Evaluation and Categorization of the Fishing Ports with a Fuzzy Spatial Multi Criteria Approach: The Case of Turkey

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Abstract

Fishing ports are the vital constituent of the fishery industry of Turkey. With governmental contribution, the number of the facilities reached to 366 and the collected fish volume has been in increasing trend in the recent years. However, due to the differences of the location characteristics and technical infrastructure of the facilities, each facility's success level is measured differently. Due to the mentioned differences, classification of the fishing ports and determination of the candidate alternatives for regional centers is a way to enhance the advantages of the scale economy. With this approach, improving infrastructures of the facilities and providing multiple services such as tourism and transportation activities can be possible. In this paper, a classification methodology based on fuzzy multi criteria spatial approach applied for classification of the Turkish fishing ports. Results showed that the methodology is capable of dealing with spatial and non-spatial characteristics of the data set and determine the convenient alternatives for regional fishing port centers.

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Keywords: fishing industry, fishing port location, f-AHP, Geographic Information Systems (GIS), location analysis

Introduction

Sea industry is an important instrument to sustain wealth in regional economies. There are different opportunities to create benefits from sea such as logistics transportation, public transportation, tourism or agricultural fishery planting or collecting fishes. The level of enhanced benefits from sea is related with policies and also the characteristics of the seas. With convenient facilities, the demand of the sea products can be covered, sightseeing activities can be provided and transportation opportunities can be supplied for a diverse range of distances. Within this context, Turkey is an important sea country with its 8303 km seaside and multiple sea based service potentials. The country has shores to four different seas which are Mediterranean, Aegean, Marmara and Black Sea. Each sea has different characteristics which causes a huge potential when considering the positive aspects of each sea.

In the last fifteen years, there has been a significant growth in the aquaculture sector of Turkey. Turkish aquaculture production has increased from 34,000 tons in 2000 to around 75,000 tons in 2009 (TURKSAT, 2011). Consequently, number of the fishing ports increased in accordance with the growth of the aquaculture production in Turkey. To be able to provide a better service level, fishing port investments are done by Turkish government with the aims of strengthen the regional economy and fishery industry. As the result of these investments, currently there are 366 fishing ports sprawled all over Turkey's sea side, and also lakes where the lakes characteristics are convenient for agricultural activities.

In addition to the increased numbers of the facilities and the agricultural capacities, the berthing capacity of Turkey's fishing ports is approximately 36.000 boats. However, the number of moored boats in the fishing ports is about 23.000 which causes 13.000 berthing capacity gap. This gap can be seen as unused capacity; however, due to the need of capacity for pleasure boats, the berthing capacity carries a potential use of the existing resources. The high number of the facilities and their infrastructure is in need of a better planning structure. Within this context, the pleasure boats and yachts are not alternatives to fishing boats, but supplementary for the use of those facilities. However since there are plenty of alternatives of fishing ports, these facilities should be evaluated to be used by different demand sources. Thus there is a need of comparison methodology which takes different characteristics of the new demands and infrastructural attributes of the facilities.

Piers, convenient physical dock structures, wintering capabilities, electricity supply are consisted the infrastructures of the fishing ports. These capabilities provide multiple services such as unloading, processing, storage and marketing of fish, as well as for maintaining and servicing the fishing fleet. Additionally, in some fishing ports sales outlet, transportation activities cooling and ice plant is existed for use of fishery industry. The mentioned capabilities are the needs of the fishing boats. When we consider the needs of the pleasure boats, they need convenient dock structure to keep their boats safe during berthing, electricity and security. During comparison of the existing fishing port service supply and the needs of the pleasure boats, it is seen that both are concordant. However there should be minor changes in the infrastructure to meet fully compatible with the needs of the boat users such as depth of the ports, shower and security services.

On one hand, for using the slack in the capacity necessary improvements in the infrastructure is required. On the other hand, new investment decisions can lead to create regional centers due to the new attractions such as new tourism destinations, yacht rallies and other activities. It is possible to merge regional demands on several issues to benefit from scale economy. With the new policy, each region can be served by a regional hub which will provide different services such as farming, public and mass transportation, and tourism centers with sightseeing and mooring capabilities. As the result of the region will have the chance of creating new labor force opportunities. For the long-term sustainable and competitive fishing facilities, these nodes should be grouped due to the mentioned advantages based on their main core competencies and the spatial characteristics. There are different parameters that are affecting the ports' categories such as service capabilities of the fishing ports, availability of tourism activities, nearby population, and volume of economic activities in ports' hinterlands, proximities to main transportation alternatives.

When considering the decision criteria for a location problem which can be facility selection, attribute clustering, policy making, land or urban planning, it is obvious that high portion of the affecting criteria will be related with spatial characteristics such as distance, density, and coverage. Thus the geographic aspect of the problem should be considered. Geographic Information System (GIS) is a popular tool due to its capability of dealing spatial attributes. GIS is capable of creation of network models which is capable of representing the transportation structure of analyzing area, measuring spatial characteristics such as densities of attributes or proximities to focused criteria. Additionally it is possible to build geo-statistical models to analyze statistical patterns of the spatial parameters.

There are different decision criteria has effects on the final result of location decisions. To deal with the different criteria, multi criteria decision making techniques are suggested by researcher in literature and those techniques are been very popular due to their suitability for a wide range problem types. A wide variety of location problems are analyzed with those approaches (Ashrafzadeh et al. 2012; Athawale, Chatterjee, and Chakraborty 2012; Onden and Eldemir 2015). Due to the spatial decision criteria have essential influences on location decision, multi criteria spatial decision making approaches are used by researchers for evaluation suitability levels for considered facilities (Malczewski 1999; Jankowski 1995). These approaches uses multi criteria analysis approaches with GIS/Spatial analysis.

To be able to perform a multi-criteria decision making approach, the first step is determination of the decision criteria. Since there are not any previous studies to be a guide for this research, experiences of the professionals are valuable to determine the decision criteria. Due to determining the decision criteria will have significant impacts of the result, this step should be carried out with carefully. The study aims categorizing and evaluating the fishing ports in Turkey to increase the use of their capacities, and determine the convenient facilities which can be served as regional centers based on decision criteria discussed by experts. To enhance the mentioned goals, a spatial multi-criteria decision analysis structure is suggested in the study

In the study a classification approach is developed for existing fishing ports located in Turkey. The approach used a multi-criteria spatial approach with integration of the Buckley's fuzzy analytical hierarcy process (f-AHP) (Buckley 1985) and GIS. The paper starts with literature review to discuss related previous studies. Next, methodology of the study is given with background of the analysis techniques. As the following section is the application where the steps of the implementation is expressed. As the final section, conclusion where the findings and a brief final discussion is given.

