www.trjfas.org
ISSN 1303-2712
Turkish Journal of Fisheries and Aquatic Sciences 17:499-508 (2017) DOI: 10.4194/1303-2712-v17_3_06

RESEARCH PAPER

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

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Received 22 June 2016
Accepted 18 November 2016

Abstract

Fishing ports are the vital constituent of the fishery industry of Turkey. With governmental contribution, the number of the fishing ports reached to 366 alongside of the shores and the collected fish volume has been in increasing trend. However, there are differences in the location characteristics and technical infrastructure so that each facility's success level is measured differently with convenient parameters. To increase the performance of fishing ports, for their better utilization, and also to understand which of them can be transformed to regional centers a classification is needed. With the transformation to the regional centers, i.e. the infrastructure improvements of the facilities and providing multiple services such as tourism and transportation activities; the efficiency of the ports can be increased. In this paper, a classification methodology is developed and it is tested. While applying the methodology, expert workshops are carried out to represent current fishery environment in Turkey. In the meetings, decision criteria are discussed by participating over 200 experts in the field. f-AHP and GIS/Spatial Analysis is used to analyze spatial suitability. Results of the study showed that the methodology is capable of dealing with spatial and non-spatial characteristics of the data-set and determine the convenient alternatives.

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. 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 destinations (TUSSIDE, 2015). 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 (Yucel-Gier, Pazi, and Kucuksezgin, 2013). This study aims to evaluate and determine candidate facilities for the regional center concept to increase service supply and diversity for a better capacity utilization. Additionally, fishery management has a spatial aspect and area-based models are increasing (St. Martin & Hall-Arber, 2008). Considering this trend, a spatial information based multi-criteria classification approach is developed and applied for Turkey's fishing ports.

In the last fifteen years, there has been a significant developments in the sector. Turkish aquaculture production has increased from 34,000 tons in 2000 to around 75,000 tons in 2009 (TUIK, 2010). Number of the fishing ports increased to 366 with the growth of the aquaculture production in Turkey. With the increased numbers of the facilities, the berthing capacity has increase to approximately to 36.000 boats (UDHB, 2011). Moreover, the number of moored boats in the fishing ports is about 23.000 which causes 13.000 berthing capacity gap (TUSSIDE, 2015). In contrast, there is high berthing demand of pleasure boats. The demand for pleasure boats can be met by unused berthing capacity of fishing ports.

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. Each center can serve as a regional hub which will provide different services

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such as farming, public transportation, and tourism centers. As a result new labor opportunities are expected to be created.

For the long-term sustainable and competitive fishing facilities, these facilities should be grouped based on their main core competencies and the spatial characteristics such as service nearby transportation alternatives, tourism attractions, population, and economic activities. It is obvious that high portion of the affecting criteria will be related with spatial characteristics. Thus the geographic aspect of the problem such as distance, density, and coverage should be taken into consideration. Geographic Information System (GIS) is a prevalent tool due to its capability of dealing spatial attributes. GIS is able to create network models which are useful for representing the transportation structure of focal study area, measuring spatial characteristics. Additionally it is possible to build geo-statistical models to analyze statistical patterns of the spatial parameters.

In the literature, different aspects of the fishing ports are researched by scholars. 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 other. 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) analyzed the spatial structure of commercial marine fisheries in Northwest Mexico. They used the official landings data from local fisheries offices in that region. The results showed that a spatial pattern is existed in fishing activities. They found a positive linear relationship between the species composition of fisheries offices and both latitude and longitude data. 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, 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 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.

