTM Zone 35N was defined as the projection coordinate system for all the data layers used in the study. The data layer for the criteria was prepared and/or obtained in the raster and vector data format. Proximity analysis' Buffer tool was used to create sub-criteria maps. Digital data that would be used in the suitability analysis were converted into raster data. The pixel size was sampled as 5 m × 5 m in all data layers. The scores of the set "criteria," "limiting criteria," and "sub-criteria," were converted into a standard scaling in order for these to be combined in accordance with the method. Therefore, all the data layers in the raster data format and/or the converted data layers were re-classified as per the suitability values presented in Table 2.

The Map Algebra tool of the Spatial Analyst module was used to obtain the map of suitable sites for industrial use in Kemalpaşa district through combining the criteria maps *(xi)*, criteria weighted values (*wi*) ascertained by utilizing the "analytical hierarchy process," and limiting criteria maps (Πc_j) in accordance with the "weighted linear combination technique."

Table 2 The suitability values for sub-criteria in criteria maps

Suitability value	Suitability level
"0"	Not suitable
"1"	Less suitable
"2"	Moderately suitable
"3"	Suitable
"4"	Most suitable

Determination of suitability values for the criteria, limiting criteria, and sub-criteria

Literature review on the research subject, related legislation, the unique qualities of the research field, and experts' evaluations was taken into consideration in the determination of the suitability values of "sub-criteria" which would be utilized within the scope of the analyses for data layers (criteria maps) that were obtained from the data acquired for the research field and scoring was conducted accordingly.

A five-stage scaling was carried out for the mapping of criteria and the evaluation and standardization of sub-criteria and scoring was conducted by allocating values of 0, 1, 2, 3, and 4 (Table 2).

"Sub-criteria for limiting criteria" were formed by using Boolean Constraint "0 and 1" values. The value "0" signified not suitable sites, in other words, the *sites which were not possible/suitable for usage as per the regulations or according to experts' evaluations* within "not suitable sites" maps formed depending on these values. Moreover, the value "1" referred to those sites other than these and represented "possibly suitable sites" in cases where other criteria were suitable. In this way, the not suitable sites were able to be masked having taken the value "0" as per the method. Furthermore, "criteria weighted values" could not be determined for the "limiting criteria maps" pertaining to *wildlife development sites, protected areas, forest lands, olive groves, pastures, agricultural lands, water surfaces, and streams* as solely the condition of being suitable and not being suitable was taken into consideration. The analytical hierarchy process, however, was utilized to ascertain the criteria weighted values pertaining to *land capability areas, settlement, transportation, slope, and erosion* criteria.

Öztürk and Batuk (2007) have stated that one of the methods yielding the most accurate results in calculating weighted scores was the pairwise comparison method, further arguing for the necessity to consult experts on the issue when needed when working with such methods that were based on subjective evaluations (Öztürk and Batuk 2007). The method utilized in this study explained that the analytical hierarchy process (AHP) was selected as the method to designate criteria weights as it enabled the condition that the sum of "weight values" which would be used as the criteria factor should be "1" (Eastman et al. 1995). The goal was to achieve differentiation of various usages/criteria and interactions in the study field according to their levels of significance pursuant to the application of the weighting procedure. Table 5 presents all the criteria, sub-criteria, suitability values, and suitability levels investigated within the scope of the study.

Determination of criteria weights through the analytic hierarchy process (AHP)

Saaty (2000) has defined the analytic hierarchy process as a decision-making mechanism that human beings were never taught but intuitively adopted when dealing with decision-making problems (Sağır Özdemir 2002). The analytic hierarchy process is a theory that assesses the priority/significance value based on experts' judgments by conducting pairwise comparisons. Such comparisons are carried out through absolute judgments which demonstrate that a criterion is more dominant/significant than another one based on its given attributes (Saaty 2008). The process is used in deriving a relative scale from both intermittent and continuous pairwise comparisons. These comparisons can both be from real measurements and from preferences and sentiments that relatively reflect a fundamental scale (Saaty 1987). Although the analytic hierarchy process is a commonly used method in multi-criteria decision-making (Sağır Özdemir 2002), it is at the same time a method that can be utilized in both physical and social fields to conduct measurements (Saaty and Vargas 2006).