Literature Review

Different aspects of the fishing ports are researched by scholars in the literature. During the analysis, spatial analysis is been an effective way to evaluate the fishing ports. (Yucel-Gier, Pazi, and Kucuksezgin 2013), analyzed the fish farming in the Gulluk Bay with GIS/spatial analysis. Gulluk Bay fish farm user behaviors and their percentages were determined by spatial analysis. The study showed how terrestrial and marine activities interacted differently with each others. Thomas J et al (2003) (Shivlani and Rudders 2003) used GIS in their study, and analyzed the commercial fishery industry in Florida Keys National Marine Sanctuary Fishing Panels. Their program determined the long-term effects of marine zoning on commercial fishing. Erisman et al (2011) (Erisman et al. 2011) analyzed the spatial structure of commercial marine fisheries in Northwest Mexico. They used an official landings data from local fisheries offices in that region. Their analyses results showed that a spatial pattern in fishing activities. They found a positive linear relationship between the species composition of fisheries offices and both latitude and longitude data. Their study suggested that it would be beneficial with an ecosystem based management framework in NW Mexico.

Albet (2010) (Albet 2010), focused on the region of Cap de Creus' fishing activities with a spatial assessment. A spatial distribution activity is presented with combining existing data of artisanal fisheries' components together with gathered substrate type and seabed composition. They revealed that benthic communities are highly affected. In order to minimize the impact on benthic communities, they propose an alternative parceling and seasonal closures among the main fishing gear types.

Portman et al (2011) (Portman, Jin, and Thunberg 2011) examined the aspects of the fishing industry and land use changes along two ports in New England. They focused on the relationship of changes in species biomass, landings and other fishing industry variables. They found that the smaller ports (Provincetown) are more vulnerable to market conditions so there is a need for greater land use controls. Israel D.C and Roque R.G (2000) (Roque and Roque 2000), analyzed port developments in Philippines. They focused the port underutilization, marine resource depletion and other issues. They revealed that, high portion of the regional ports were underutilized and also municipal ports were inadequate for the region.

METHODOLOGY

In the study a classification methodology is discussed based on a fuzzy spatial multi-criteria decision analysis for determining the regional centers of a set of similar facilities. Within that context, a holistic solution approach is suggested for classifications of the fishing ports. In the calculations, two main analysis approaches which are GIS and Buckley's F-AHP are integrated. F-AHP is recommended for evaluating and prioritizing the decision criteria. GIS is used to analyze the spatial patterns of the affecting decision criteria that have influence over the decision. Mentioned two different approaches are integrated with a logical flow, and the steps of the methodology are illustrated in Figure 7.

The methodology started with the decision criteria determination. That step carried an importance since it draws the scope and limitations of the study. Besides, the convenience of the decision criteria will enhance the reliability of the decision analysis. Thus this step has significant importance for enhancing convenient classifications. Due to it is a crucial part of the study, relevant experts should be gathered together in workshops and discuss which criteria have influence on the decision and what are their priorities. Hence there will be multiple decision criteria, a convenient evaluation methodology is necessary. F-AHP has been found useful and numerous studies are conducted based on that technique for evaluation and also decision making [13]. The technique is capable of representing the fuzziness in the experts' judgments. It also provides simplicity in comparisons with pair-wise comparisons. The technique is capable of measuring the criteria weights which is the input of the GIS. GIS is capable of analyze spatial patterns of geographic data and draw a conclusion based on the considered spatial data.

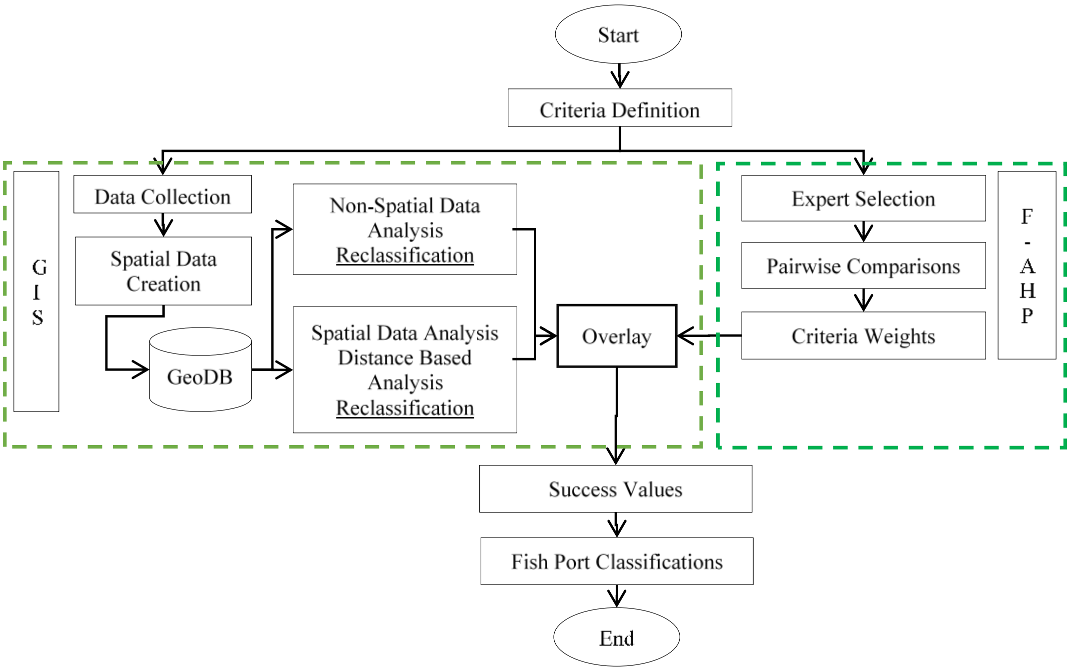


Figure 1. Methodology

F-AHP

F-AHP is a decision making and evaluation technique that allows you to measure the criteria priorities and compare the alternatives. For th**e** analysis, three steps to reach the decision are expressed and formulas are given here. The first step is the construction of the pairwise comparison matrix. During this step linguistic values can be used for pair-wise comparisons to take the judgments of the experts. Saaty's fuzzy scale is adequate as scale and the components are given in Table 1.

