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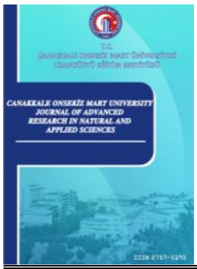

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Prioritization of Negative Carbon Strategies in the Cargo Industry with the SWARA/WASPAS Method

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Abstract − The ever-increasing consumption of fossil fuels with the increasing population in the world has brought along the obligation of countries to take some precautions. Determining the measures to be taken to prevent carbon emissions, turning these measures into a strategy and implementing them has become one of the important issues that concern almost every field. Reducing, neutralizing and turning negative carbon emissions significantly reduces the side effects of climate change. In this study, it is aimed to develop strategies within the scope of carbon negative by considering the cargo sector, which is one of the important fields of activity of the transportation sector, where the carbon emission rate is high. SWARA and WASPAS methods, which are among the Multi-Criteria Decision Making methods, are used in the evaluation phase of the strategies determined through the Delphi technique and literature review. Strategies are asked to be prioritized for the implementation of 16 determined strategies within the cargo sector, and "Using electric vehicles" ranked first in both methods. "Use of carbon capture, exploitation and storage technologies", "Balancing greenhouse gas emissions", "Existence of carbon tax to reduce carbon emissions" strategies have also been identified as other top priority strategies. It is thought that the strategies listed as a result of the study can help reduce our carbon footprint and help reach negative carbon by reducing CO_2 levels in the atmosphere.

Keywords − *Cargo industry; delphi technique; negative carbon strategies; SWARA method; WASPAS method*

1. Introduction

Carbon emission is the main reason of global warming. There are several industrial processes that release significant amounts of CO_2 into the atmosphere (Sinha and Chaturvedi, 2019). Greenhouse gas emissions from human activities have caused significant climate change since the Industrial Revolution (Guo et al., 2022), and climate change and its social, environmental, economic and ethical implications are major interconnected challenges facing human societies. is widely accepted (Huisingh et al., 2015). However, global awareness of the effects of climate change has led to a more restrictive and demanding society on consumption-related greenhouse gas emissions (Florindo et al., 2018). Furthermore, carbon emissions from processes could be controlled by the technologies in different processes of industries (Sinha and Chaturvedi, 2019). In this context, reducing carbon emissions has been an inevitable tendency and a global concurrence. Therefore, it is an important task for supply chain members to reduce their emissions in a low carbon environment (Ji et al., 2017). So, achieving net zero carbon emissions (Chen et al., 2022) and reducing carbon emissions is an important requirement. In order to meet climate reduction targets and achieve a net reduction in atmospheric carbon, some strategies need to be implemented at a large scale (Sanchez and Kammen, 2016). With negative carbon intensity, efficiency can be achieved both in the conversion of energy and in the conversion of carbon (Budzianowski, 2012). While many countries aim to be carbon neutral by 2050-2070, only 4.5% of countries have achieved carbon neutrality (Chen et al., 2022).