To deal with the different criteria, multi criteria decision making techniques are suggested by researcher in literature, as well. These techniques are been very popular due to their suitability for a wide range problem structures (Ashrafzadeh, Rafiei, Isfahani, & Zare, 2012; Athawale, Chatterjee, and Chakraborty, 2012; Onden and Eldemir, 2015). One of the most popular multi-criteria technique is AHP and it is conceptualized by Saaty (1990). The AHP technique evaluates decision criteria and alternatives with pair-wise comparisons and reaches preference orders of the alternatives based on decision makers/experts' opinions. The analysis can use a linguistic or numeric scale for the comparisons. However due to the result is solely related to the expert judgments, the perception of the experts carry a huge significance on the decision. To balance the pessimistic and optimistic approaches, fuzzy analytic hierarchy process (f-AHP) is proposed in the literature. F-AHP uses a fuzzy interval with a membership degree for stating a judgment. That smooths the effect of the decision makers' attitude and results a better decision. There are different types of f-AHP approaches in literature such as Laarhoven and Pedrycz (1983), Chang (1996) and Buckley (1985)'s approaches. There are some criticism for fuzzy extent analysis and applicability of Laarhoven's approach (Onden, Eldemir, & Acar, 2016). Thus Buckley's approach is used in the paper. In addition, multi criteria spatial decision making with GIS/Spatial analysis approaches are used for evaluation of suitability levels for candidate facilities by researchers such as Malczewski (1999); Jankowski (1995).

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 (1985)'s f-AHP and GIS. In the following section, the methodology of the study is given with background of the analysis techniques. Then the study area, Turkey shoreline, is covered. After the methodology and the study area, the application section follows where the steps of the implementation are expressed, necessary calculations are done and the findings are given. The final chapter concludes the work by summarizing the study with a brief discussion.

Materials and Methods

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 1.

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 reaching the convenient classifications. Due to it is a crucial part of the study, experts who has experience related to the topic should be gathered together in workshops and discuss which criteria have influence on the decision and what their priorities are. 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 (Saaty, 2008). 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.

F-AHP

F-AHP is a decision making and evaluation technique that allows researchers to measure the criteria priorities and compare the alternatives, then reach the best alternative among an alternative set. For the analysis, three steps to reach the decision are expressed and formulas are given.

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 for converting linguistic judgements of the experts. The fuzzy triangular numbers convert the crisp numbers into fuzzy values where lower (L), median (M) and upper (U) stands for the triangular fuzzy number components with a membership degree. With this approach instead of representing an exact (crisp) value, it is possible to define an interval for representing a judgement. The suggested fuzzy triangular scale's expression expressed in the Table 1 and the illustration of the fuzzy values are given in Figure 2.

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. The table will be the experts simple pair-wise comparison's fuzzy representation in a matrix.

$$\tilde{C}_k = \begin{bmatrix} 1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \tilde{a}_{21} & 1 & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & 1 \end{bmatrix} = \begin{bmatrix} 1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ 1/\tilde{a}_{12} & 1 & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/\tilde{a}_{1n} & 1/\tilde{a}_{2n} & \cdots & 1 \end{bmatrix}, k=1,2,\ldots n \quad (1)$$

The next step is the weight calculation. Geometric means of the triangular fuzzy values, $\tilde{r}_i$ and fuzzy weights $\tilde{w}_i$(Li,Mi,Ui) will be found in this step. In other wordsi multiple expets' opinions represented by a matrix will be converted to an