A scale of numbers, which indicates how many times more important or dominant one element is over another element with respect to the criterion or property pertaining to which they are compared, is needed to make comparisons (Saaty 2008). In cases where judgments are used instead of ratios in the comparison, the fundamental scale (Table 3) on which the AHP method is based is utilized (Saaty 2004).

Following the measurement of relative significance of criteria is conducted; matrix consistency is measured (Sağır Özdemir 2002). When "matrix consistency" is measured below 0.1, this signifies that the matrix consistency is at an acceptable level (Saaty and Ramanujam 1983; Saaty 2004). In the event that this value is surpassed, it is suggested that corrections be made in the judgments (Saaty and Ramanujam 1983).

Seven experts, who were serving as professors at the departments of landscape architecture, urban and regional planning, soil science, and plant nutrition in various faculties, were consulted within the framework of the study by using the analytic hierarchy process to obtain the weight values. These professors were experts in the "field, method, and/or study of research who worked on planning, natural preservation, geographical information systems, regional planning, and planning of industrial sites." Table 4 presents the "criteria weight values" of site selection for industrial sites in Kemalpaşa district that were calculated pursuant to expert judgments. When the results were scrutinized, it was seen that the experts participating in the survey evaluated that the "land capability area criterion" was about twice as more important than the transportation and settlement criteria which had the closest scores to it and that the settlement and transportation criteria got similar scores. It was also observed that the slope criterion got the

Table 3 The fundamental scale of the analytic hierarchy process (Saaty 2004)

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
2	Weak or slight	
3	Moderate importance	Experience and judgment slightly favor one activity over another
4	Moderate plus	
5	Strong importance	Experience and judgment strongly favor one activity over another
6	Strong plus	
7	Very strong or demonstrated importance	An activity is favored very strongly over another; its dominance demonstrated in practice
8	Very, very strong	
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation

Table 4 Criteria weight values measured pursuant to the analytic hierarchy process

Criteria (n)	Criteria weight (W)
Land capability areas	0.368
Settlement	0.191
Transportation	0.190
Erosion	0.139
Slope	0.113
Consistency ratio (CR) = 0.013	CR<0.1 Matrix is consistent.

Table 5 The criteria, suitability values, and levels investigated within the scope of the study

Sub-criterion	Suitability value	Suitability level	Criterion weight	Sources used[1]
(1) Limiting criterion/wild life development				
Wild life development area	0	Not suitable		Land Hunting Code (2003), Sapmaz et al. (1997), Reisi et al. (2011), and Sobhanardakani et al. (2013)
Non-wild life development area	1	Suitable sites		
(2) Limiting criterion/protected areas				
Protected areas	0	Not suitable		Code of Protection of Cultural and Natural Properties (1983) and Resolution-658 (1999) with Resolution-728 (2007) and Sapmaz et al. (1997)
Non-protected areas	1	Suitable sites		
(3) Limiting criterion/vegetation (forest land)				
Forest lands	0	Not suitable		Forestry Code (1956), Rachdawong and Apawootichai (2002), Dudukovic and Stanojevic (2005), Jiang (2007), Akten (2008), Ohri et al. (2010), Yeşil (2010), and Reisi et al. (2011)
Non-forest lands	1	Suitable sites		
(4) Limiting criterion/olive groves				
Olive grove borders + 3000 m protection band	0	Not suitable		Code of the Improvement of Olive Cultivation and Wild Olive Grafting (1939), Regulation on the Improvement of Olive Cultivation and Wild Olive Grafting (1996)
Non-protection band	1	Suitable sites		
(5) Limiting criterion/pasture				
Pastures	0	Not suitable		Pasture Code (1998)
Non-pasture sites	1	Suitable sites		
(6) Limiting criterion/agricultural lands				
Absolute agricultural lands	0	Not suitable		Code of Soil Protection and Land Use (2005)
Planted agricultural lands	0	Not suitable		
Irrigated agricultural lands	0	Not suitable		
Special produce lands	1	Suitable sites		
Non-agricultural lands	1	Suitable sites		
(7) Limiting criterion/water surfaces				
Water surfaces + 5000 m protection band	0	Not suitable		Regulation on Water Pollution Control (2004), Sapmaz et al. (1997), Rachdawong and Apawootichai (2002), Dudukovic and Stanojevic (2005), Ohri et al. (2010), Reisi et al. (2011), and Rikalovic et al. (2014)
Non-protection band	1	Suitable sites		
(8) Limiting criterion/streams				
Streams with water 0–200 m protection band	0	Not suitable		Regulation on the Control of Water Basins (2002), Sapmaz et al. (1997), Rachdawong and Apawootichai (2002), Bukhari et al. (2010), Ohri et al. (2010), Reisi et al. (2011), Almodaresi et al. (2012), and Sobhanardakani et al. (2013)
Dry stream 0–100 m protection band	0	Not suitable		
Non-protection band areas	1	Suitable sites		
Sub-criterion	Suitability value	Suitability level	Criterion weight	Sources used[1]
(9) Limiting criterion and criterion/land capability areas				
1st and 2nd class lands	0	Not suitable	0.368	Sapmaz et al. (1997), Akten (2008), Yeşil (2010), and Cengiz and Gönüz (2011)
3rd class lands	1	Less suitable		
4th class lands	2	Moderately suitable		

