# Deniz Taşımacılığı ve Lojistiği Dergisi

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# Deniz Taşımacılığı ve Lojistiği Dergisi

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**İÇİNDEKİLER / CONTENTS**

## Editörden

Deniz Taşımacılığı ve Lojistiği Dergisinin 3. Cilt 2. Sayısını değerli okuyucularımızın ilgisine sunuyoruz. Derginin bu sayısında biri Türkçe olmak üzere beş adet çalışma bulunmaktadır. Deniz taşımacılığının farklı alanlarında yapılmış çalışmaları derlediğimiz bu sayıda marinalarda yatlardan kaynaklı salım miktarlarının hesaplandığı, yolcular için sürdürülebilir bir denizyolu ulaştırma aracının tasarlandığı, pandeminin denizcilik öğrencilerinin meslek algısına etkisinin incelendiği, navlun oranlarının filo üretkenliğine etkisinin incelendiği ve son olarak liman seçim kriterleri, ve kriterlerin belirlenmesinde kullanılan yöntemlerin tartışıldığı makaleler yer almaktadır

.

Deniz Taşımacılığı ve Lojistiği Dergisi olarak değerlendirme sürecinden başarı ile geçerek ICI Journal of Master List veritabanında endekslendiğimizi okuyucularımızla paylaşmaktan mutluluk duyarız. Dergimizin bu başarıyı elde etmesinde ve hem ulusal hem de uluslararası tanınırlığını artırmada emeği ve katkısı olan eski editörümüz Prof. Dr. Soner ESMER'e, dergi sekretaryasına, danışma kurulumuza, yazarlarımıza ve hakemlerimize teşekkürlerimizi sunarız.

Ayrıca bu sayıda emeği geçen bilim insanlarımıza, dergi sekretaryamıza ve danışma kurulumuzda yer alan değerli bilim insanlarımıza ve değerli görüş ve önerileriyle yayınlara katkı sağlayan hakemlerimize teşekkür ederiz.

Dr. Öğr. Üyesi Seçil GÜLMEZ
Editör

## Editorial

We are pleased to submit Volume 3 and Issue 1 of the Journal of Maritime Transport and Logistics to our valuable readers' interests. This issue involves five articles one of which is in the Turkish language. In this issue, articles carried out in different fields of maritime transport have addressed the calculation of yacht-based emissions in marinas, design of a sustainable waterway transport vehicle for passengers, the impact of pandemic on the occupational perception of maritime students, the effects of freight rates on fleet productivity, and port selection criteria and the methods used in port selection literature.

We are also pleased to inform our readers that the Journal of Maritime Transport and Logistics has passed the evaluation process positively and started to be indexed in the ICI Journal of Master List database. We would like to submit thanks to the journal secretariat, advisory board, scholars and our former editor-in-chief Prof. Dr Soner ESMER who have made a significant effort to achieve this success and increase the national and international reputation of our journal.

Also, we would like to submit many thanks to scholars who contributed to this issue with their valuable research, to the journal secretariat, advisory board, and the reviewers who contributed to the research with their valuable opinions and suggestions.

Asst. Prof. Seçil GÜLMEZ
Editor-In-Chief

*Deniz Taşımacılığı ve Lojistiği Dergisi*
*2022, 3(1)*

*Araştırma Makalesi*

**Örnek Bir Marina Sahasında Yatlardan Kaynaklı Ortalama Salım Miktarlarının Hesaplanması**

*Onur YÜKSEL[1], Süleyman Aykut KORKMAZ[2], Olgun KONUR [3*]*

Yayın Geliş Tarihi
*12 Ocak 2022*
Yayına Kabul Tarihi
*24 Ocak 2022*
Elektronik Yayın Tarihi
*31 Ocak 2022*

Anahtar Kelimeler
*Emisyon*
*Yakıt tüketimi*
*Marina*
*Gemi makineleri işletme mühendisliği*

**Öz**

Bu çalışmanın amacı, örnek bir marina içerisindeki yatların yanaşma ve kalkış manevraları sırasında ortaya çıkan salım miktarlarının hesaplamasıdır. Bu çalışmayı gerçekleştirmek için referans bir marinadan yatların yıllık ortalama giriş-çıkış verileri, boyut ve makine bilgileri alınmıştır. Marinada yatların 3 knot hızla giriş çıkış kuralına uydukları varsayılmış, buna göre yakıt tüketimleri, makine yükü ve salım hesaplamaları yapılmıştır. Marina sahasından çıktıktan sonra da MCR'de gittikleri kabulü yapılmıştır. Ayrıca teorik hesaplar marinadaki 3 millik alanı kapsayacak şekilde gerçekleştirilmiştir. Bir yıl içerisinde yatların referans marinada ürettiği salım miktarları hesaplanmış bu miktarı azaltmak için yapılabilecek uygulamalar tartışılmıştır. Hesaplar yapılırken 1,2 km'lik alan marina sahası olarak alınmış, geri kalan 4,3 km ise açık deniz bölgesi olarak adlandırılmıştır. Marina sahasında marina bölgesi olarak kabul edilen 5,5 km'lik bölgede yatların yıllık ortalama 105,96 t yakıt harcadıkları hesaplanmıştır. Marina sahasında 128,1 t, açık denizde 251,57 t olmak üzere toplam 339,67 t ortalama karbon salımı gerçekleştiği hesaplanmıştır. Yıllık ortalama 10,18 t $NO_x$ gaz salımının bu bölgede yapıldığı hesaplanmıştır ve bunun %37,7'si marina sahası olarak belirlenen 1,2 km'lik alan sınırlarında gerçekleşirken geri kalanı seyir alanı olarak kabul edilen 4,3 km'lik bölgede üretildiği saptanmıştır. Marina bölgesindeki yatların yıllık ortalama 1,06 t $SO_2$ gazı ürettiği hesaplanmıştır.