Table 1. Fuzzy scale

Fuzzy number	Linguistic scales	Scale of triangular fuzzy number	Reciprocal triangular fuzzy numbers
$\tilde{1}$	Extremely Strong	(9, 9, 9)	(0,11, 0,11, 0,11)
$\tilde{2}$	Intermediate Value	(7, 8, 9)	(0,11, 0,13, 0,14)
$\tilde{3}$	Very Strong	(6, 7, 8)	(0,13, 0,14, 0,17)
$\tilde{4}$	Intermediate Value	(5, 6, 7)	(0,14, 0,17, 0,2)
$\tilde{5}$	Strong	(4, 5, 6)	(0,17, 0,2, 0,25)
$\tilde{6}$	Intermediate Value	(3, 4, 5)	(0,2, 0,25, 0,33)
$\tilde{7}$	Moderately Strong	(2, 3, 4)	(0,25, 0,33, 0,5)
$\tilde{8}$	Intermediate Value	(1, 2, 3)	(0,33, 0,5, 1)
$\tilde{9}$	Equally Strong	(1, 1, 1)	(1, 1, 1)

The comparison matrix of C should be consisted with the linguistic comparison values of $\tilde{c}_{ij}$. The fuzzy comparison matrix $\tilde{C}_k$ will represent the fuzzy equivalents of the comparisons and the structure is given in the equation 1.

$$\tilde{C}_k = \begin{bmatrix} 1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \tilde{a}_{21} & 1 & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & 1 \end{bmatrix} = \begin{bmatrix} 1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ 1/\tilde{a}_{12} & 1 & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/\tilde{a}_{1n} & 1/\tilde{a}_{2n} & \cdots & 1 \end{bmatrix}, \text{k=1,2,…,n} \tag{1}$$

The next step is weight calculation. Geometric means of the triangular fuzzy values, $\tilde{r}_i$ and fuzzy weights $\widetilde{w}_i$(Li,Mi,Ui) are found in this step. Equation 2 and 3

$$\tilde{r}_i = (\tilde{a}_{i1} \otimes \tilde{a}_{i1} \otimes \ldots \otimes \tilde{a}_{in})^{\frac{1}{n}}, \tag{2}$$

$$\widetilde{w}_i = \tilde{r}_i \otimes (\tilde{a}_{i1} \oplus \tilde{a}_{i1} \oplus \ldots \oplus \tilde{a}_{in})^{-1}, \tag{3}$$

In the last step, fuzzy numbers are defuzzified into crisp numbers. To reach the crisp values firstly fuzzy relative matrix should be obtained. Total integration value method with $\omega \in [0,1]$ index optimism is used (Liou and Wang 1992).

GIS

GIS is suggested to analyze the spatial characteristics of the study area. Two types of data analysis tools are appropriate for dealing the data types can be used in the study. The first is the Euclidean distance analysis, can be applied for point or line data. The analysis tool takes the existing geographic attribute's location and create a raster map that expresses distances towards to the considered attribute. The output maps are useful when a continuous plane is considered for a location analysis. (For further analytical background of the analysis see: (ESRI 2014a)). The other convenient data analysis approach is hot spot analysis which is an example of spatial statistical analysis and clustering analysis. This analysis approach is useful when spatial characteristics of a plane are considered. Polygon type data can be used for a wide-range variety of data such as purchasing power, population, and these data types can be analyzed with a hot spot analysis. Hot spot analysis is convenient to examine the data is clustered or not and the results can lead you to create regions based on statistically classifications (for further explanation, see: (ESRI 2014b; Önden, Eldemir, and Çancı 2014).

The GIS analysis and fuzzy multi criteria analysis create a various set of outputs. Overlaying which is an analysis tool of GIS ensures to meet the need of a final decision associated by different outputs. Overlaying tool calculate a final result map with the inputs of distance or hot-spot maps in raster format. It is capable of using weights of each decision criteria derived from f-AHP analysis. With overlay tool, decision makers' expressions and judgements over decision criteria and spatial analysis results can be integrated and a final map which is the output of overlay analysis express the success value of considered study area. The output is also a raster map and the results show the values of whole considered area. Those values can intersect with point, line or polygon data if a vector data is considered as alternatives. For details of the analysis, see ("ArcGIS Help 10.1 - Understanding Overlay Analysis" 2015). The results of the overlay analysis give the success values of each considered attribute. These values should be clustered. For defining the intervals of the success values natural break (Jenks 1967) approach can be used, and the labels of the considered facilities can defined with the break values of their success values. After that, new policies can be discussed and reported to the decision makers based on the quantitative holistic approach which takes spatial characteristics of the decision environment.

STUDY AREA

Turkey is selected as study area to apply the methodology in the paper. Turkey has shores in Black Sea, Marmara Sea, Aegean Sea, and Mediterranean Sea, and the total seashore reaches to 8303 kilometer. Additionally Istanbul and Canakkale Bosporus are one of the most dense transportation corridor mostly used for oil transportation between Black Sea and Mediterranean Sea is located in Turkey. The mentioned characteristics make Turkey as an important maritime country and increase its potential related to sea issues. However it can be said that the mentioned potential can be used in a more effective way. One of the ways is to focus on fishing industry and strengthen the fishery economy. Centralization of the facilities and creating regional centers is discussed by researchers who have different expertises. With this approach scale economy can be enhanced and different services can be given due to integrated and increased demand and supply. Currently, there are 361 fishing ports on Turkey coast lines and 5 are located on lakesides (Turkish Transportation Agency 2011). The numbers are suitable for classification strategies.

The fishing ports are mainly considered as farming facilities for fishery industry. However due to these facilities are located in different sea environments, the service capabilities of the facilities show differences individually. For instance, the facilities located in South Aegean Region of Turkey can be used for tourism activities and the facilities located in Black Sea can also be used for transportation. Due to the mentioned difference, capacities of the facilities show variety to meet the service demand. These characteristics show the variety in the fishing ports and the evaluations should represent different aspects of the facilities. Figure 2 is used to illustrate the geographic locations of the facilities with their boat capacities.

