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Türkiye's Maritime Training and Education Institutes Non-Conformities Historical Evaluation by Grey Relation Analysis and Geographical Information System

Esat Güzel[1], Pelin Bolat[2]

[1]Girne American University School of Marine and Logistics, Girne, TRNC
[2]İstanbul Technical University Faculty of Maritime, Department of Basic Sciences, İstanbul, Türkiye

Abstract

The main aim of the study is to determine an objective method for maritime training and education institutes quality assessment based on objective data. To achieve this, results of external audits carried out by independent evaluation are analysed using the Entropy Weighted Grey Relation Analysis method. In the final stage, results of Entropy Weighted Grey Relation Analysis method are demonstrated on QGIS, an open source Geographic Information System, thus Türkiye maritime training and education institutes non-conformities concentration and distribution maps are generated.

Keywords: Maritime training and education, Quality assessment, Grey relation analysis, Geographic information system, Non-conformities

1. Introduction

Maritime training and education governed by national and international regulations and all maritime training and education institutes needs to comply with these regulations in order to certify their students /trainees. The Standards of Training, Certification and Watchkeeping of Seafarers International Convention (STCW-1978) and amendments prescribe minimum standards relating to training, certification and watchkeeping for seafarers, which all countries need to comply with. National maritime administrations ratify and implement the STCW-1978 Convention, the STCW Code, and their amendments. Turkish Maritime Administration ratified STCW Convention and regulate its national maritime training and education institutes with legislations including "Regulation for Seafarers and Sea Pilots" and "Directive for Seafarers and Sea Pilots Training and Examination" which are prepared in reference to STCW-1978 Convention and STCW Code as amended.

Compliance with national and international regulations is checked by audits in accordance with the "Directive for Seafarers and Sea Pilots Training and Examination". An initial audit, as a pre-condition of accreditation, and 2-year periodic audits are carried out. However, there are no studies found on these audits' results which can help to identify the weakness of the maritime training and education institutes or how training quality can be improved in these institutes.

There are 168 maritime training and education institutes, of which 20 offer associate degrees, 26 offer bachelor degrees, 52 offer high school degrees, and 70 offer private courses in Türkiye as of December 2020 [1]. Audit results of Turkish Maritime training and education institutes are kept in a software called GAEBS, under the control of the Ministry of Transport and Infrastructure, which is also recognized as Türkiye's Maritime Administration. Table 1 shows the distribution of maritime training and education as per their education degrees, their accreditation from Administration, and their geographical distribution.

Data acquired from GAEBS is analysed by entropy-weighted Grey Relation Analysis (GRA), and the grey relation coefficient of each non-conformity category is determined. This analysis is then applied to non-conformities categorized by geographical distribution.

Address for Correspondence: Esat Güzel, Girne American University School of Marine and Logistics, Girne, TRNC
E-mail: esatguzel@hotmail.com
ORCID iD: orcid.org/0000-0002-8037-9537

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Table 1. *Geographical distribution of Türkiye's maritime training and education institutes*

Province	Assoc. Degree		Bachelor Degree		Highschool		Private Training Centers		Total
	Accredited	None-Accredited	Accredited	None-Accredited	Accredited	None-Accredited	Accredited	None-Accredited	
Bartın	1								1
Kastamonu					1				1
Aydın				1	2				3
Bitlis					1			1	2
Tekirdağ					1				1
Van				1	1				2
Zonguldak	1			1	1				3
Yalova	1				1				2
Çanakkale				1	1		1		3
Hatay			1		1			1	3
Sinop		1				2		1	4
KKTC	1		2						3
Balıkesir				1	2			2	5
Ordu	1		1		1			2	5
Giresun		1		1	3			1	6
Kocaeli	1		1		2		2		6
Rize			1		3		1		5
Samsun				1	1		3	2	7
Antalya				1	2		2	3	8
Trabzon		1	1		1	2	1		6
Mersin	1			1	2		3		7
Muğla	1				5		6	5	17
İzmir	1		1	1	5	2	2	9	21
İstanbul	4	3	5		6	2	11	10	41
Adana				1		1			2
Bursa				1				1	2
Sakarya		1							1
Gaziantep				1					1
Total	13	7	13	13	43	9	32	38	168

The result of Entropy Weighted GRA is demonstrated on QGIS, an open source Geographic Information System (GIS), and thus, maps of non-conformities analysis of Türkiye are generated.

2. Literature Review

In the literature, much research have been found on GRA, in which for different areas. However, no specific study on maritime training and education institutes, quality assessment of training institutes, or segmentation using of GRA is found. Lin et al. [2] used the GRA method to assess watermarking schemes in digital multimedia copyright protection. Vatansever and Akgul [3] applied entropy and GRA method to determine airlines websites performance evaluation.

Another example of use of entropy and GRA is found by Lee et al. [4] in which financial positions of two shipping companies are compared by this method.