Table 5 (continued)

Sub-criterion	Suitability value	Suitability level	Sources used[1]	
6th class lands	4	Most suitable		
7th and 8th class (bare rock) lands	3	Suitable		
(10) Limiting criterion and criterion/settlement				
Settlement area + 250 m protection band	0	Not suitable	0.191	Regulation on the Evaluation and Management of Environmental Noise (2010), Rachdawong and Apawootichai (2002), Dudukovic and Stanojevic (2005), Ohri et al. (2010), Reisi et al. (2011), and Sobhanardakani et al. (2013)
Protection band between 250 and 500 m	1	Less suitable		
> 500 m and higher. Non-protection band	4	Most suitable		
(11) Limiting criterion and criterion/transportation				
Between 0 and 100 m	0	Not suitable	0.190	Rachdawong and Apawootichai (2002), Dudukovic and Stanojevic (2005), Jiang (2007), Akten (2008), Bukhari et al. (2010), Ohri et al. (2010), Yeşil (2010), Reisi et al. (2011), Almodaresi et al. (2012), Sobhanardakani et al. (2013), and Rikalovic et al. (2014)
Between 100 and 500 m	4	Most suitable		
Between 500 and 1000 m	3	Suitable		
Between 1000 and 2000 m	2	Moderately suitable		
> 2000 m and above	1	Less suitable		
(12) Limiting criterion and criterion/slope				
Between 0 and 2%	0	Not suitable	0.113	Taneri (1977), Eldrandaly et al. (2003), Jiang (2007), Rachdawong and Apawootichai (2002), Akten (2008), Bukhari et al. (2010), Ohri et al. (2010), Yeşil (2010), Cengiz and Gönüz (2011), Reisi et al. (2011), Almodaresi et al. (2012), and Sobhanardakani et al. (2013)
Between 2 and 6%	1	Less suitable		
Between 6 and 12%	2	Moderately suitable		
Between 12 and 20%	4	Most suitable		
> 20% and above	3	Suitable		
(13) Criterion/erosion				
None or mild erosion	4	Most suitable	0.139	Dudukovic and Stanojevic (2005)
Moderate erosion	3	Suitable		
Severe erosion	2	Moderately suitable		
Very severe erosion	1	Less suitable		

[1] The mentioned sources were reviewed within the scope of particular features of the research subject and field, while criterion/sub-criterion classifications and/or values were utilized and/or adapted following modifications in line with expert opinions