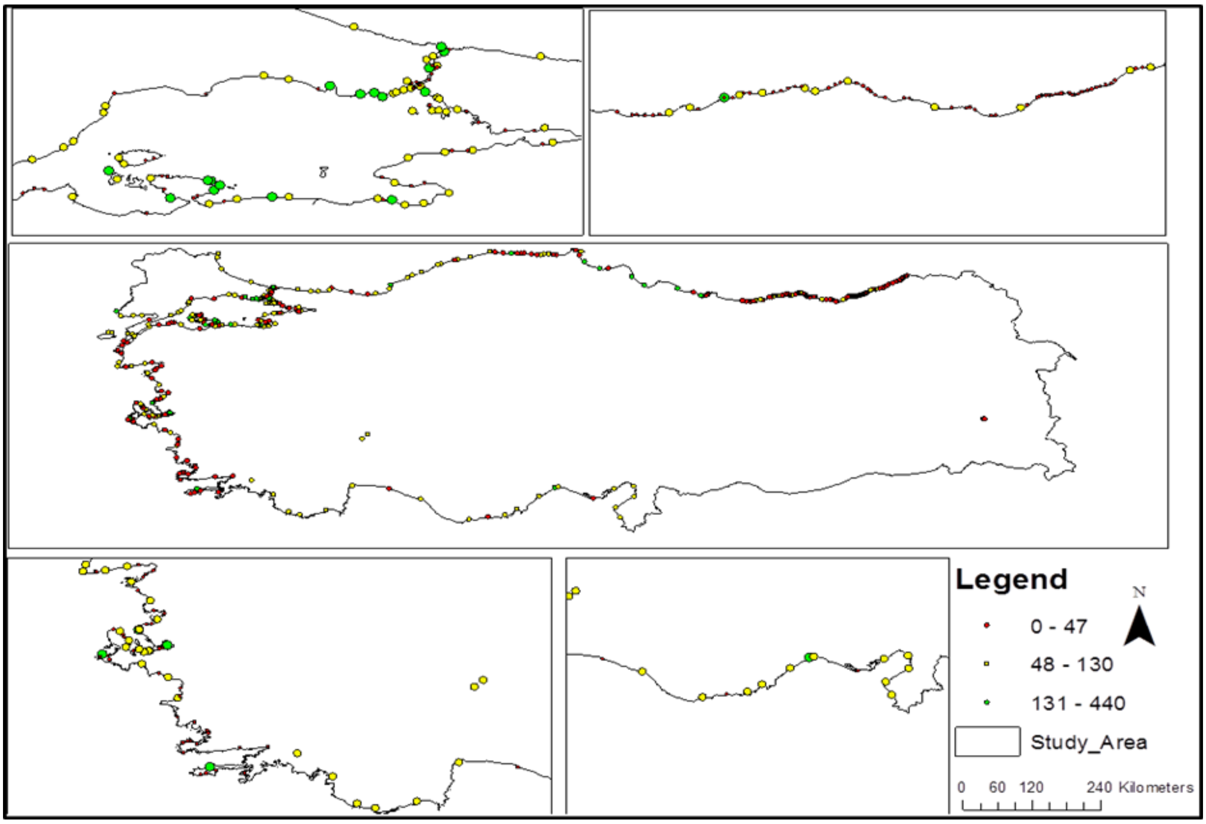


Figure 2. Fishing Port Capacities

The distribution of the fishing ports based on their capabilities of farming and transportation is expressed in Table 2. The table also gave the regional distributions of the facilities.

Table 2. Fishing Ports Qualification services

Qualification	Marmara	Aegean	Mediterranean	Black Sea	Lakes	Total
Farming	121	51	11	133	5	321
Farming and Tourism	10	5	6	6		27
Farming, Transportation and Tourism	1	2		2		5
Farming and Transportation	1	2	2	8		13
Total	**133**	**60**	**19**	**149**	**5**	**366**

APPLICATION

The previous chapters expressed the proposed methodology and the characteristics of the study area. The methodology applied in Turkey to evaluate and classify the existing fishing ports based on the considered decision criteria. For the classifications, a geographic model is developed in ArcGIS, and a toolbox in GIS software is created to analyze the dataset and reach the clusters of the fishing ports. The toolbox gives the clusters of the fishing ports as the result of the analysis.

The methodology starts with determining the decision criteria. The criteria determination is the most important step due to it forms the analysis structure, data set in the decision environment. However, due to lack of studies in literature determining the decision criteria based on previous studies is not possible. Thus, four different workshop studies with over 200 experts are done to discuss current status of the fishing industry and problems of the sector and what decision criteria should be considered for evaluating the fishing ports. Fishery industry specialists, local fishery corporation authorities, academics are invited to participate the workshops. Each workshop is focused on different geographic areas of Turkey, and criteria list is created as the result of the meetings. Fishing Port Classifications decision criteria are grouped in 4 main titles. These are Facility Specialties, Port Services, Transportations and Social Effects. These classifications and their sub-criteria details are expressed in Table 3.

Table 3 Fishing Port Classification Criteria

Facility Specialties	Port Services	Transportation	Social Effects
Collection	Pier length	Highway	Population
Distribution	Utilities	Seaports	Shopping
	Catering and other services	Railway	
	Refueling	Airport	
	Pre-Cooling		

After the workshops, a relatively small group of experts are gathered to evaluate the selected decision parameters with pairwise comparisons. The focal group consisted by five experts. The experts represented the private and public sector on the subject. Three experts represented the private and public sector side of the considered problem. Two expert who has also academic background, were organized and participated the workshops events and participated the evaluations to represent the findings and discussions of the mentioned events. The participants have background about data analysis, spatial and city planning, maritime science and fishery.

The evaluations of the decision parameters are done based on the Buckley's f-AHP methodology in the focal meeting. During the discussions of the pairwise comparisons, group decision making approach is used. The experts expressed the superiorities of the decision criteria with the linguistic scale. These linguistic judgments are converted to fuzzy triangular values. Then, these values are used in f-AHP analysis. Table 4 expressed the fuzzy numbers of the five experts' judgments over main criteria.

Table 4 Geometric means of the fuzzy evaluation matrix with respect to the goal

Cluster	Facility Specialties	Port Services	Transportation	Social Effects
Facility Specialties	$\tilde{1}$	$\widetilde{0.33}$	$\tilde{2}$	$\tilde{2}$
Port Services	$\tilde{3}$	$\tilde{1}$	$\widetilde{0.5}$	$\tilde{3}$
Transportation	$\widetilde{0.5}$	$\tilde{2}$	$\tilde{1}$	$\tilde{3}$
Social Effects	$\widetilde{0.5}$	$\widetilde{0.33}$	$\widetilde{0.33}$	$\tilde{1}$

Table 5-8 expressed the fuzzy values of the pairwise comparison of the experts over sub-criteria of the each main criteria.

Table 5. Geometric means of the fuzzy evaluation matrix with respect to the facility specialties

Facility Specialties	Collection	Distribution
Collection	$\tilde{1}$	$\tilde{1}$
Distribution	$\tilde{1}$	$\tilde{1}$

Table 6. Geometric means of the fuzzy evaluation matrix with respect to the port services

Port Services	Pier length	Utilities	Catering and other services	Refueling	Pre-Cooling
Pier length	$\tilde{1}$	0,5	$\tilde{1}$	$\tilde{1}$	$\tilde{2}$
Utilities	$\tilde{2}$	$\tilde{1}$	$\widetilde{0.5}$	$\tilde{2}$	$\tilde{1}$

Catering and other services	$\tilde{1}$	$\tilde{2}$	$\tilde{1}$	$\tilde{3}$	$\tilde{2}$
Refueling	$\tilde{1}$	$\widetilde{0.5}$	$\widetilde{0.33}$	$\tilde{1}$	$\tilde{2}$
Pre-Cooling	$\widetilde{0.5}$	$\tilde{1}$	$\widetilde{0.5}$	$\widetilde{0.5}$	$\tilde{1}$