Kokoç and Ersöz [5] found 119 publications regarding the perception of service quality offered by higher education institutions. Some of the scales used in the evaluation of service quality of higher education institutions are ClassroomQual, EduQUAL, HedQUAL, HedPERF (stands for Higher Education Performance) HESQUAL, INSTAQUAL, SERPERF (stands for Service Performace), Student Satisfaction Scale, SERVQUAL (stands for Service Quality) and UNIQUAL. In fact, there are scales developed by researchers using different service quality measurements and criteria. The most commonly used criteria that can be counted are physical facilities, reliability and security, sensitivity/empathy, fees, academic staff, transport facilities, and infrastructure. In scales developed in recent years, new criteria such as academic attendance, cognitive attendance, training quality, academic staff profiles, curriculum, infrastructure, and facilities have become the main measurements in these scales. However, common specifications of these scales are mostly subjective and based on questionnaires. In fact, some of the studies mentioned that these scales are insufficient to determine the service quality of higher education institutes [5].

Saeidi et al. [6] have used the SERVQUAL standard questionnaire to evaluate the service of maritime training institutions while Dacuray et al. [7] used a descriptive type of research in their study on Maritime Students' Satisfaction with the Services of one Training Center in the Philippines.

Only one study by Chen et al. [8], using entropy weighted GRA, is used in the maritime field in which port state control results are analysed by this method.

In the literature review of maritime training and education institutes, research is usually carried out by comparison of quantitative data, such as the number of trainers, the number of students, or the facilities of the institutes. No study has been found, based on non-conformities in the training institutes. Similarly, no research is found in the area of maritime training and education institutes segmentation by the GISs.

The application of the entropy-weighted GRA method to analyse non-conformities of maritime training and education institutes, and the demonstration of results using GIS, makes this research an objective assessment method never used before.

3. Application

3.1. Entropy Weighted GRA

Grey Relation theory was formulated by Ju-Iong Deng in 1982, and it is a mathematical method that can be applied interdisciplinarily. It is especially useful when the datasets are not sufficient to run statistical analysis [9].

GRA is a decision-making method, to be used to generate discrete sequences for the correlation analysis of such sequences with processing uncertainty, multi-variable input, and discrete data [2]. Also, the ability to work with small and uncertain data sets makes this method preferable to other statistical methods [10,11].

GRA is independent of a probability distribution. It gives more reliable results with small data sets, especially when compared to statistical analysis [12].

However, where inconsistent dimensions or data types makes use of conventional GRA insufficient, method is improved by entropy weight method. Integrated method of entropy weighted GRA is used frequently in technical areas and engineering [8]. The entropy weighted method reflects the real importance of each factor in the system.

3.2. Methodology

In this study, Entropy Weighted GRA is applied to audit results of the Directive for Seafarers Training and Examination for audits carried out between 2011 and 2017 at Turkish Maritime Training and Education Institutes. Data obtained from the software called GAEBS (Seafarers Training Information System) with written permission of Ministry of Transport and Infrastructure. With this analysis, grey relational coefficient and ranking for each non-conformity category are determined.

In the second step of the analysis, by using grey relation coefficient, maritime training institute non-conformities calculated by their geographical distribution.

In the final step of the study, the geographical distribution of GRA results is demonstrated by using QGIS.

3.3. Datasets

Information and audit results of Turkish Maritime Training and Education Institutes are stored and managed by software called GAEBS, which stands for Seafarers Training Information System. In this database, information such as, capacity, departments, infrastructure and facilities, lecturers, audit reports, and other details of the institutes are kept. With official permission from the Administration, data on the 117 training institutes and their audit results, which were carried out in accordance with the Directive on Seafarers Training and Examination for the period between 2011 and 2017, were obtained.

In this respect, 2,086 non-conformities are used as raw data. This data is classified as Documentation, Lecturer, Equipment, Curriculum, Simulator Specifications and System Non-conformities categories. The raw data are filtered against uncertainties and 861 non-conformities are used in the analysis.

3.4. Entropy Weighted GRA Analysis of Turkish Maritime Institutes Audits Results

The aim of this study is to establish a quality assessment model for maritime training and education institutes and find the degree to which the non-conformities found in the audits affect the outcomes. In order to do this, GRA and Entropy Weight Method are integrated. In the first step, non-conformities are categorized, and the GRA method with the entropy weight model is applied. Methodological framework of the process is given in Figure 1 and steps of GRA of the data is given in Table 2.

3.5. Application of Entropy Weighted GRA on Non-conformities Based on Cities Distribution

Steps of GRA given in Figure 1 are applied to non-conformities found in the audits. These non-conformities are categorized and distributed according to the geographical location of the respective maritime training institute. A decision matrix is formed by these categorisations (Table 3).

Further calculations are carried out by using formulas given in Table 2. In the next step, a "normalised decision matrix" is formed. At this step, there are 3 approaches, namely the Benefit Approach, the Reduction Approach, and the Mean Approach. In our study, a reduction approach, which means "smaller is better," is used since the aim is to reduce the non-conformities.

In the third step the analysis entropy weights are calculated and "entropy measure matrix" is formulated. The calculation results are the distance between the normalized value and the reference criteria series in terms of absolute value.