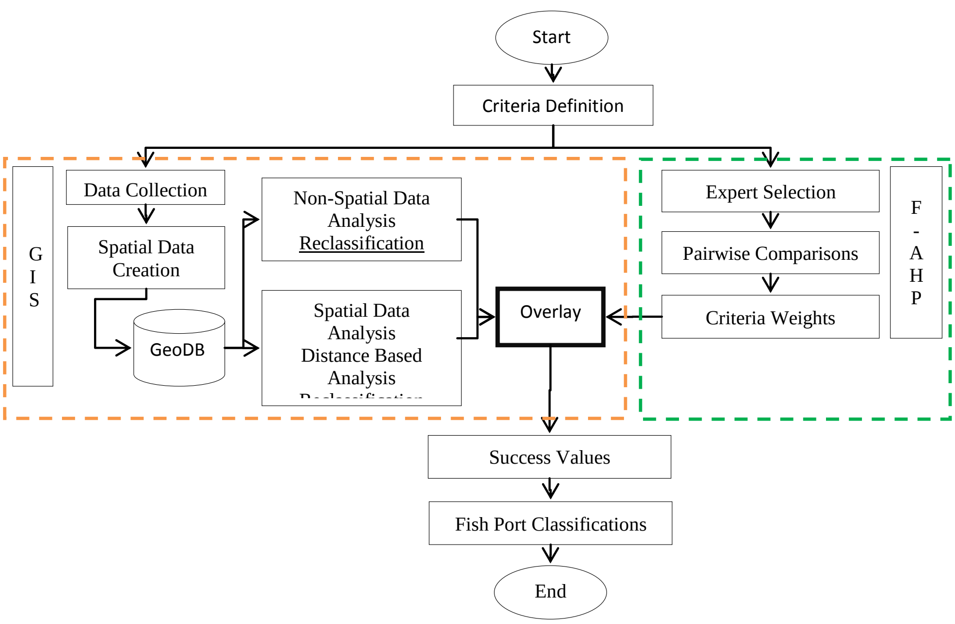

Figure 1. Methodology.

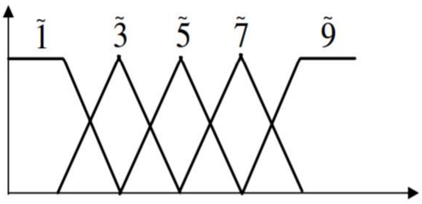

Figure 2. Saaty scale expressed as fuzzy sets (Durán & Aguilo, 2008).

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)

understandable fuzzy numbers. Equation 2 and 3 explains the mathematical representation of the calculations of the $\tilde{r}_i$ and $\tilde{w}_i$. These values give the fuzzy priority values of the decision criteria based on the comparisons.

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

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

In the last step, fuzzy numbers' conversions into crisp numbers by defuzzification operation will be taken place. 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 & Wang, 1992).

GIS

GIS is suggested to analyze the spatial characteristics of the considered decision criteria. Two types of data analysis tools are suitable for dealing the data types used in the study. The first is the euclidean distance analysis can be applied for point or line types of data. The analysis tool takes the existing geographic feature's location and creates a raster map that expresses distances towards to the considered feature. 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 the hot spot analysis which is an example of spatial statistical analysis and clustering analysis. This analysis approach is useful when the 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 statistical classifications (for further explanation, see: (ESRI, 2014b; Onden, Eldemir, & 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 calculates a final result map with the inputs of a distance or a hot-spot map in raster format. It is capable of using weights of the each decision criteria derived from f-AHP analysis. With an overlay tool, decision makers' expressions and judgements over decision criteria and spatial analysis results can be integrated and a final map can be obtained. The analysis will express the success value of considered study area. The output is also a raster map and the results show the values of the 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

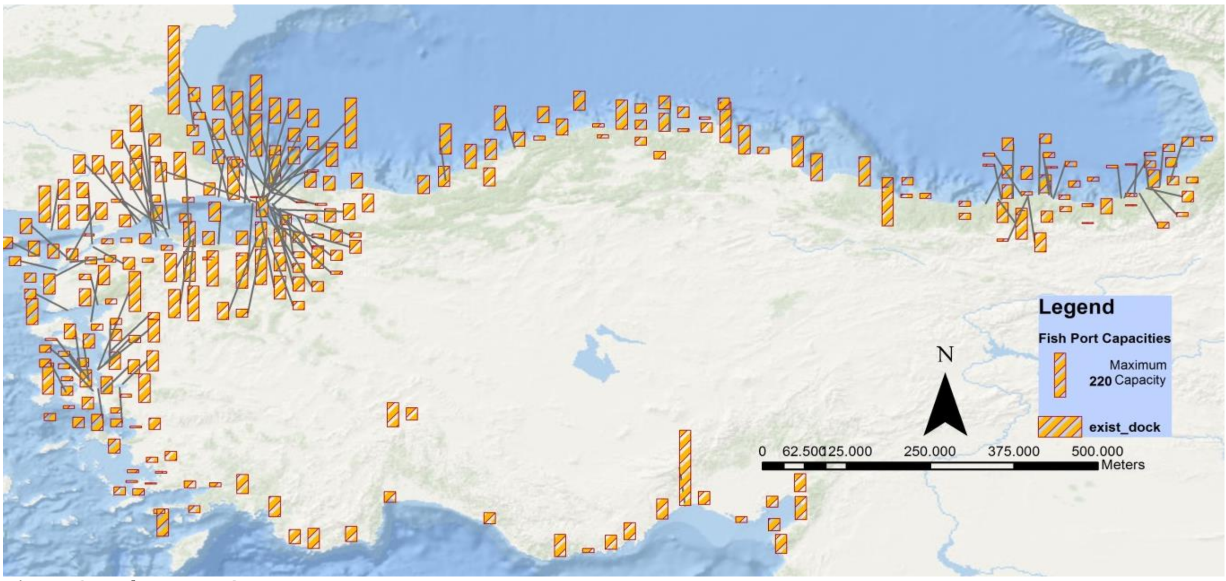

Figure 3. Fishing Port Capacities.