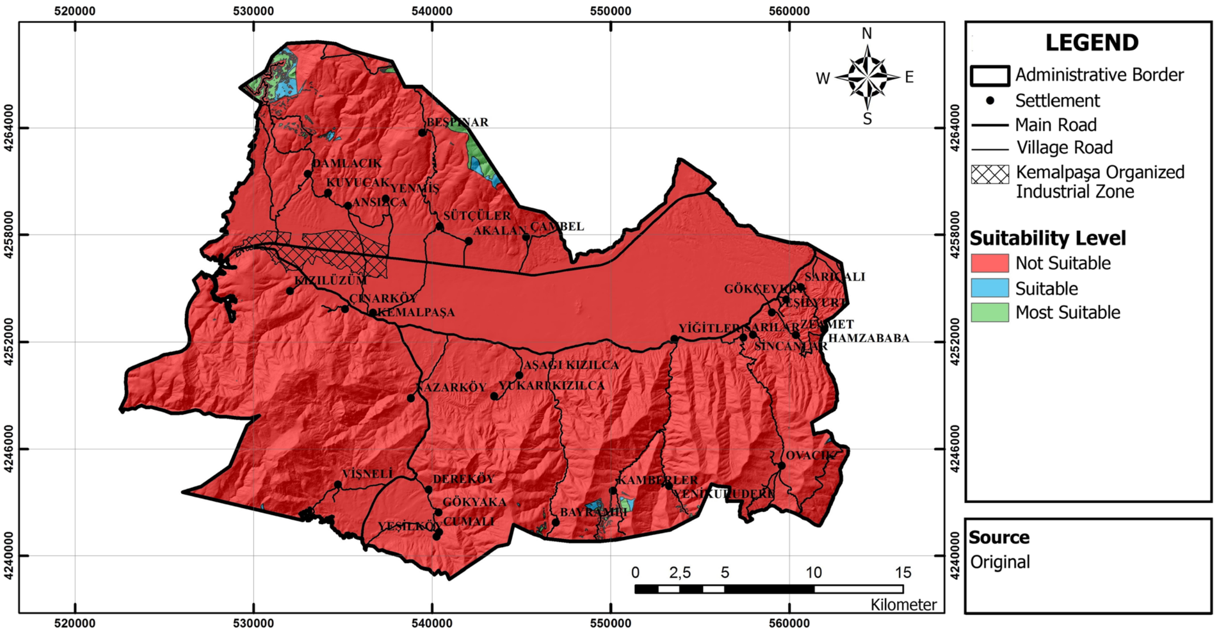

Fig. 3 The map of suitable sites for industrial use within Kemalpaşa district's administrative borders

lowest score as per the research subject and field example (Table 4).

Table 5 presents all the criteria, sub-criteria, suitability values, suitability levels, and criteria weights investigated for the site selection of industrial sites within the scope of the study.

Creation of suitable lands map through the weighted linear combination method

Eastman et al. (1995) cited Voogd (1983) stating that the most common method utilized in multi-criteria evaluation was weighted linear combination method. Hopkins (1977), Voogd (1982), and Eastman et al.'s (1995) studies were mainly used within the framework of the study to designate suitable sites. Modifications were done in the scoring and/or standardization of the particular criteria of the study. Consequently, "criteria suitability maps" were created by combining the scores of the suitability levels in accordance with the method used and a "suitable lands map" was finally produced following the classification, inquiry, and combination procedures (Fig. 3).

Following the creation of criterion maps after the multiplication of each criterion used in the study by criterion coefficients (criterion weight/significance level), all criteria maps were added giving way to suitability maps. While the mathematical equation of the procedure is $S\!: \; w_i \times x_i$, "S" refers to suitability, "w" refers to the weight coefficient of the criterion "i," and "x" refers to the score of the criterion "i" (Eastman et al. 1995). In the measurement of suitability by the inclusion of the "not suitable lands map" that would be created through the Boolean Constraint "0" and "1," the equality cited in Eastman et al.'s (1995) study was utilized. While the process of measurement of suitability in this case was set as $S\!: \; (w_i \times x_i) \times \Pi c_j$ in mathematical terms, the Π = in the "Πc_j," which signifies the Boolean limiting criterion, refers to the final product while "c_j" is the criterion score of the "j" = limiting criterion (Eastman et al. 1995).

Table 6 The suitability values, classes, and sizes obtained in the study

Suitability value	Suitability class	Surface area (ha)	Percentage (%)
0	Not suitable	72,034	98.64
3	Suitable	365	0.50
4	Most suitable	625	0.86
Total		73,024	100

Results and discussion

Figure 3 presents the "suitable lands map" which was obtained through the inquiry of 17 maps created by 13 criteria and data pertaining to these criteria within the framework of the study which was conducted in order to determine suitable sites for industrial use within the administrative borders of Kemalpaşa district.

The suitability values obtained as a result of the inquiries were between “0” minimum and “3.726” maximum. These values were distributed according to the suitability classification between “0” and “4” conducted at the onset of the study.

When Table 6 was examined, it was found that a total of 72,034 ha of area in Kemalpaşa district, in other words, 98.64% of the district’s surface area was “not suitable” for industrial use.