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There are various studies in the literature. Such as; related to carbon reduction (Galinato and Yoder, 2010; Li et al., 2021; Siegel et al., 2021; Derse, 2023) and carbon neutral (Kato and Yamagata, 2014; Anderson and Peters, 2016; Van Vuuren et al., 2017; Emmerling et al., 2019) there are many studies on it. Budzianowski (2012) analyzes renewable energy technologies to reach carbon negative. Gallego-Alvarez et al. (2015) analyzes the impact of changes in carbon dioxide emissions on financial and operational performance. Huisingh et al. (2015) focus on researchsing technical innovations and policy interventions for improved energy efficiency and reduction of carbon emissions for different sectors. Ji et al. (2017) focus on a model that includes a low-carbon preference. The article analyzes a detailed model that includes a low carbon preference. The results show that the introduction of the online channel is profitable for the manufacturer when the low carbon sensitivity degree of consumers meets certain conditions. Florindo et al. (2018) lists in their work, taking into account the criteria in possible improvement actions that allow the reduction of the Carbon Footprint. A SWOT matrix is presented for each evaluated alternative and MCDM methods are applied to measure and rank possible improvement actions. Liu et al. (2019) analyzes the impact of income inequality on carbon emissions in the United States, taking into account the effects of income inequality on carbon emissions and the distribution of emissions. The results provide policymakers with important information on improving the quality of economic development and addressing climate change. In their study, Sinha and Chaturvedi (2019) review the research studies carried out for the execution of energy efficient and low carbon technologies for industries at different stages and classify these studies as process stages. Research studies for the planning of carbon emission limits are also examined. Johansson et al. (2020) produce and compare cost-effective emission routes that meet two different climate targets. Xuan et al. (2020) Based on China's carbon emissions trading experiment, this study adopts a model to explore the impact of carbon emissions trading policies on carbon emission reduction. Zhang et al. (2020) uses an econometric method to evaluate the impact of the emissions trading system on carbon emission reduction in their work. Li et al. (2021) measured the order and differences in the development and use of renewable energy in different regions in terms of carbon emission reduction, which provides an analytical perspective and a renewable energy-based solution for the use and distribution of renewable energy in China. Chen et al. (2022) presents decarbonisation technologies and initiatives, as well as negative emission technologies, and discusses carbon trading and carbon tax. Guo et al. (2022) states that China aims to reach its carbon emission peak before 2030 and carbon neutrality before 2060. The paper reviews and discusses technical strategies to achieve their goals in China's metal mines. Siksnelyte-Butkiene et al. (2022) develops a framework by establishing the TOPSIS method to obtain the ideal synthesizing properties, materials and electrochemical measurements of the activated carbons electrode. Rahimirad and Sadabadi (2023) considers the goals of low-carbon energy transition and sustainable carbon-neutral society creation.

In the study, SWARA and WASPAS methods, which are among the Multi-Criteria Decision Making methods, are discussed. It is aimed to rank the negative carbon strategies with the methods discussed. When the literature was evaluated, no study was found in which these methods were sorted. However, there are some studies (Ghorshi Nezhad et al., 2015; Yurdoğlu and Kundakçı, 2017; Sremac et al., 2018; Toklu et al., 2018; Ghoushchi et al., 2021; Yücenur and Ipekci, 2021; dealing with SWARA and WASPAS methods.

In this study, which deals with the cargo sector, it is aimed to rank the strategies determined by considering the strategies that can be applied within the scope of reducing and making negative for the carbon arising from the activities occurring in the sector, according to their importance with Multi-Criteria Decision Making methods. Increasing carbon emissions, climate change, the ozone layer, and the negative effects of human health, and increasing awareness and strategies are the motivation of the study. In the first part of the study, information and research on carbon neutrality and carbon reduction are presented. The second part of the study includes Materials and Methods, the third part includes the Findings, the fourth and last part includes Conclusions and Discussions.

2. Materials and Methods

In this part of the study, the determination of the strategies developed for being carbon negative and their evaluation studies are presented (Fig.1). The desired and required strategies for carbon negative were primarily determined through literature review. Then, the opinions of 2 people working in the cargo sector, 4 academicians who are well-versed in carbon emissions, carbon footprint and climate change, and opinions that will affect the cargo sector's reaching negative carbon were received. The Delphi method was used to clarify and decide on the strategies in this context.