The next step is the calculation of the absolute value of the criteria matrix. Calculated results are reflected in the study findings. Reference series and minimum and maximum values are determined.

In the last step of the GRA, objective weight for each criteria is calculated and Grey Relation Coefficient (ε_i) matrix formed (Table 4). Grey Relation Coefficient (ε_i) is the objective weight of each criterion, thus showing the importance of the effect of non-conformities on the training institute quality assessment.

The Grey analysis process is repeated for the non-conformities recorded between 2011 and 2017, and the Grey Relation Coefficient (ε_i) is found for each category. Accordingly, the following results were returned from the calculation (Table 5).

According to the GRA of the non-conformities found in the audits, the ranking of the grey relation coefficients is as follows: Equipment (1.137), Curriculum (1.055), Documentation (0.762), Simulator Specifications (0.602), System Non-conformities (0.338) and Lecturer (0.145). The above-mentioned relation coefficients (ε_i) are applied to entropy weights to obtain grey relation degrees of each category by cities distribution, and results are shown in Table 6.

4. Demonstration of The GRA Results on GIS

GRA has been applied to the audit results of 117 training institutions carried out between 2011-2017, and results of the analysis are applied to non-conformities of 14 cities selected based on a useful dataset.

Results of GRA analysis are demonstrated using QGIS, an open-source GIS. With the help of GIS, segmentation map of entropy weighted grey relation coefficients of non-conformities factors have been generated.

According to this GRA analysis, "Equipment" category has returned the highest GRA coefficient of 1.137. The distribution map of GRA coefficients for each non-conformities category is formed by using QGIS.

In the equipment category, which has the highest GRA coefficient, the densest cities are observed to be Kocaeli and Ordu. These provinces are followed by Mersin, Balıkesir, and Çanakkale respectively. The provinces with the least density in the equipment category were Giresun and Antalya.

The primary aim of the study is to see the distribution of non-conformity categories throughout Türkiye and create charts of these distributions. On the other hand, these findings will only be useful through root cause analysis and addressing root causes. Therefore, sampling is conducted on Non-conformities Correction Forms, and root causes are assessed.

Among the root causes of non-conformities in the equipment category is the insufficient financial resources required for

Table 2. *Entropy weighting and grey relation analysis process*

	Entropy weighting	Grey relation analysis
Step 1	Construction of a decision matrix (X). A set of alternatives (A= {A_i. i=1.2,…,n}), compared with a set of criteria (C= {C_i ,i=1,2,…,n}). Therefore, an n×m performance matrix (the decision matrix; X) can be obtained as follow: $X=\begin{bmatrix} x_{11} & \cdots & x_{1m} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{nm} \end{bmatrix}$ where X_{ij} is a crisp value indicating the performance rating of each alternative A_i with regard to each criterion C_j.	A decision matrix is constructed with original data. $X=\begin{bmatrix} x_1(1), x_1(2), ...x_1(n) \\ x_2(1), x_2(2), ...x_2(n) \\ .... \\ .... \\ x_m(1), x_m(2), ...x_m(n) \end{bmatrix}$
Step 2	To ascertain objective weights by the entropy measure, the decision matrix in Step 1 needs to be normalized for each criterion C_j (j=1,2,...., m) as $p_{ij}=\frac{x_{ij}}{\sum_{p=1}^{n} x_{pj}}$, $i=1,2,....n$ $P=\begin{bmatrix} p_{11} & \cdots & p_{1m} \\ \vdots & \ddots & \vdots \\ p_{n1} & \cdots & p_{nm} \end{bmatrix}$	Standard data normalization formulas: I) Benefit approach (Larger is better): $x_i(k)=\frac{x_i(k)-\min x_i(k)}{\max x_i(k)-\min x_i(k)}$ or II)Reduction approach (Smaller is better): $x_i(k)=\frac{\max x_i(k)-x_i(k)}{\max x_i(k)-\min x_i(k)}$ or III)Mean approach (Nominal is best): $x_i(k)=\frac{\left\|x_i(k)-x_0(k)\right\|}{\max x_i(k)-x_0(k)}$
Step 3	Calculate the entropy measure of every index using the following equation: $e_j=-k\sum_{i=1}^{n} p_{ij}\ln p_{ij}$, Where k=1/ln(n)	For determination grey relation ranking I) Calculate the distance between normalized value with reference criteria series by absolute value: $\Delta x_i(k)=\left\|x_0(k)-x_i(k)\right\|$ II) Find reference sequence. III) Determine min. and max. values IV) Use (distinguishing coefficient) p=0.5.
Step 4	The degree of divergence (d_j) of the average intrinsic information contained by each criterion (C={C_j ,j=1,2,…,m}) can be calculated as: $d_j=1-e_j$ the more d_j is, the more important the criterion jth. is.	Calculate the grey relational degree (ξ) and degree of grey coefficient (r_i) $\xi_i(k)=\frac{\Delta\min+p\Delta max}{\Delta x_i(k)+p\Delta max}$ $r_i=\sum[w(k)\xi(k)]$
Step 5	The objective weight for each criterion (C= {C_j, j=1,2,…,m}) is thus given by: $w_j=\frac{d_j}{\sum_j d_j}$	
Vatansever and Akgul [3]		

purchasing or renewing equipment. The difficulty of the budget approval process for equipment requests in public training institutions makes it challenging to eliminate these inconveniences. Private training institutions try to minimize their expenses, as they eventually carry out a commercial activity with profit maximization aims.