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		

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 8333 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 way 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 expertise. 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 (UDHB, 2011). The numbers are suitable for classification strategies.

The fishing ports are mainly considered as farming facilities for the 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

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

Main-Criteria	Facility Specialties	Port Services	Transportation	Social Effects	Weight
Facility Specialties	$\tilde{1}$	$\widetilde{0.33}$	$\tilde{2}$	$\tilde{2}$	0.24
Port Services	$\tilde{3}$	$\tilde{1}$	$\widetilde{0.5}$	$\tilde{3}$	0.33
Transportation	$\widetilde{0.5}$	$\tilde{2}$	$\tilde{1}$	$\tilde{3}$	0.31
Social Effects	$\widetilde{0.5}$	$\widetilde{0.33}$	$\widetilde{0.33}$	$\tilde{1}$	0.12

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

Facility Specialties	Collection	Distribution	Weight	Global Priority
Collection	$\tilde{1}$	$\tilde{1}$	0.5	0.12
Distribution	$\tilde{1}$	$\tilde{1}$	0.5	0.12

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	Weight	Global Priority
Pier length	$\tilde{1}$	0,5	$\tilde{1}$	$\tilde{1}$	$\tilde{2}$	0.18	0.06
Utilities	$\tilde{2}$	$\tilde{1}$	$\widetilde{0.5}$	$\tilde{2}$	$\tilde{1}$	0.22	0.07
Catering and other services	$\tilde{1}$	$\tilde{2}$	$\tilde{1}$	$\tilde{3}$	$\tilde{2}$	0.30	0.10
Refueling	$\tilde{1}$	$\widetilde{0.5}$	$\widetilde{0.33}$	$\tilde{1}$	$\tilde{2}$	0.16	0.05
Pre-Cooling	$\widetilde{0.5}$	$\tilde{1}$	$\widetilde{0.5}$	$\widetilde{0.5}$	$\tilde{1}$	0.14	0.05

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

Transportation	Highway	Seaports	Railway	Airport	Weight	Global Priority
Highway	$\tilde{1}$	$\tilde{3}$	$\tilde{3}$	$\tilde{5}$	0.50	0.15
Seaports	$\widetilde{0.33}$	$\tilde{1}$	$\widetilde{0.33}$	$\tilde{5}$	0.18	0.05
Railway	$\widetilde{0.33}$	$\tilde{3}$	$\tilde{1}$	$\tilde{3}$	0.26	0.08
Airport	$\widetilde{0.2}$	$\widetilde{0.2}$	$\widetilde{0.33}$	$\tilde{1}$	0.07	0.02

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

Social Effects	Population	Shopping	Weight	Global Priority
Population	$\tilde{1}$	$\tilde{3}$	0.43	0.05
Shopping	$\tilde{1}$	$\tilde{4}$	0.55	0.06

transportation (TUSSIDE, 2015). 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 3 is used to illustrate the geographic locations of the facilities with their boat capacities.

The distribution of the fishing ports based on their capabilities of farming and transportation is expressed in Table 2 based on the Turkish maritime fishery report (UDHB, 2011). The table also gave the regional distributions of the facilities which also illustrated in Figure 3. The numbers are also showing that fishing ports have different capabilities than fishery activities. Despite the fact that high portion of the facilities serve as a farming facility, other services are already being taken care of by these facilities.