The results of the study also revealed that 365 ha of area was found to be “suitable,” while 625 ha was “most suitable” for industrial use within the district. Classes of “suitable” and “most suitable” sites together made up 1.36% of the district’s surface area (Table 6).

When the sites in the suitable sites’ map (Fig. 3) were generally assessed, it was observed that these sites had common features, namely, they were outside of wild life development areas, protected areas, forests, olive groves and 3000m protection bands, pastures, agricultural lands (except for special produce lands), dams and long-distance protection bands, and streams and stream protection bands. Moreover, these sites were at least 250 m far from the settlement areas, while the distance between them and transportation lines were 100 m minimum. When the land structure was generally addressed, it was found out that they had medium, severe, and very severe levels of erosion with land capability classes ranging between the “third class” and “bare rock” while land slopes were found to be 2% and more. Further, when the suitable sites were studied with regard to depth, it was observed that they had medium depth, bare rocks, and were predominantly located in shallow lands.

The necessary minimum surface area was measured through utilizing Taneri’s work (1977) when the suitable sites to be assessed within the scope of the study were determined. The active population within the total population was calculated and this figure was multiplied with the population working in industry. The Turkish Statistical Institute (2014) offered an average value of 31.8% for İzmir for the year 2013 and this figure was used for the rate of population working in industry. According to Taneri (1977), the intensity of industrial laborers was generally set at 50–100 individuals/ha. While the total population between 15 and 59 years of age in Kemalpaşa district was 64,636 according to the address-based population registry system’s age distribution results of 2014; the number of industrial workers was 20,554 when İzmir’s average of 31.8% was taken into consideration. When the intensity of 100 individuals/ha (100 individuals per 1 ha) was also taken into consideration, the necessary area was found to be 205.54 ha and if 75% of the existing sites were allocated

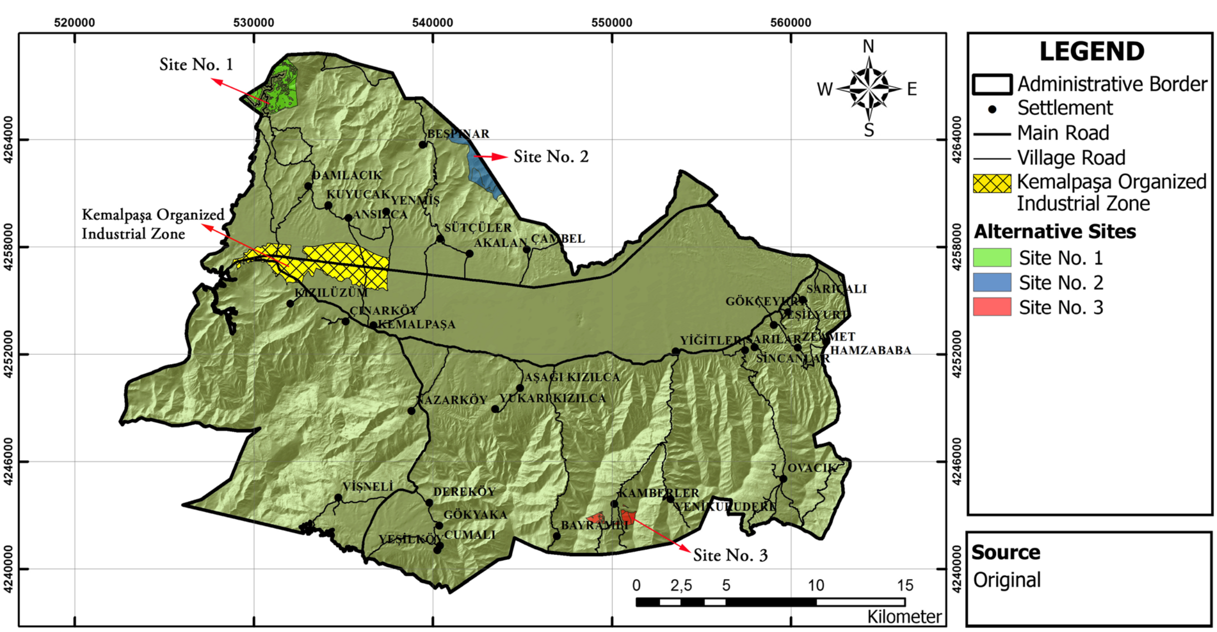

Fig. 4 The suitable alternative sites for industry within Kemalpaşa district’s administrative borders