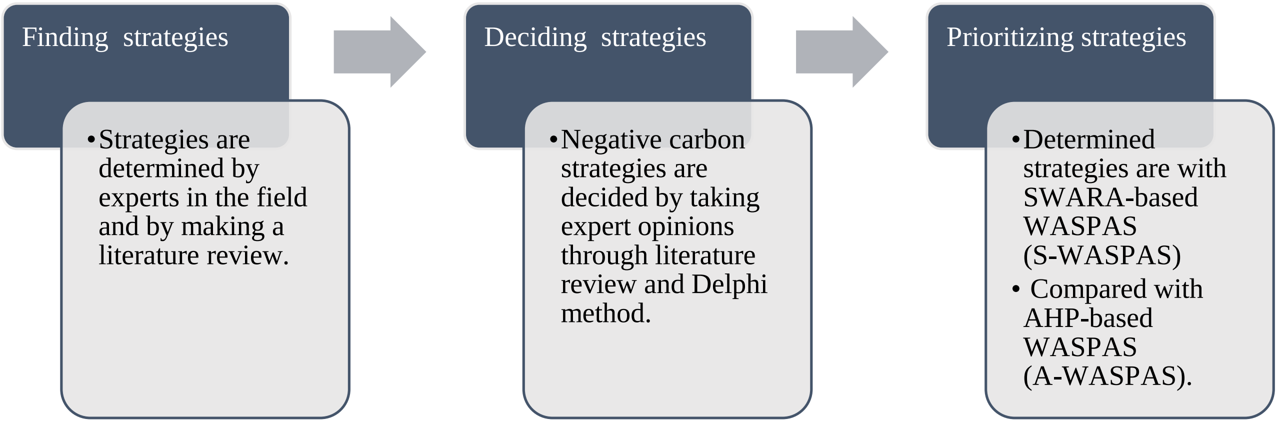

Figure 1. Analysis steps of developed strategies

The Delphi technique is a quantitative method that enables the development, evaluation and synthesis of ideas expressed on a particular subject (Christopher, 1994). According to Dalkey and Helmer (1963), the aim of the Delphi technique is to reach consensus on the opinions of a group of experts on a subject in the most reliable way. The application of the Delphi technique consists of a series of stages to reveal the approaches and perspectives of the experts (Cho and Turoff, 2001) or the representatives of the target audience on the problem situation, to examine and to reach a consensus. In this context, first of all, the development of a strategy for negative carbon includes the general purpose of the problem, in terms of transportation and transportation being a heavy sector in the cargo sector and causing carbon emissions. Within the framework of the defined problem, firstly, possible strategies that will contribute to the literature were discussed with the expert consisting of 6 people and their thoughts were asked. In line with the answers received, the suggested strategies, which were written in items, were presented to the experts' opinions again and they were asked to be scored on the Likert scale. With the repeated answers, one more cycle was achieved and the final criteria table was reached (Table 1). The determined strategies are 16 and are based on the answers of the literature and expert opinions.

Table 1
Developed negative carbon strategies

Code	Negative carbon strategies	Authors	Description
NC1	Balancing greenhouse gas emissions	*	It refers to the efforts to increase the reduction of greenhouse gas emissions and to prevent their increase.
NC2	Use of carbon capture, exploitation and storage technologies	Chen et al., 2022; Fu et al., 2022; Fawzy et al. 2020	It refers to a series of processes that allow CO2 to be captured, stored and used directly or indirectly in various products.
NC3	Using electric vehicles	Chen et al., 2022	It refers to the use of alternative vehicles (electric vehicles).
NC4	Ensuring the use of renewable energy sources	Millot and Maïzi 2021; Fawzy et al. 2020	It refers to the use of renewable and sustainable energy as an alternative to fossil fuels.
NC5	Using recyclable packaging in packaging	*	It refers to reducing the carbon footprint and reducing the environmental impact of life cycle assessment.
NC6	Increasing environmental awareness trainings for employees	*	It emphasizes the necessity of organizing periodic trainings on climate change and carbon footprint issues.
NC7	Increasing vehicle efficiency	Chen et al., 2022; Sharifi, 2021	It expresses the quality and number of vehicles used in the cargo sector.
NC8	Existence of carbon tax to reduce carbon emissions	Qiu et al., 2020	In terms of its deterrent feature, it means ensuring the continuity of the carbon tax rate set by the governments.
NC9	Implementation of afforestation/reforestation studies per transport	Terlouw et al., 2021; Schirmer and Bull, 2014	Afforestation refers to afforestation where there is no forest cover recently, while reforestation refers to the re-establishment of deforested forest areas.
NC10	Presence of resistant designs resistant to natural disasters in cargo buildings	Wang et al., 2018	It emphasizes the need to innovate and use resilient designs in cargo buildings as well as in transportation.
NC11	Spreading the circular economy model	*	It refers to the use of resource management with the logic of reduce-recycle-reuse instead of the logic of buy-make-consume.
NC12	Optimization of cargo distribution management	*	It means reducing the transportation time by making a good road analysis of the cargoes for distribution.
NC13	The growth of sharing economies such as parking spaces and crowdsourcing	Chen et al., 2022	It refers to making a less needed tool or service available to other users who need it.
NC14	Existence of recycling incentives for packaging for end users	*	It covers the incentives for the packages in the hands of the customers to be delivered to the cargo companies after the distribution.
NC15	Increasing stakeholder engagement and collaboration	*	It means raising awareness and taking a role of all stakeholders, from the supplier to the customer, for a carbon neutral life.
NC16	Limitation of cargo distribution contrary to what is known	*	It refers to the limitation of the distribution of cargo distributions on certain days and hours (during heavy traffic, etc.).