Maritime training institutions should have maritime safety training centers in order to carry out STCW courses. These training centers consist of fire training centers, life-saving appliances (lifeboats, etc.), and survival at sea training facilities (pools or water areas with jumping platforms). In addition to the size of the initial investment cost of these

facilities, the difficulty in obtaining sea and water area permits also contributes negatively to this category. For this reason, many training institutions have chosen to operate a shared training center or sign a protocol to use the facility of another institution during training periods.

The second highest GRA coefficient category is the Curriculum. The density map for this category shows that the highest density is in Samsun and Mersin provinces. These provinces are followed by İstanbul and Trabzon.

The root cause of the non-conformity in this category is considered to be the delays in the inclusion in the curriculum

Table 3. *Non-conformities frequency matrix by city distribution*

	Documentation	Lecturer	Equipment	Curriculum	Simulator specs.	System non-conformities
Antalya	12	15	59	3-	2	5
Balıkesir	14	18	9	0	0	10
Çanakkale	11	14	17	0	0	8
Giresun	0	15	31	2	3	0
Mersin	36	31	110	23	5	15
İstanbul	112	89	178	52	38	77
İzmir	46	34	47	12	8	36
Kocaeli	27	18	99	7	9	5
Muğla	33	34	96	17	23	24
Ordu	26	9	23	6	7	4
Rize	7	11	32	1	2	0
Samsun	9	12	10	6	0	8
Sinop	2	1	22	0	0	0
Trabzon	5	6	5	4	0	4

Table 4. *Grey relational coefficients (ε) distributions by cities*

	Documentation	Lecturer	Equipment	Curriculum	Simulator specs.	System non-conformities
Antalya	0.336	0.385	0.451	0.333	0.361	0.356
Balıkesir	0.605	1.000	0.356	0.333	0.333	0.385
Çanakkale	0.515	0.680	0.392	0.333	0.333	0.385
Giresun	0.333	0.586	0.434	0.367	0.451	0.385
Mersin	0.688	0.668	0.630	1.000	0.333	0.270
İstanbul	0.433	0.399	0.324	0.395	0.475	0.317
İzmir	0.384	0.359	0.324	0.343	0.352	0.363
Kocaeli	0.712	0.486	1.000	0.359	0.939	0.294
Muğla	0.347	0.368	0.324	0.336	1.000	0.277
Ordu	1.000	0.362	0.324	0.382	0.806	0.311
Rize	0.392	0.443	0.414	0.347	0.390	0.385
Samsun	0.413	0.459	0.347	0.434	0.333	0.385
Sinop	0.356	0.333	0.418	0.333	0.333	0.385
Trabzon	0.367	0.368	0.333	0.384	0.333	0.385

Table 5. *Grey relation coefficient (ε) and grey relation ranking (r_j)*

	Documentation	Lecturer	Equipment	Curriculum	Simulator specs.	System non-conformities
$\varepsilon_{.}$	0.762	0.145	1.137	1.055	0.602	0.338
r_j	3	6	1	2	4	5

Table 6. *Geographical distribution (by cities) of GRA degrees of non-conformities*

	Documentation	Lecturer	Equipment	Curriculum	Simulator specs.	System non-conformities
Antalya	0.044	0.025	0.054	0.077	0.105	0.058
Balıkesir	0.079	0.065	0.042	0.077	0.097	0.062
Çanakkale	0.068	0.044	0.047	0.077	0.097	0.062
Giresun	0.044	0.038	0.052	0.085	0.131	0.062
Mersin	0.09	0.043	0.075	0.231	0.097	0.044
İstanbul	0.057	0.026	0.039	0.091	0.139	0.051
İzmir	0.05	0.023	0.039	0.079	0.103	0.059
Kocaeli	0.094	0.031	0.119	0.083	0.274	0.048
Muğla	0.046	0.024	0.039	0.078	0.292	0.045
Ordu	0.131	0.023	0.039	0.088	0.235	0.05
Rize	0.051	0.029	0.049	0.08	0.114	0.062
Samsun	0.054	0.03	0.041	0.1	0.097	0.062
Sinop	0.047	0.022	0.05	0.077	0.097	0.062
Trabzon	0.048	0.024	0.04	0.089	0.097	0.062

of new training requirements in the STCW-1978 Convention and Code and amendments, known as the Manila 2010 changes. In the audits carried out, it was observed that the knowledge level of the representatives of the institutions and trainers on the STCW-1978 Convention and amendments was very limited. Awareness about the training methodology envisaged in the Convention and the Code was low, and, the education system was structured on the basis of the national legislation. However, Seafarers and Pilots Regulations and the Directive of Seafarers and Pilots Training and Examination do not include all details of the STCW-1978 Convention, the STCW Code and amendments. Lecturers and maritime training and education institutes should be aware of all requirements of the STCW Convention and Code and amendments.