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

Table 9. Criteria Weights

Main Criteria	Weights	Sub-Criteria	Weight	Global Priority
Facility Specialties	0.24	Collection	0.50	0.12
		Distribution	0.50	0.12
Port Services	0.33	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	0.31	Highway	0.50	0.15
		Seaports	0.18	0.05
		Railway	0.26	0.08
		Airport	0.07	0.02
Social Effects	0.12	Population	0.43	0.05
		Shopping	0.55	0.06

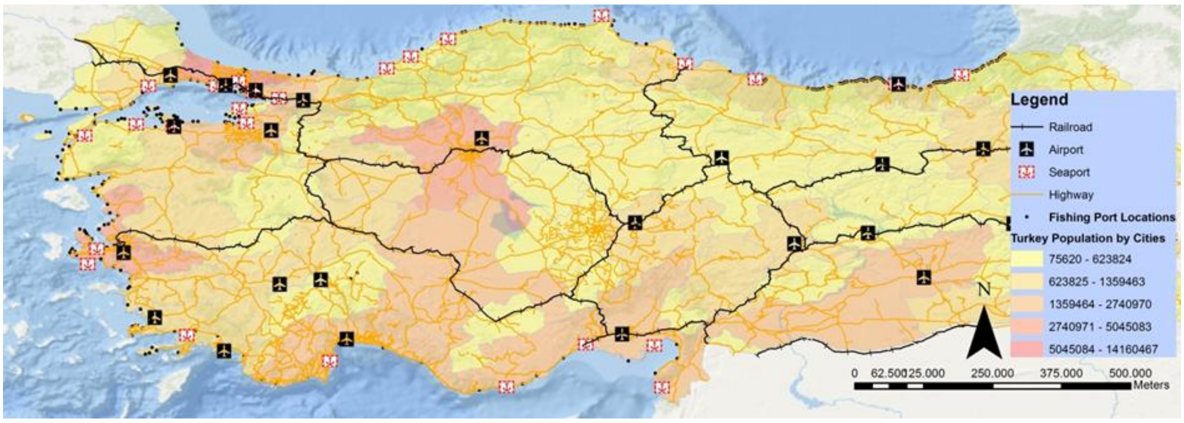

Figure 4. Spatial data used in analysis.

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 focused on classifications or location decisions of fishing ports, 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 in Turkey. 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.

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 experts, who have 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 discussed the superiorities of the decision criteria with the linguistic scale and reach a comparison decision. 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 the main criteria.

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

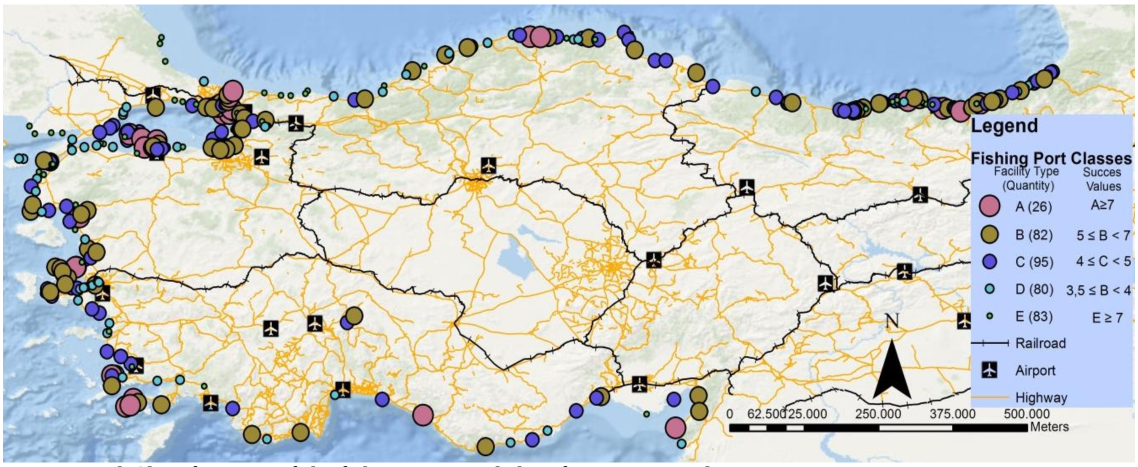

Figure 5. Final Classifications of the fishing ports and classification intervals.