2.1. SWARA method

SWARA (Stepwise Weight Assessment Ratio Analysis) was developed in 2010 by Kersuliene et al. It is a multi-criteria decision-making method developed by and aiming to rank the criteria to be analyzed in order of importance (Kersuliene et al., 2010).

Step 1: The criteria are sorted in descending order of importance in line with expert opinion and the geometric mean is taken.

Step 2: The importance level of the criteria is determined. The value known as sj (comparative significance of the mean value), j. criterion, (j+1). by comparison with the criteria j. your criterion (j+1). it is determined as how important it is from the criterion (Ruzgys et al., 2014).

Step 3: The coefficient kj for each criterion is determined as in Equ (2.1).

$$kj = \begin{Bmatrix} 1 & \middle| j = 1 \\ sj + 1 & \middle| j > 1 \end{Bmatrix} \tag{2.1}$$

Step 4: The coefficient qj, which expresses the weights, is calculated as in Equ (2.2).

$$qj = \begin{Bmatrix} 1 & \middle| j = 1 \\ \frac{qj-1}{kj} & \middle| j > 1 \end{Bmatrix} \tag{2.2}$$

Step 5: With the help of (2.3) in the last step of the method, wj, j. the relative weight of the criterion is determined.

$$wj = \frac{qj}{\sum_{k=1}^{n} qk} \tag{2.3}$$

2.2. WASPAS Method

WASPAS is a multi-criteria decision-making approach that combines the results of two different models, “Weighted Sum Model” and “Weighted Product Model” (Chakraborty & Zavadskas, 2014). By using these two methods together, it is aimed to increase the reliability of the solution results and to correctly order the decision alternatives.

Step 1: At the stage of creating the decision matrix, the xij values are combined into a matrix.

Step 2: In order to normalize the decision matrix, the values are normalized with the help of Equ (2.4) and (2.5) to take values in the range of [0,1].

$$x_{ij} = \frac{x_{ij}}{\max(x_{ij})} \quad \text{i=1,2..m j=1,2..n} \tag{2.4}$$

$$x_{ij} = \frac{\min(x_{ij})}{(x_{ij})} \quad \text{i=1,2..m j=1,2..n} \tag{2.5}$$

Step 3: Based on the weighted sum method i. calculation of the total relative importance of the alternative is performed.

$$Qi^{(1)} = \sum_{j=1}^{n} x_{ij}.w_j \tag{2.6}$$

Step 4: Based on the weighted multiplication method i. Calculation of the total relative importance of the alternative is carried out according to equation (2.7) by taking the force.

$$Qi^{(2)} = \prod_{j=1}^{n} x_{ij}^{w_j} \tag{2.7}$$

Step 5: The (Qi) value is calculated by calculating the weighted common general criterion value for the weighted sum and weighted product models (2.8).

$$Qi = 0.5Qi^{(1)} + 0.5Qi^{(2)} \tag{2.8}$$

3. Application of the Study

The next step for the determined negative carbon strategies is to make an evaluation from six experts in the status of expert. At this stage, it was desired to use SWARA and WASPAS techniques. AHP technique was used for comparison. First of all, the criteria determined for the ranking of the strategies were asked from the experts to rank correctly from the most important criterion to the less important criterion with the SWARA technique, and the results obtained in Table 2 are presented.