The Directive on Seafarers and Sea Pilots Training and Examination ordered all maritime training and education institutions to reflect the Manila-2010 changes in their curriculum as of July 1, 2013. However, comprehension of these changes, and their inclusion in the curriculum, occurred only as part of the corrective and preventive actions for the non-conformities documented in this category as a result of the audits. Regarding this, the administration requested that the Manila-2010 changes and the STCW Convention and Code comparison chart, which show how the competence, knowledge, understanding, and expertise required in the STCW Code, along with competency measurement methods and evaluation criteria, are reflected in the curriculum, be presented in the audits.

The documentation categories rank third in the GRA coefficient of non-conformity factors. In this category, there are non-conformities arising from not complying with the documentation requirements by the Quality Management System (QMS). When the distribution in this category is examined, it is found that Kocaeli and Ordu share the first place. It is followed by Mersin and Balıkesir. The provinces with the least density in this category are Antalya and Giresun.

The grey relation coefficient of the "Simulator Specifications" category was calculated as 0.602. Empirical results show that factors with a degree of grey relationship higher than 0.5 are highly effective as indicators for warnings for maritime education institutions, so these factors should also be carefully considered. In this category, Kocaeli and Muğla were identified as the provinces with the highest values. Then Ordu and Samsun provinces comes.

With the developing technologies, the number of simulator-based training has increased in many fields. In simulators with enhanced reality, trainees or students can carry out practical training on scenarios and gain experience for the profession. However, high simulator costs, trainee/student limitation per simulator, and restriction on common use of simulators between training institutions bring additional costs to training institutions. Also, due to rapid changes in simulator technologies, software updates, maintenance, and repair costs of simulators have a significant share in the budget. When all these facts are evaluated together, it can be said that there is an inverse relationship between the degree of the non-compliance factor in this category and the financial strength of the institution.

There are two categories with a grey relation coefficient less than 0.5. These categories are "System Non-conformities"

and "Lecturer". Considering that these two categories were strictly inspected during the initial authorization of maritime training institutions, and those who could not meet the conditions were not authorized, training institutes pay much attention to these categories. This attention is reflected in the results.

In the category of "System Non-conformities" the density of the GRA coefficient follows the order of Çanakkale, Balıkesir, Sinop, Samsun, Giresun, Trabzon and Rize. Considering the distribution of training institutions in these provinces, it can be concluded that the number of high schools and private courses is substantial. It can be concluded that the implementation of the QMS in high schools and private courses is relatively weak compared to higher education institutions.

Distribution of non-compliance factors according to the "Lecturer" category follows the order of Balıkesir, Çanakkale, and Mersin. Considering the distribution of training institutions in these provinces, the non-conformities are observed to be the non-conformities in the lecturer category are also concentrated in high school and private training institutions.

Due to the restriction on the number of figures, only 2 selected maps are included in this article, one of which