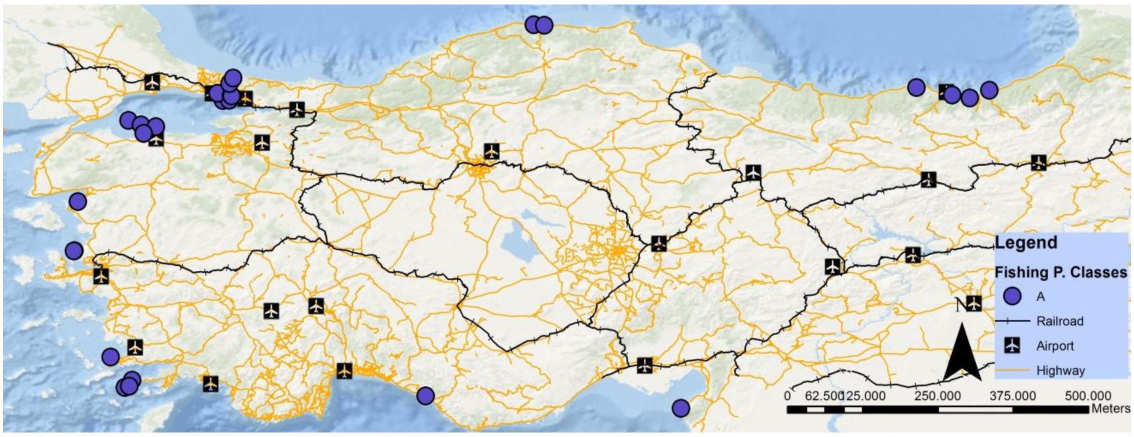

Figure 6. Type A Fishing Ports.

of the each main criteria.

The criteria priorities found as the result of the f-AHP analysis and calculated values are expressed in the Tables 4, 5, 6, 7 and 8. The global weight values expressed in Table 4 shows the priorities of the main-criteria. The weight given in Tables 5, 6, 7 and 8 is the comparison results of the sub-criteria and the global priority means how much affect the sub-criterion has over the decision. The results showed that the port services criteria is the most important criterion among the criteria. Transport, facility specialties and social effects followed the port services criterion based on the priority values. After reaching the priorities of the main criteria, sub-criteria weights are calculated with the same approach and the weights are given in Table 9.

Spatial analysis is the 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, lighthouse existence, 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 added to the feature's attribute table. 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.

Spatial analysis step is carried out after data preparation step. In that step a geographic model and a toolbox in ArcGIS is developed. The toolbox takes the created criteria data and criteria weights as input, analyzes 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.

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 according to their success values in Figure 5. The figure expresses the spatial sprawl of the classes and the classification values. 26 fishing ports are found as type A, and those nodes are convenient facilities for the conversion to a regional center.

It is seen in Figure 6 that 10 regions are found as convenient as the result of the applied methodology. Since the goal of the study is detecting the most suitable regions among alternatives for serving as the regional centers, it can be said that the outputs are covering the demands expected by the goals.

Conclusion

The classification of the fishing ports located in Turkey based on their capabilities is done in this 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. Expert thoughts and spatial analysis results are combined in an 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 in 10 regions, 26 facilities is convenient for conversion to a regional center with the considered parameters. That conversions might create a greater impact on regional economy with centralized services and increase economic potential of the facilities.

As the result of the workshops, all decision criteria are prioritized by experts and the most important criterion is found as port services. Although it is not solely able to ensure a facility alternative as a regional center, it carries the highest impact on the decision. Since the whole study area has different alternatives, it is important to drive a candidate forward in the alternative set. With other words, port services such as pier length and utilities are important in differentiating the close facilities. The second most important main criterion is found as transportation. Third and fourth important criteria are found as facility specialties and social effects in sequence. Although their weights are less, however they affect the ranks of the alternatives significantly. It can be said that all criteria has some level of significance on the regional center classification decision. The decision criteria results are combined with the GIS outputs which are the alternatives' spatial analysis performance.

It is important to use of pair-wise comparisons and detecting superiorities of the decision criteria in fishery industry. That approach gives chance to evaluate the affecting criteria and calculating their weights. In addition that is a novelty in literature; it also shows that the fuzzy multi-criteria applications are applicable for the research area. The approach can be used for other arguable problems in the field. However it is not satisfactory in most of location decision. Thus, the use of GIS analyses is also another contribution to the literature. The application is shown that qualitative analysis approaches might generate practicable results for policy makers.

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