Table 2
SWARA expert opinions

Code	Criteria	1	2	3	4	5	6	Rank (Ave)
C1	Strategy implementation cost	1	3	2	1	2	1	1.51
C2	Strategy implementation time	3	2	4	3	3	3	2.94
C3	Contribution to carbon reduction	2	1	1	2	1	1	1.26
C4	Contribution to sustainable development goals	6	5	6	4	6	6	5.44
C5	Social acceptability	4	4	3	5	5	4	4.11
C6	Strategy implementation risk	5	6	5	6	4	5	5.12

SWARA steps were followed for each expert and their importance levels were determined according to the results. Table 3 shows an example order for Expert 3. Accordingly, the most important criteria for Expert 3 were determined as C1 and C3. By applying the same steps with other experts, the importance level of each strategy was averaged and the final ranking was determined (Table 4).

Table 3
SWARA steps for Expert 3

Code	Negative carbon strategies	Rank	Order of importance	s_j	k_j	q_j	w_j
C3	Contribution to carbon reduction	1.26	1.00		1.00	1.00	0.20
C1	Strategy implementation cost	1.51	2.00	0.01	1.01	0.99	0.20
C2	Strategy implementation time	2.94	3.00	0.15	1.15	0.86	0.18
C5	Social acceptability	4.11	4.00	0.15	1.15	0.75	0.15
C6	Strategy implementation risk	5.12	5.00	0.10	1.10	0.68	0.14
C4	Contribution to sustainable development goals	5.44	6.00	0.10	1.10	0.62	0.13

Table 4
Ranking as a result of averaged values

Code	Negative carbon strategies	w_j Ave	Rank
C1	Strategy implementation cost	0.20	2
C2	Strategy implementation time	0.18	3
C3	Contribution to carbon reduction	0.21	1
C4	Contribution to sustainable development goals	0.12	6
C5	Social acceptability	0.16	4
C6	Strategy implementation risk	0.14	5

When the results obtained according to the SWARA method (Table 3) are interpreted, the “Contribution to carbon reduction” criterion becomes the first priority criterion for negative carbon studies. Then the “Strategy implementation cost” criterion took the second place.

For the WASPAS method, it was first requested to rank the strategies within the framework of certain criteria (C1 (Strategy implementation cost), C2 (Strategy implementation time), C3 (Contribution to carbon reduction), C4 (Contribution to sustainable development goals), C5 (Social acceptability), C6 (Strategy implementation risk)). According to these criteria, a decision matrix was formed by taking the average of the scores between 1-10 obtained from the experts (Table 5).

Table 5
WASPAS decision matrix

Criteria direction	min	min	max	max	max	min
Code	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**
NC1	1.67	4.67	7.67	6.33	7.67	3.00
NC2	1.33	3.33	7.33	6.00	5.33	2.33
NC3	1.00	3.67	8.33	7.00	8.33	5.33
NC4	2.67	4.33	6.67	7.33	7.00	4.33
NC5	4.33	4.33	5.33	7.00	7.33	4.67
NC6	3.67	4.33	5.00	6.67	7.33	7.33
NC7	5.33	7.33	5.67	6.67	5.67	7.33
NC8	7.00	2.67	7.33	6.00	5.33	4.00
NC9	4.33	5.67	5.33	7.00	5.00	5.33
NC10	4.67	4.00	5.00	5.33	4.67	4.67
NC11	5.67	4.67	4.67	7.33	6.67	5.33
NC12	7.33	6.33	5.33	5.33	5.33	6.00
NC13	6.67	4.67	5.00	5.33	4.67	4.67
NC14	7.00	5.00	4.33	6.00	4.33	6.33
NC15	6.33	4.00	5.33	7.33	4.67	5.00
NC16	7.00	5.67	5.67	5.00	3.67	4.33
Criteria weight	**0.20**	**0.18**	**0.21**	**0.12**	**0.16**	**0.14**

For the normalized decision matrix as a result of the decision matrix, the criterion aspect is taken as minimum for the implementation cost of the strategy, the implementation time of the strategy and the implementation risk criteria of the strategy; maximum direction has been taken for its contribution to carbon reduction, its contribution to sustainable development goals, and social acceptability criteria. Again, in line with the WASPAS steps, the weights of the criteria were determined by the SWARA method with expert opinion (Table 4). As a result of the applications, the ratings based on the weighted sum and weighted multiplication methods in Table 6 and Table 7 were calculated.