Table 7 The sites assessed within the scope of the study and their sizes

Suitability value	Location	Surface area (ha)	Surface area (%)
Suitable (3)	Site no. 1, North West of Kemalpaşa	160.52	19.41
Most suitable (4)		245.23	29.66
Suitable (3)	Site no. 2, North East of Kemalpaşa	77.82	9.41
Most suitable (4)		243.79	29.48
Suitable (3)	Site no. 3, South East of Kemalpaşa	55.40	6.70
Most suitable (4)		44.11	5.33
Total		826.87	100

to industry, the necessary area size should have been measured to be 154.15 ha. If this percentage was 50%, the result would have been 102.77 ha. Among the "suitable" and "most suitable" sites, which were ascertained in the suitability map that was created through analyses, those that were and/or could be close and related to one another with a total of about 100 ha and more surface area were assessed. The location of suitable sites that were determined through analyses and the current industry in Kemalpaşa district is presented in Fig. 4.

When the data presented in Table 7 were assessed, it was found out that a total of 826.87 ha of area in the district was "suitable" and "most suitable" for industrial use.

The alternative sites as revealed by the results of the study are located in the north and south of the Kemalpaşa Plain, as was targeted within the scope of the objective of the study, where the productivity and workability of the lands diminished (Fig. 4). When the size of the surface area and the development opportunities were taken into consideration as per the surface area sizes measured based on the population data of Kemalpaşa district, it was seen that site number 1 proved to be the most suitable one. It was followed by alternative sites numbered 2 and 3. According to Tandy (1975), raw material, power supply, market opportunities, and waste needs should be met in site selection and the area size should be 250 ha. Further, enlargement opportunities three or five times this figure should exist. In the present case, however, the mentioned condition was only met by sites 1 and 2 without referring to enlargement opportunities (Table 7). When the current industry was assessed in terms of area size, it was seen that it met the conditions of both 250 ha of land and three to five times enlargement opportunity with its 1226 ha. 92.39% of the current organized industrial zone, however, is located on the first and second class agricultural lands. According to Kocamaz (1999), the first, second, and third class agricultural lands cannot be selected according to the procedures and principles of organized industrial zones as well (Kocamaz 1999).

According to results of Almodaresi et al.'s (2012) study, the appropriate sites are characterized by a sufficient amount of water source, a quality transport infrastructure beside a flat and smooth structure with respect to other areas in terms of slope and natural hazards. Marsh (2010) has stated that slope maps were used in land use planning studies with regard to environmental effects, infrastructure costs, and security reasons arguing that areas with less than 5% of slope should be used for large-scale commercial ventures and industry (Marsh 2010). Further, Steiner et al. (2000) have indicated that the most suitable sites were those that had less than 3% of slope with good drainage and had easy access to public services, while old settlement areas and agricultural lands that had a slope of 3 to 15% with average erosion were secondarily suitable lands (Steiner et al. 2000). If one takes into account the significance of developing technology and natural resources today, it is possible to offer multi-stage terracing for industrial sites located on lands with 20% or more slope. "Cost-benefit analyses" should be conducted about this condition which would be more costly in economic terms for both economic expenses and environmental gains.

When the three alternative sites were compared in terms of slope, it was seen that the first area had more suitable conditions as per slope. 92.77% of the current industry has less than 6% of slope, while the areas that have 20% and more slope are only 1.65%. The current industrial site has a rather suitable slope. It should, however, be remembered that the current site is settled on the Kemalpaşa Plain. Moreover, the selection of flat terrains close to rivers for industrial sites and the use of the first and second class agricultural lands to this end will bring about the disuse of fertile agricultural lands (Çakmak 1992). In cases where fertile lands are selected for industrial establishment sites, various wastes coming out of existing facilities will create environmental problems (Tanrıvermiş and Mülayim 1999).

In Kemalpaşa district, where flat and approximately flat lands prove to be fertile as per their location and features, the suitability values allocated to these lands are set at a low level. Nevertheless, the suitability scores are set at a high level in order to protect the existing structure as the slope increases having taken developing technology and construction techniques into consideration.

As is seen in the final map, three alternative sites which were created pursuant to criterion scores and weight calculations were designated within the framework of the study (Fig. 4).