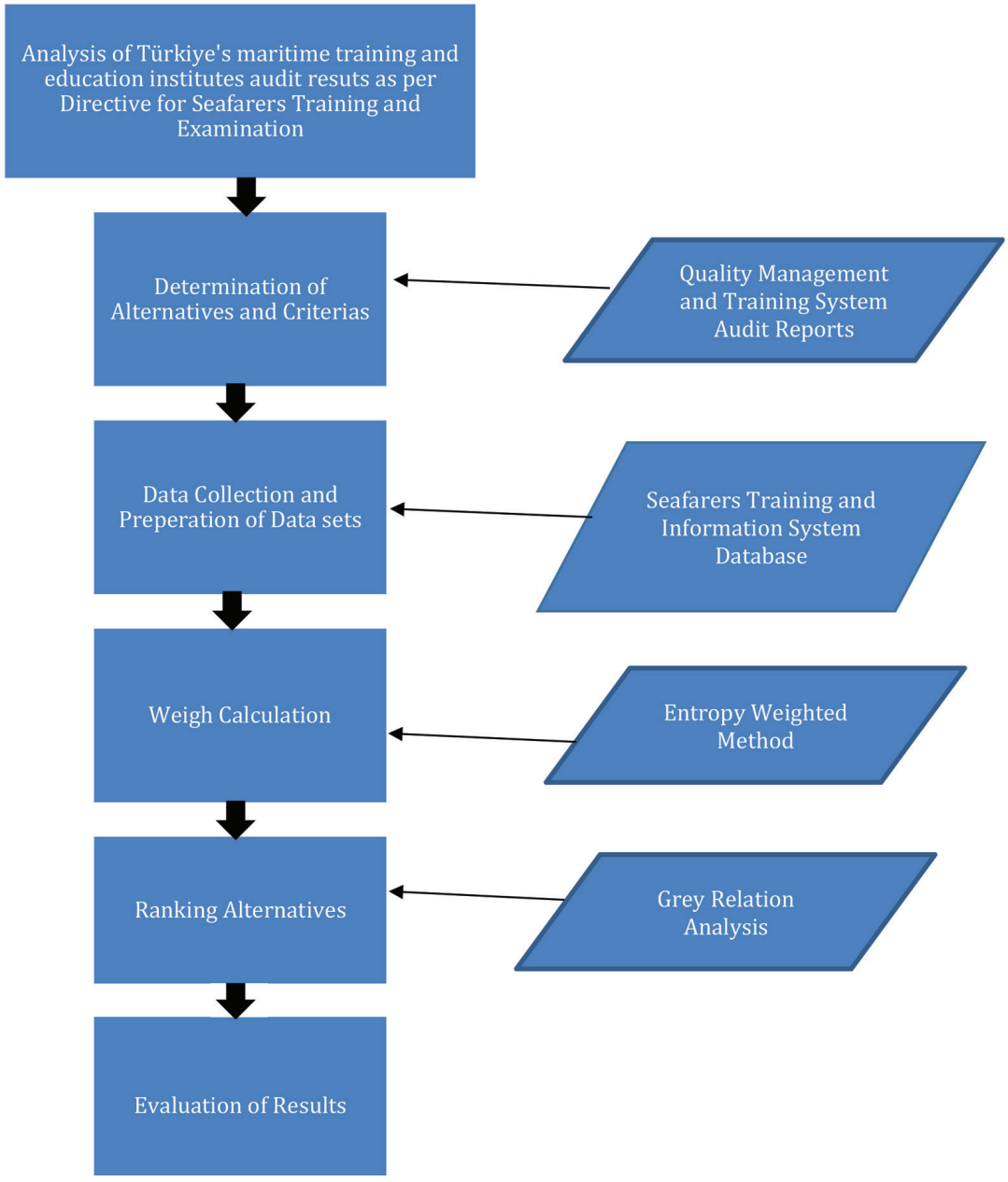

Figure 1. *Methodological framework of analysis of Türkiye's maritime training and education institutes audit results as per Directive for Seafarers Training and Examination*

shows all non-conformities in a single map (Figure 2), and the total coefficient of Entropy Weighted GRA Analysis geographical distribution is given in Figure 3.

In QGIS demonstration of the GRA results, the Equipment category map is selected as the base chart, since it has the highest GRA coefficient and other categories are also shown in pie charts. The legends of the maps were automatically created because the numbers within the range of coefficients were close. Densities of the non-conformities are displayed in order where higher density is darker.

In Figure 2, Kocaeli and Mersin, which have the highest non-conformity factor in the equipment category on the map, also have high GRA coefficients in curriculum and simulator specifications categories.

Figure 3 shows the distribution of maritime education institutions, according to GRA factors of total non-conformity. In the quality assessment of institutions: considering the total non-conformity factor as an appropriate method includes all non-conformities together in the analysis, since the weight of each invoice is included. According to the results of this analysis, the highest total non-conformity distribution was seen in Mersin, Kocaeli, and Ordu. These provinces were followed by Muğla, Balıkesir, Trabzon and İstanbul.

İstanbul, which has a total of 41 maritime education institutions, 26 of which are accredited, ranks 7th in terms of total non-compliance factors. Türkiye's center of maritime industry stakeholders accepted involved being involved to a large extent with the oldest training institutions in İstanbul. The perception of hosting the best maritime training institution does not coincide with the results obtained. These results show that training institutions in İstanbul have correctable and improvable weaknesses.

In Antalya, Trabzon, and Samsun, which are included in the map, the non-conformity factor has been assigned relatively less weight. These provinces are followed by Rize. The best results in distribution according to total non-conformity factors were obtained in Sinop and İzmir.

Comparing the distribution of non-conformity categories and the distribution of total non-compliance factors of training institutions according to all categories, it was determined that the distribution of total non-compliance factors does not always coincide with the provinces with the highest non-compliance weight. For example, Muğla province is one of the provinces with the lowest density in the equipment category, which has the highest degree of relation, while it is one of the densest provinces in the distribution of total non-compliance factors.