Table 6
Relative importance values based on weighted sum method

	C1	C2	C3	C4	C5	C6	Qi (1)
NC1	0.12	0.1	0.19	0.1	0.15	0.11	0.768097
NC2	0.15	0.14	0.18	0.1	0.1	0.14	0.811492
NC3	0.2	0.13	0.21	0.11	0.16	0.06	0.866688
NC4	0.07	0.11	0.16	0.12	0.13	0.08	0.676897
NC5	0.05	0.11	0.13	0.11	0.14	0.07	0.611165
NC6	0.05	0.11	0.12	0.11	0.14	0.04	0.58014
NC7	0.04	0.06	0.14	0.11	0.11	0.04	0.503139
NC8	0.03	0.18	0.18	0.1	0.1	0.08	0.668735
NC9	0.05	0.08	0.13	0.11	0.1	0.06	0.532059
NC10	0.04	0.12	0.12	0.09	0.09	0.07	0.530694
NC11	0.03	0.1	0.11	0.12	0.13	0.06	0.560166
NC12	0.03	0.07	0.13	0.09	0.1	0.05	0.476877
NC13	0.03	0.1	0.12	0.09	0.09	0.07	0.501077
NC14	0.03	0.09	0.11	0.1	0.08	0.05	0.462485
NC15	0.03	0.12	0.13	0.12	0.09	0.07	0.555812
NC16	0.03	0.08	0.14	0.08	0.07	0.08	0.479009

Table 7
Relative importance values based on weighted multiplication method

	C1	C2	C3	C4	C5	C6	Qi (2)
NC1	0.9	0.91	0.98	0.98	0.99	0.97	0.753051
NC2	0.94	0.96	0.97	0.98	0.93	1	0.804416
NC3	1	0.94	1	0.99	1	0.89	0.836249
NC4	0.82	0.92	0.96	1	0.97	0.92	0.643782
NC5	0.75	0.92	0.91	0.99	0.98	0.91	0.554095
NC6	0.77	0.92	0.9	0.99	0.98	0.85	0.527121
NC7	0.72	0.84	0.92	0.99	0.94	0.85	0.43906
NC8	0.68	1	0.97	0.98	0.93	0.93	0.559569
NC9	0.75	0.87	0.91	0.99	0.92	0.89	0.487778
NC10	0.74	0.93	0.9	0.96	0.91	0.91	0.492383
NC11	0.71	0.91	0.89	1	0.97	0.89	0.490548
NC12	0.68	0.86	0.91	0.96	0.93	0.88	0.414654
NC13	0.69	0.91	0.9	0.96	0.91	0.91	0.44655
NC14	0.68	0.89	0.87	0.98	0.9	0.87	0.407327
NC15	0.7	0.93	0.91	1	0.91	0.9	0.483385
NC16	0.68	0.87	0.92	0.96	0.88	0.92	0.423011

As a result of the weighted sum method and the weighted multiplication method, the λ value was taken as 0.5 and the final ranking table was created (Table 8).

Table 8
Strategies sorted by S-WASPAS method

Negative carbon strategies code	Qi	Rank
NC1	0.76	3
NC2	0.81	2
NC3	0.85	1
NC4	0.66	4
NC5	0.58	6
NC6	0.55	7
NC7	0.47	13
NC8	0.61	5
NC9	0.51	11
NC10	0.51	10
NC11	0.53	8
NC12	0.45	15
NC13	0.47	12
NC14	0.43	16
NC15	0.52	9
NC16	0.45	14

As a result of the SWARA-based WASPAS application, the first priority strategy in the ranking was determined as NC3 coded “Using electric vehicles”. In order to compare the results of S-WASPAS, the AHP method was used, and the decision matrix was determined within the framework of the (1-9) scale, which was determined by Saaty's opinion of six experts (Table 9), and the degree of importance was calculated by normalizing it (Table 10).