Table 7. Geometric means of the fuzzy evaluation matrix with respect to the transportation

Transportation	Highway	Seaports	Railway	Airport
Highway	$\tilde{1}$	$\tilde{3}$	$\tilde{3}$	$\tilde{5}$
Seaports	$\widetilde{0.33}$	$\tilde{1}$	$\widetilde{0.33}$	$\tilde{5}$
Railway	$\widetilde{0.33}$	$\tilde{3}$	$\tilde{1}$	$\tilde{3}$
Airport	$\widetilde{0.2}$	$\widetilde{0.2}$	$\widetilde{0.33}$	$\tilde{1}$

Table 8. Geometric means of the fuzzy evaluation matrix with respect to the social effects

Social Effects	Population	Numb. Tours.
Population	$\tilde{1}$	$\tilde{3}$
Shopping	$\tilde{1}$	$\tilde{4}$

The criteria priorities found as the result of the f-AHP analysis and expressed in the Table 8. The results showed that the port services criteria is the most important criteria among the criteria. Transport, facility specialties and social effects followed the port services criteria based on the priority values. After reaching the priorities of the main criteria, sub-criteria are calculated with the same approach. The calculated priority values of the sub-criteria are also given in the Table 9.

Table 9 Criteria Weights

Cluster	Overall Weight	Social Effects	Weight	Local P.	Facility Specialties	Weight	Local P.	Port Services	Weight	Local P.	Transportation	Weight	Local P.
Facility Specialties	0.24	Population	0.43	0.05	Collection	0.50	0.12	Pier length	0.18	0.06	Highway	0.50	0.15
Port Services	0.33	Shop.	0.55	0.06	Distribution	0.50	0.12	Utilities	0.22	0.07	Seaports	0.18	0.05
Transport.	0.31							Catering and other services	0.30	0.10	Railway	0.26	0.08
Social Effects	0.12							Refueling	0.16	0.05	Airport	0.07	0.02
								Pre-Cooling	0.14	0.05			

Spatial analysis is next step after criteria determination meetings and evaluations. To be able to perform the spatial analysis input geographic data should be created. Data collection and creation is carried out in this step.

Fishing port locations and their attributes such as capacity, total berthing capacities, cooling capability, anchor length, lightning capability, overwintering capacities and so on is collected and vector data is created for fishing port locations. In addition to fishing specialties of the facilities, social facilities on the ports are collected and linked with the created fishing port data. Besides, other geographic data and their attributes are collected such as city borders, railway and highway line data as transportation infrastructure, and population. Non-spatial demographic data is digitized in city border scale. Figure 4 is illustrated the considered geographic data and study area.

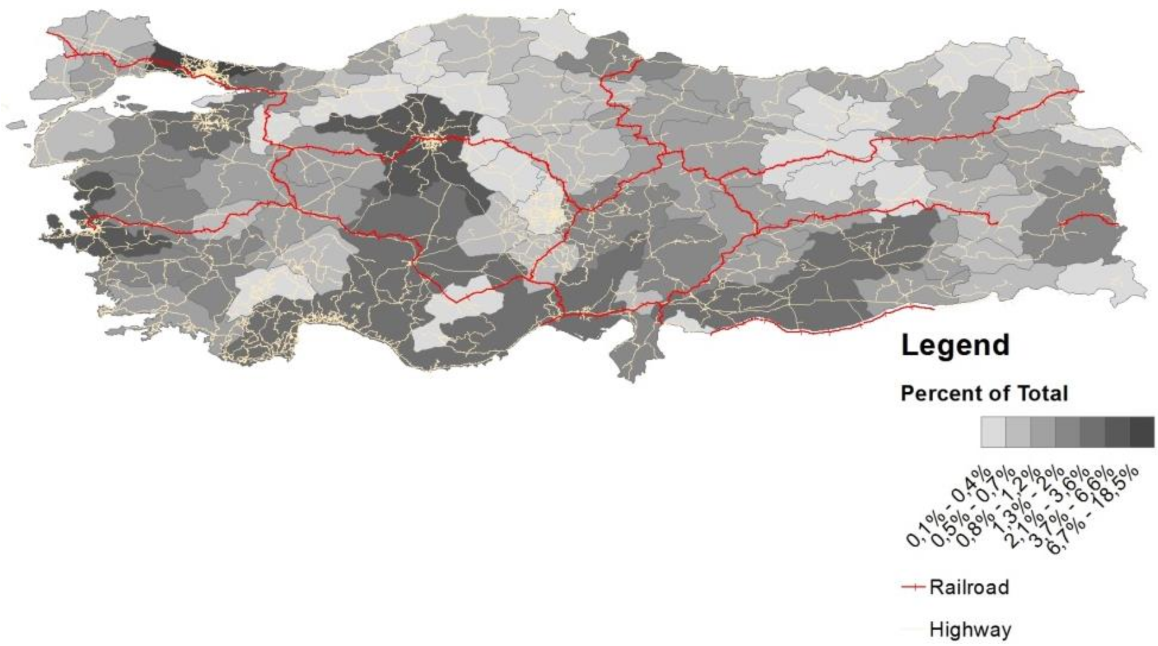
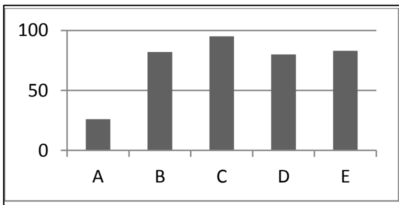


Figure 3. Spatial data used in analysis

Spatial analysis step is carried out after data preparation step. In that step a geographic model and toolbox in ArcGIS is developed. The toolbox takes the created criteria data and criteria weights as input, analyze the data and gives a final map that represents the success value of fishing ports. In addition to data preparation tool such as project, data environment properties, Euclidean distance analysis and hot spot analysis are used in model as data analysis tools. The model takes each sub criteria map as inputs and after carrying out of the spatial analysis and spatial statistics analysis, overlaying tool reached the success values with calculated criteria weight gathered from f-AHP analysis.

As the result of the analysis, success values for 366 fishing are found. These values are between 0 and 10. The most successful alternative had 9.712 and the least successful alternative had 2.215 value. The calculated values are clustered based on natural break points and clustered in 5 classes. Figure 4 expresses the numbers of the distribution, success value intervals of the each label.



Class.	Quantity	Range
A	26	A>=7
B	82	5<=B<7
C	95	4<=C<5
D	80	3,5<=D<4
E	83	E<=3,5

Figure 4. Fishing port classification intervals

The classification labels are given as type A, B, C, D and E. Type A stands for the most successful candidate fishing ports to become regional centers and E is given for the least successful ones. How the spatial success values distributed on plane ports are illustrated in Figure 6 to express the spatial sprawl of the classes. 26 fishing ports are found as type A, and those nodes are convenient facilities for the transitions to a regional center.