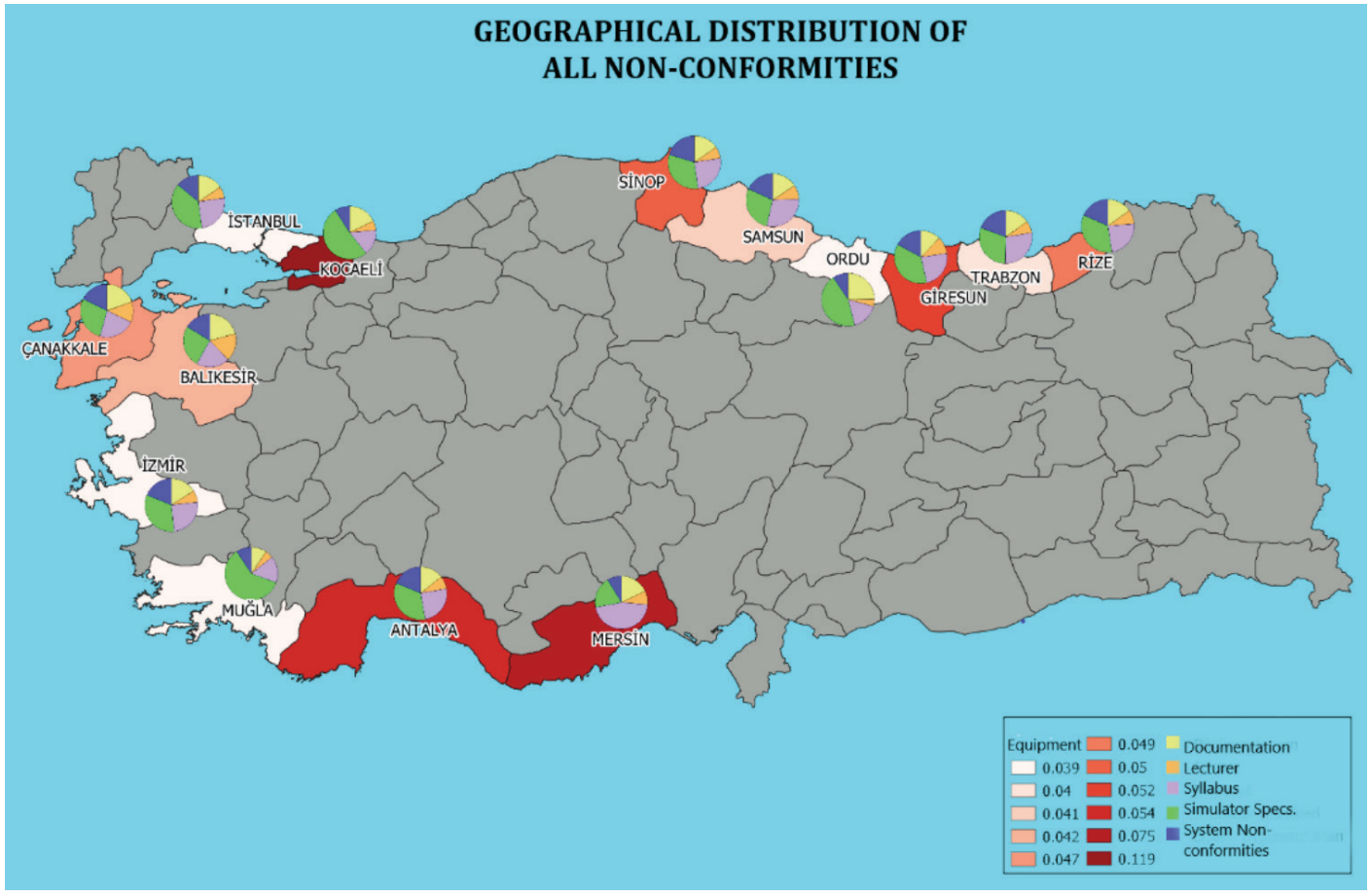

Figure 2. *Non-conformities distribution of all categories*

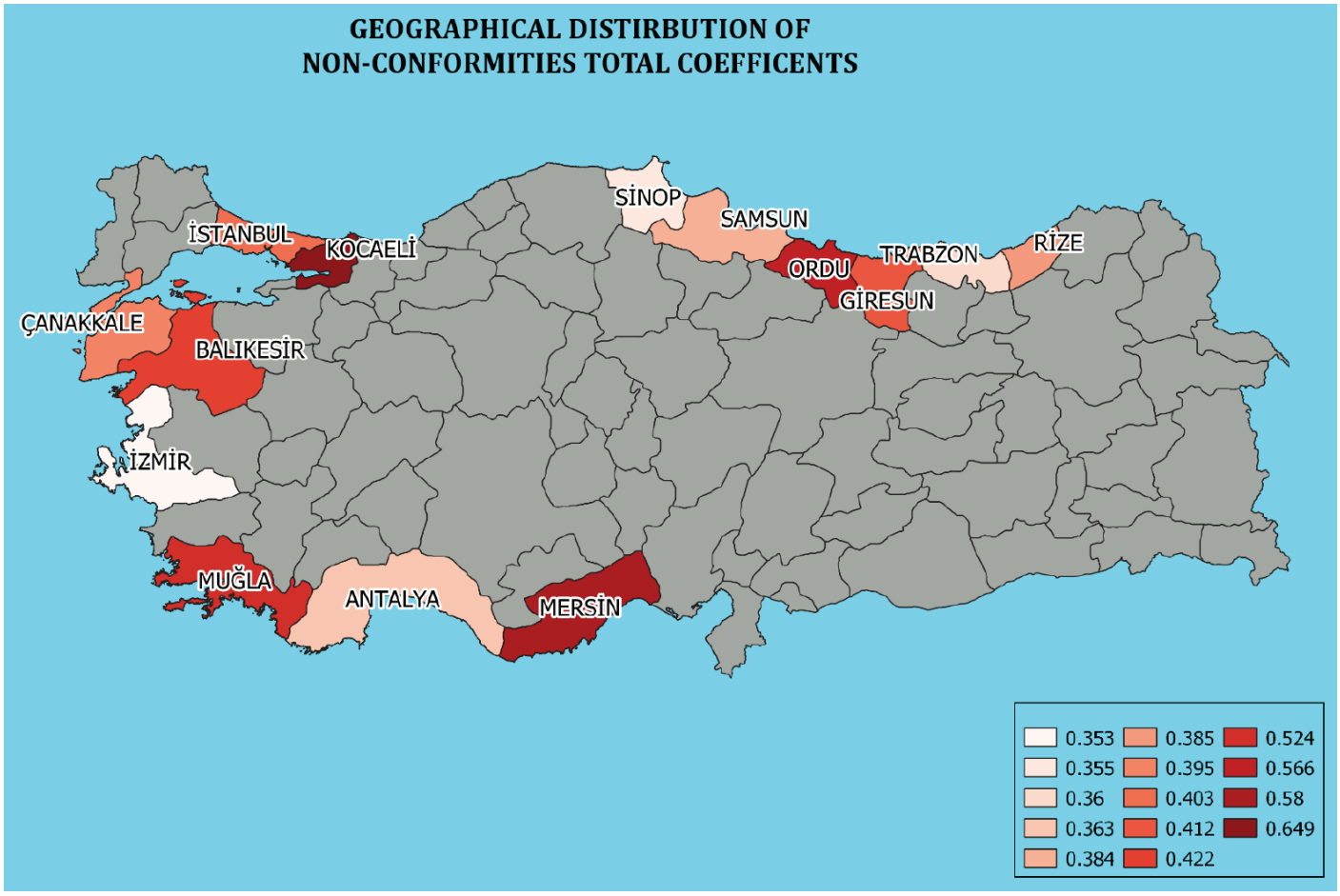

Figure 3. *Non-conformities distribution of total GRA coefficients*

GRA: Grey Relation Analysis

5. Conclusion

Quality assessment of higher education institutes is an attractive subject for researchers, and many studies have been carried out, with numerous quality measurement scales developed. However, common shortcomings of these scales are the lack of objectivity in the criteria, and most of these scales are based on questionnaires. No study has been found analysing the results of findings of audits carried out by third parties, which can provide a more objective assessment of the training institute.

Different factors and criteria can be selected for quality assessment of training facilities. Physical facilities, reliability and security, sensitivity/empathy, fees, academic staff, transport facilities and infrastructure are the most commonly used criteria in research. However, in scales developed in recent years, new criteria such as academic attendance, cognitive attendance, training quality, academic staff profiles, curriculum, infrastructure, and facilities have become main measurements in these scales. Nevertheless, the common specification of these scales is mostly subjective and based on questionnaires.

Also, results of these assessments can be useful in many ways, including the concentration of non-conformity categories, their root causes, and their geographical distribution.

In this study, entropy weighted GRA of audits done in accordance with the Directive of Seafarers Training and Examination results of maritime training and education institutes is carried out, and results are reflected in GISs. The outcome of the study reveals Türkiye's Maritime Training Institutions non-conformities map, thus, serving as an indicator of their quality relative to their geographic distribution.