Table 9
AHP decision matrix

	C1	C2	C3	C4	C5	C6
C1	1.00	4.33	0.54	4.83	6.00	5.17
C2	0.23	1.00	0.23	3.50	3.50	2.50
C3	2.17	4.50	1.00	5.50	5.33	5.50
C4	0.21	0.29	0.18	1.00	3.50	0.42
C5	0.17	0.31	0.17	0.26	1.00	0.38
C6	0.20	0.42	0.18	2.50	2.83	1.00
Total	**3.98**	**10.85**	**2.30**	**17.60**	**22.17**	**14.96**

Table 10
AHP normalized matrix

	C1	C2	C3	C4	C5	C6	Importance value
C1	0.251	0.399	0.236	0.275	0.271	0.345	**0.30**
C2	0.059	0.092	0.098	0.199	0.158	0.167	**0.13**
C3	0.544	0.415	0.435	0.313	0.241	0.368	**0.39**
C4	0.053	0.027	0.080	0.057	0.158	0.028	**0.07**
C5	0.042	0.028	0.072	0.015	0.045	0.025	**0.04**
C6	0.051	0.038	0.080	0.142	0.128	0.067	**0.08**

It is desired that the consistency ratio of the importance degrees obtained as a result of the calculation of the normalized matrix should be below 0.1. For this reason, the ratios determined by the experts in the study emerged as CR=0.089 and its consistency was confirmed. Then, the determined weights were applied in the WASPAS method, as in the equation 2.6 and 2.7, and the sequences of operations were applied and the strategies listed as a result of AHP-based WASPAS were determined (Table 11).

Table 11
Strategies sorted by A-WASPAS method

Negative carbon strategies code	Qi	Rank
NC1	1	3
NC2	1.04	2
NC3	1.2	1
NC4	0.94	4
NC5	0.8	5
NC6	0.77	9
NC7	0.72	11
NC8	0.8	6
NC9	0.77	8
NC10	0.66	12
NC11	0.76	10
NC12	0.61	16
NC13	0.62	14
NC14	0.62	13
NC15	0.78	7
NC16	0.61	15

4. Conclusion and Discussions

According to the results, the "Using electric vehicles" strategy took the first place and gave a similar result with the SWARA technique and AHP technique (Fig.2). "Use of carbon capture, exploitation and storage technologies" took the second place and "Existence of carbon tax to reduce carbon emissions" took the third place.