When these sites are evaluated, it was found that site no. 1 is more suitable for industrial settlement in comparison to the other two sites as per its features. It should, however, be noted that environmental factors were taken into consideration with a goal to protect the environment in this study.

When factors other than environmental ones like economic factors (investment and infrastructure costs, etc.) and the low level of enlargement opportunities are regarded, the suitability of site no. 1 can also be a controversial issue. This study, on the other hand, is concerned with the sites on which industry should be settled within the borders of Kemalpaşa district without damaging the natural and cultural resources of the district.

Conclusion and suggestions

The selection of sites for industry is very important with regard to both economic and ecological concerns as per its consequences. The aim of this study, therefore, was to designate the most suitable industrial sites for Kemalpaşa district by prioritizing the district's unique characteristics, its ecological priorities rather than economic ones based on protecting natural resources.

The scope of the study field covers Kemalpaşa district's administrative borders. Thirteen criteria set in line with the reviewed literature and the obtained data were used in the study, and 17 maps related to these criteria were used in the analysis. Three alternative sites were designated following the results revealed by the criteria set within the framework of the study. The suitability of these sites, however, can also prove to be controversial when the alternative sites' enlargement opportunities and economic factors alongside with height and exposure criteria, which were not included in the study, are taken into consideration. It was observed that nowhere in the study area would have been suitable for industry particularly when the height criterion was incorporated.

The results of the study revealed that the total surface area of suitable and most suitable sites for industrial use within the borders of Kemalpaşa district was 990 ha and this figure accounted for 1.36% of the total surface area of the district. Those areas that were found to be not suitable were 72,034 ha and this figure referred to 98.64% of the total surface area.

The size of the existing organized industrial site in the district is about 1226 ha. As has been stated in the results of the study, 92.39% of the current organized industrial zone was located on the first and second class agricultural lands. According to the results of this study, these areas are not suitable for industrial settlement.

Economic, social, and ecological factors should be evaluated simultaneously when prudential decisions are taken with regard to settlements with fertile agricultural lands and forests whose economies are based on industry and agriculture as in the case of Kemalpaşa district.

In cases where different sites with the same qualities are designated in suitable site selection studies, the ones that are more suitable in economic terms should be preferred.

- In site selection studies, plains with fertile lands should not be selected.
- Such factors as the improvability and expandability of transportation systems should be taken into consideration in site selection studies. Locations in close proximity to airports, railways, highways, and harbors with regard to transportation opportunities should be preferred.
- In cases where suitable sites for industry are close to settlement areas, environmental harmonization of borders through both natural and structural screening practices would bring about positive results in terms of visual perception as well.
- Sites to the opposite of dominant wind direction should be evaluated in order to protect settlements or protected areas from pollutant factors when site selection studies are conducted having taken the dominant wind direction into consideration.
- The construction of infrastructure and treatment plants where industrial waste will be

discharged should simultaneously be planned and commissioned at the planning stage for industrial sites and wastewater should not be directly discharged into water sources and/or the site. Industrial sites should be in close proximity to or have easy access to solid waste landfill areas and/or recycling facilities.

- The flora should be taken into consideration in planning studies; forestry lands and species unique to the region should be protected. Along the same lines, measures should be taken to enable both regional flora and fauna not to be affected by new uses brought into the site and its habitat should be protected. Specifically endangered rare and endemic species should be regarded.
- The aquifers feeding underground water sources should be considered within the scope of suitable site selection studies and such sites should not be utilized as industrial sites.
- As "height" affects microclimatic and climatic features, it should be taken into consideration alongside with distance to fault lines, exposure, and areas at risk for floods and landslides.

Planning studies should not be conducted within a small-scale scope such as a city's and/or a district's administrative borders but they should be carried out within the framework of a goal set in line with the experiences and knowledge of expert groups on a nationwide or region wide basis. The most suitable sites for alternative uses (settlement, agriculture, industry, tourism, etc.) should be designated through a multidisciplinary perspective in this context. Usage decisions based on public interest and needs for different sectors should be taken by considering economic, ecological, and social factors. Accurate decisions should be taken by maintaining a balance between protection and usage when solutions are offered to meet needs. A sustainable structure and an outcome that bring about minimum environmental effect which simultaneously create maximum socio-economic benefit will be obtained in sites designated in this way.

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