Analysis results show that the effect of the non-conformities categories, that are reflected as GRA coefficients, is in the following ranking: Equipment (1.137); Curriculum (1.055); Documentation (0.762); Simulator Specifications (0.602); System Non-conformities (0.338); and Lecturer (0.145). These weighted coefficients are applied to non-conformities segmented by geographic distribution of maritime training and education institutes, and results are reflected with the help of the GIS.

Because returning the highest equipment category returns the highest GRA coefficient along with the root causes, resource management of the maritime training institutes needs to be improved. However, legislation and administrative requirements limit the common use of training facilities, and in most cases, equipment is used only for a very limited period of the year, and remains idle for the rest, which can be interpreted as ineffective resource management. The same conclusions can be made for simulators.

Curriculum, which yields the second highest coefficient, should follow both national and international legislation, mainly STCW Convention and STCW Code and amendments, and should have uniform implications. Administration or Higher Education Board can provide draft curriculum to avoid any discrepancies between training institutions.

Documentation results show the culture and familiarity with QMS, and in order to establish a well-functioning QMS, dedicated personnel with relevant training should be assigned as Quality Coordinator with sufficient authority.

The result of the study can be helpful to both maritime training and education institutes and administrations to minimize the categories of non-conformities and improve their training quality.

Ethics

Ethics Committee Approval: For the study, data usage permission was obtained from the Ministry of Transport, Maritime Affairs and Communications, General Directorate of Sea and Inland Waters Regulation (approval no.: 51056, date: 18.08.2017).

Footnotes

Authorship Contributions

Concept design: E. Güzel, Data Collection or Processing: E. Güzel, and P. Bolat, Analysis or Interpretation: E. Güzel, and P. Bolat, Literature Review: E. Güzel, Writing, Reviewing and Editing: E. Güzel.

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