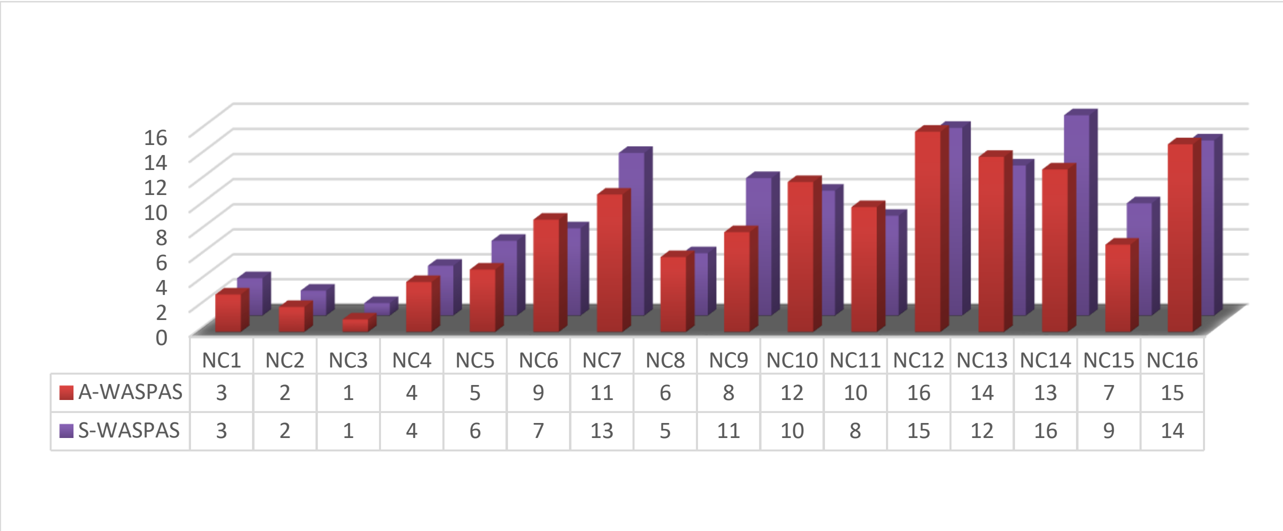

Figure 2. S-WASPAS and A-WASPAS comparison

Considering the strategies that the cargo sector should prioritize in order to reach negative carbon, the top five are; NC3 "Using electric vehicles", NC2 "Use of carbon capture, exploitation and storage technologies", NC1 "Balancing greenhouse gas emissions", NC4 "Ensuring the use of renewable energy sources", NC5 "Using recyclable packaging in packaging", NC8 "Existence of carbon tax to reduce carbon emissions" strategies are coming (Fig.2).

The ever-increasing consumption of fossil fuels based on the growing population has caused the greenhouse gas effect with the CO_2 levels in the atmosphere rising rapidly from 280 ppm to 415 ppm by 2021 (Friedlingstein et al., 2020). The increasing greenhouse gas effect, which causes climate change along with global warming, brings along many problems. Therefore, each of the countries, institutions and sectors need to determine and implement strategic targets and policies in order to fulfil their emissions reduction commitments (Fu et al., 2022).

The current study aimed to apply the transportation sector in the cargo sector in order to reduce the greenhouse gas effect as well as to increase the negative carbon applications. Taking into account the activities in the cargo sector, "Balancing greenhouse gas emissions, Use of carbon capture, exploitation and storage Technologies, Using electric vehicles, Ensuring the use of renewable energy sources, Using recyclable packaging in packaging, Increasing environmental awareness trainings for employees, Increasing vehicle efficiency, Existence of carbon tax to reduce carbon emissions, Implementation of afforestation/reforestation studies per transport, Presence of resistant designs resistant to natural disasters in cargo buildings, Spreading the circular economy model, Optimization of cargo distribution management, The growth 16 strategies were determined, of sharing economies such as parking spaces and crowdsourcing, Existence of recycling incentives for packaging for end users, Increasing stakeholder engagement and collaboration, Limitation of cargo distribution contrary to what is known". Evaluation of the specified strategies in SWARA based WASPAS method and AHP based WASPAS method C1 (Strategy implementation cost), C2 (Strategy implementation time), C3 (Contribution to carbon reduction), C4 (Contribution to Sustainable Development Goals), C5 (Social acceptability), C6 (Strategy implementation risk) ranked in order of importance, taking into account the criteria. When the results of the Multi-Criteria Decision Making methods (S-WASPAS, A-WASPAS) are examined, it is seen that consistent rankings are obtained. "Using electric vehicles" took the first place in both methods. “Use of carbon capture, exploitation and storage technologies”, “Balancing greenhouse gas emissions”, “Existence of carbon tax to reduce carbon emissions” strategies have also been identified as other top priority strategies.

As a result of increasing environmental concerns, it has become important for the sectors to determine strategies to eliminate this concern, to set relevant targets and to work towards these targets. The cargo sector, which has an important place in the transportation sector, is at the forefront of the companies that want to contribute to sustainability by carrying out these studies. Being carbon negative is an opportunity for the cargo sector by putting the strategies suggested in the current study into practice and putting the prioritized strategies into practice.

As a result of the study, it is thought that the carbon footprint will decrease, the damage to the environment and the greenhouse gas emission levels in the atmosphere will decrease with the implementation of the strategies listed to reach negative and neutral carbon. In future studies, the situation of carbon reduction strategies in different sectors can be examined and the importance of strategies can be examined with different Multi-Criteria Decision Making methods.

Author Contributions

Emel Yontar: Conceptualization, methodology, analysis and modelling, writing original draft, review and editing.

Onur Derse: Conceptualization, methodology, writing original draft, review and editing.

Conflicts of Interest

The authors declare no conflict of interest.

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