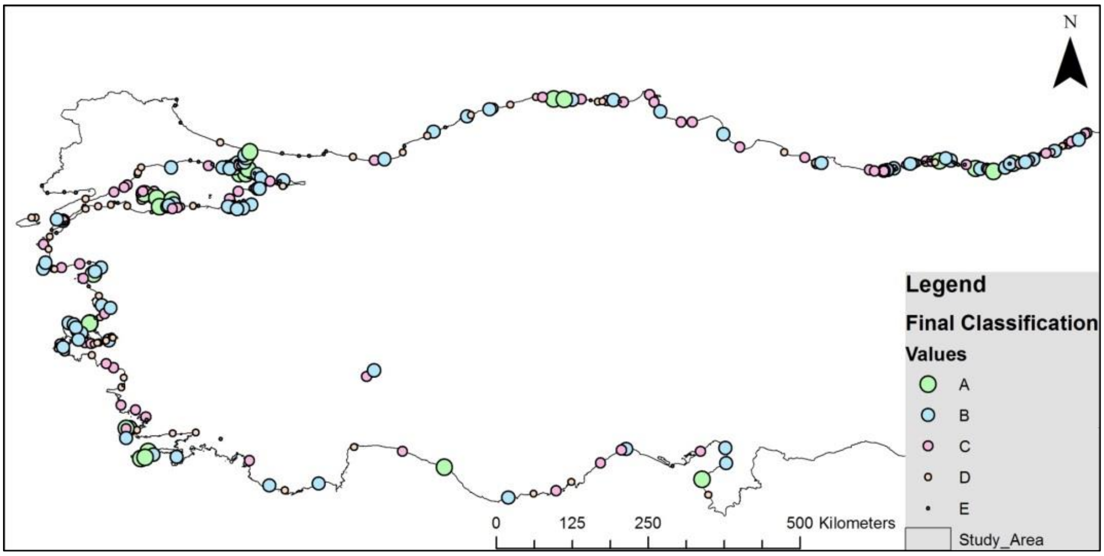


Figure 5. Final Classifications of the fishing ports

Calculations of the spatial success value of fishing ports show which alternatives should be considered as regional centers. Figure 6 shows the Type A fishing ports and the spatial distribution shows a clustered structure. It can be seen that four regions have multiple alternatives due to the similarity of the geographic specialties. In these areas calculated suitability values are convenient for determining the preference orders.

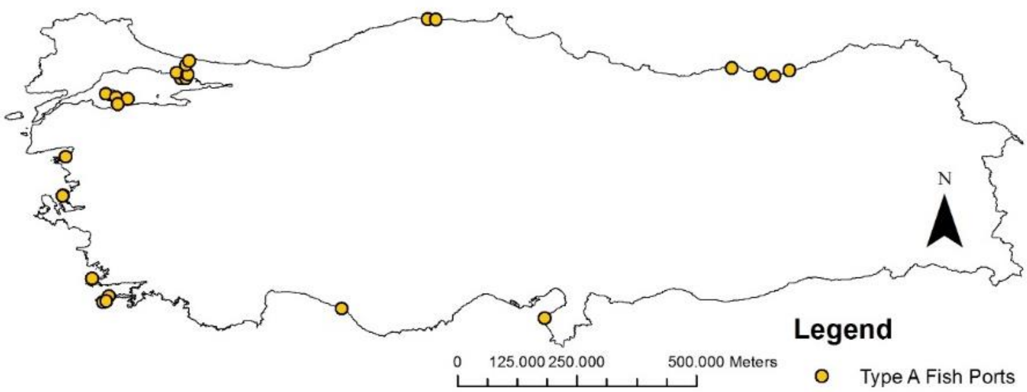


Figure 6. Type A Fishing Ports

CONCLUSION

The evaluation of the fish ports located in Turkey based on their core competencies are done in the study. The idea was to detect the ports which can be a regional center among the alternatives. To reach the classifications, a spatial multi-criteria solution approach is applied in the study area and expert thoughts, spatial analysis results are combined in the iterative solution methodology based on GIS and f-AHP. The success values of the fishing ports are calculated via the mentioned methodology. The analysis gave the result that 26 facility is convenient for transition to a regional center due to considered parameters and that will create a greater impact on regional economy with centralized services and increased economic potential of the facilities. The study methodology considered a set of criteria, in the following studies the criteria list should be re-considered according to the study area's characteristics.

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Table 2. Fuzzy scale

Fuzzy number	Linguistic scales	Scale of triangular fuzzy number	Reciprocal triangular fuzzy numbers
$\tilde{1}$	Extremely Strong	(9, 9, 9)	(0,11, 0,11, 0,11)
$\tilde{2}$	Intermediate Value	(7, 8, 9)	(0,11, 0,13, 0,14)
$\tilde{3}$	Very Strong	(6, 7, 8)	(0,13, 0,14, 0,17)
$\tilde{4}$	Intermediate Value	(5, 6, 7)	(0,14, 0,17, 0,2)
$\tilde{5}$	Strong	(4, 5, 6)	(0,17, 0,2, 0,25)
$\tilde{6}$	Intermediate Value	(3, 4, 5)	(0,2, 0,25, 0,33)
$\tilde{7}$	Moderately Strong	(2, 3, 4)	(0,25, 0,33, 0,5)
$\tilde{8}$	Intermediate Value	(1, 2, 3)	(0,33, 0,5, 1)
$\tilde{9}$	Equally Strong	(1, 1, 1)	(1, 1, 1)

Table 2. Fishing Ports Qualification services

Qualification	Marmara	Aegean	Mediterranean	Black Sea	Lakes	Total
Farming	121	51	11	133	5	321
Farming and Tourism	10	5	6	6		27
Farming, Transportation and Tourism	1	2		2		5
Farming and Transportation	1	2	2	8		13
Total	**133**	**60**	**19**	**149**	**5**	**366**

Table 3 Fishing Port Classification Criteria

Facility Specialties	Port Services	Transportation	Social Effects
Collection	Pier length	Highway	Population
Distribution	Utilities	Seaports	Shopping
	Catering and other services	Railway	
	Refueling	Airport	
	Pre-Cooling		

Table 4 Geometric means of the fuzzy evaluation matrix with respect to the goal

Cluster	**Facility Specialties**	**Port Services**	**Transportation**	**Social Effects**
Facility Specialties	$\tilde{1}$	$\widetilde{0.33}$	$\tilde{2}$	$\tilde{2}$
Port Services	$\tilde{3}$	$\tilde{1}$	$\widetilde{0.5}$	$\tilde{3}$
Transportation	$\widetilde{0.5}$	$\tilde{2}$	$\tilde{1}$	$\tilde{3}$
Social Effects	$\widetilde{0.5}$	$\widetilde{0.33}$	$\widetilde{0.33}$	$\tilde{1}$

Table 5. Geometric means of the fuzzy evaluation matrix with respect to the facility specialties

Facility Specialties	**Collection**	**Distribution**
Collection	$\tilde{1}$	$\tilde{1}$
Distribution	$\tilde{1}$	$\tilde{1}$

Table 6. Geometric means of the fuzzy evaluation matrix with respect to the port services

Port Services	Pier length	Utilities	Catering and other services	Refueling	Pre-Cooling
Pier length	$\tilde{1}$	0,5	$\tilde{1}$	$\tilde{1}$	$\tilde{2}$
Utilities	$\tilde{2}$	$\tilde{1}$	$\widetilde{0.5}$	$\tilde{2}$	$\tilde{1}$
Catering and other services	$\tilde{1}$	$\tilde{2}$	$\tilde{1}$	$\tilde{3}$	$\tilde{2}$
Refueling	$\tilde{1}$	$\widetilde{0.5}$	$\widetilde{0.33}$	$\tilde{1}$	$\tilde{2}$
Pre-Cooling	$\widetilde{0.5}$	$\tilde{1}$	$\widetilde{0.5}$	$\widetilde{0.5}$	$\tilde{1}$

Table 7. Geometric means of the fuzzy evaluation matrix with respect to the transportation

Transportation	Highway	Seaports	Railway	Airport
Highway	$\tilde{1}$	$\tilde{3}$	$\tilde{3}$	$\tilde{5}$
Seaports	$\widetilde{0.33}$	$\tilde{1}$	$\widetilde{0.33}$	$\tilde{5}$
Railway	$\widetilde{0.33}$	$\tilde{3}$	$\tilde{1}$	$\tilde{3}$
Airport	$\widetilde{0.2}$	$\widetilde{0.2}$	$\widetilde{0.33}$	$\tilde{1}$

Table 8. Geometric means of the fuzzy evaluation matrix with respect to the social effects

Social Effects	Population	Numb. Tours.
Population	$\tilde{1}$	$\tilde{3}$
Shopping	$\tilde{1}$	$\tilde{4}$

Table 9 Criteria Weights

Cluster	Overall Weight
Facility Specialties	0.24
Port Services	0.33
Transport.	0.31
Social Effects	0.12

Social Effects	Weight	Local P.
Population	0.43	0.05
Shop.	0.55	0.06

Facility Specialties	Weight	Local P.
Collection	0.50	0.12
Distribution	0.50	0.12

Port Services	Weight	Local P.
Pier length	0.18	0.06
Utilities	0.22	0.07
Catering and other services	0.30	0.10
Refueling	0.16	0.05
Pre-Cooling	0.14	0.05

Transportation	Weight	Local P.
Highway	0.50	0.15
Seaports	0.18	0.05
Railway	0.26	0.08
Airport	0.07	0.02

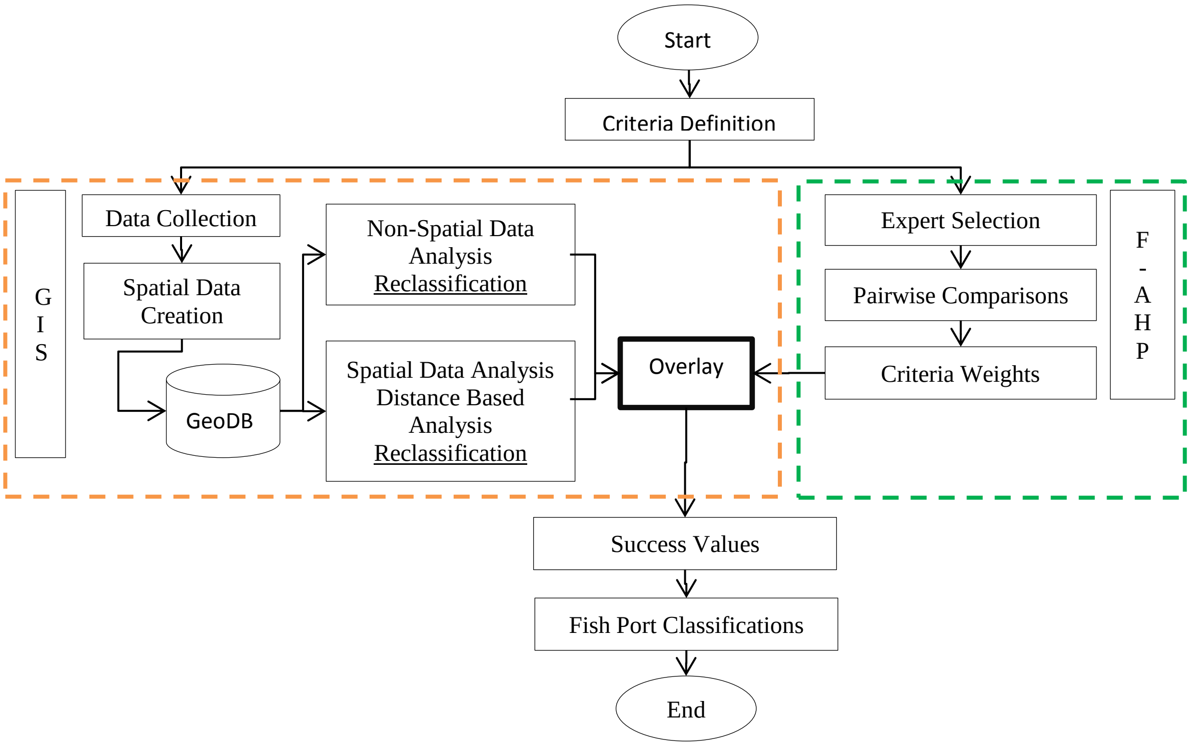


Figure 7. Methodology

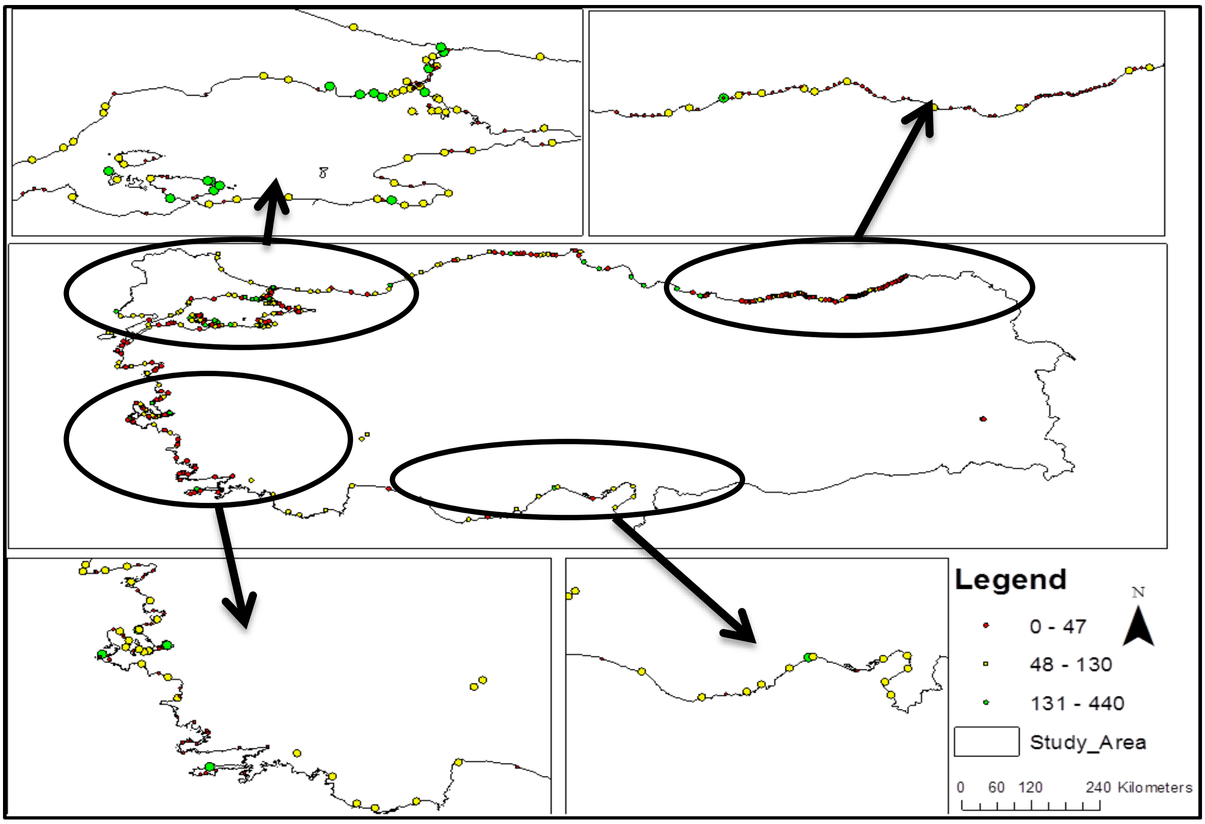


Figure 8. Fishing Port Capacities

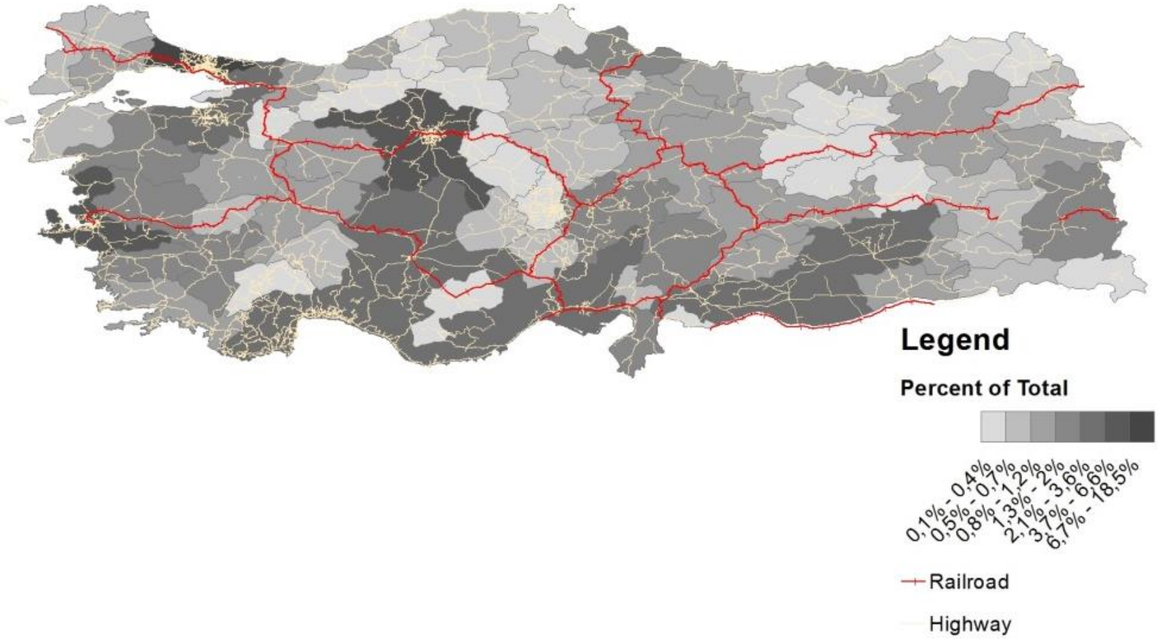
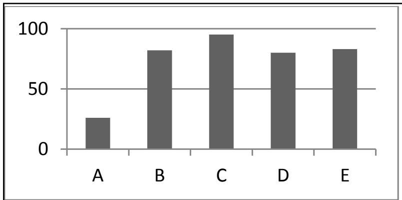


Figure 9. Spatial data used in analysis



Class.	Quantity	Range
A	26	A>=7
B	82	5<=B<7
C	95	4<=C<5
D	80	3,5<=D<4
E	83	E<=3,5

Figure 10. Fishing port classification intervals

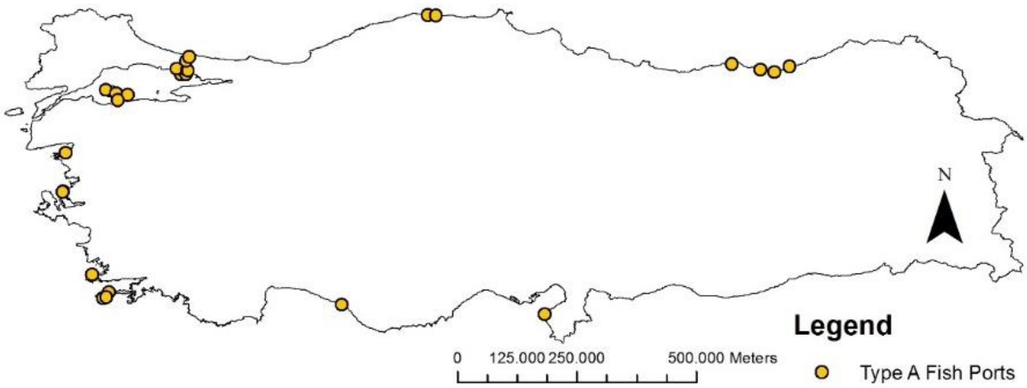


Figure 11. Type A Fishing Ports