*Research Article*

**The Calculation of Average Yacht-Based Emission Production in a Case Marina Area**

Article Submitted
*12 January 2022*
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*2 January 2022*
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Keywords
*Emission*
*Fuel consumption*
*Marina*
*Marine engineering*

**Abstract**

The aim of this study is to calculate the emission amounts that occur during docking and take-off manoeuvres of yachts in a case marina. Annual average entry-exit data of yachts, size and machinery information were obtained from a reference marina. It is assumed that the yachts in the marina comply with the 3-knots speed entry and exit rule, and fuel consumption, engine load and emission calculations are made accordingly. After leaving the marina, it was assumed that the main engine rpm was reached to the MCR. In addition, theoretical calculations were carried out to cover the 3-mile area in reference marina. The amount of emissions produced by yachts in the marina within a year were calculated and the measures that can be done to reduce this amount were discussed. The 1.2 km area was taken as the marina area, and the remaining 4.3 km was named as the open sea area. It is found that yachts consume an average of 105.96 tons of fuel annually in the 5.5 km area, which is accepted as the marina area. It is calculated that a total of 339.67 t carbon emissions, of which 128.1 t in the marina area and 251.57 t in the open sea, have emitted. An annual average of 10.18 t $NO_x$ emission is made in this region and 37.7% of this occurs within the 1.2 km area determined as the marina area, while the rest is produced in the 4.3 km area, which is considered as the cruise area. The yachts produce an average of 1.06 t $SO_2$ gas per year in the marina region.

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## 1. Giriş

Turizm gelişiminin geleceği büyük ölçüde doğal çevreye ve bu çevrenin korunmasına bağlıdır (Hall ve Lew, 1998). Bu nedenle çevre, sadece turizmde sürdürülebilir kalkınma için önemli bir temel değil, aynı zamanda turistlere eşsiz konumlar sunabilmek için de bir zorunluluk teşkil etmektedir (Zi, 2015). Turizm, doğası gereği kaynak bağımlı bir endüstridir. Endüstrinin kaynakları kirletme ve tüketme kabiliyeti göz önüne alındığında, turizmin sürdürülebilirliği ilginç bir tartışma konusu olarak karşımıza çıkmaktadır (Johnson, 2002). Hava kirliliği turizmin maruz kalabileceği en önemli etkenlerden biridir. Ayrıca, akciğer kanseri, kardiyovasküler hastalık ve doğum kusurları gibi ciddi sağlık sorunlarına neden olabilmektedir (Tian ve diğerleri, 2013).

Limanlar ise, kara ve denizlerin hayati bağları olarak önemli bir rol oynamakta, geçiş yolları olarak hareket etmekte ve ulaşım koridorlarını birbirine bağlayarak ticaret ve iletişimi güçlendirmektedir. Bunun yanında, liman kentlerinde denizcilik faaliyetleri, kentsel kirlilik açısından büyük bir sorun yaratmakta, hem insan sağlığını hem de ekosistemleri etkileyen çevresel sorunlara neden olmaktadır (Miola ve diğerleri, 2009). Yoğun nüfuslu bölgelere yakınlığı ve birçok hava kirletici unsuru belli bir alanda toplaması nedeniyle, limanların atmosfere ve insan sağlığına olan etkileri son derece önemlidir. Salımların yarattığı sonuçlar, pratik olarak öncelikle yerel toplumu etkilemektedir (Maragkogianni ve Papaefthimiou, 2015). Bu etkiler, hava kirletici salımların ölçümü yoluyla değerlendirilmektedir (Cooper, 2003).

Literatürde yer alan birçok çalışmada, gemi kaynaklı salımların ciddi bir hava kirliliği kaynağı olduğunu belirtilmektedir (Cooper, 2003; Yau ve diğerleri, 2012; Dragovic´ ve diğerleri, 2015). Gemilerden yayılan salımlar, denizden gelen rüzgarların etkisi altında karaya kolayca yayılabilmektedir. Bu durum, kıyı bölgelerdeki hava kirliliği ve sağlık problemlerini şiddetlendirmektedir (Papanastasiou ve Melas, 2009; Mavrakou ve diğerleri, 2012; Yau ve diğerleri, 2012). Bunun yanında, liman sahalarındaki hava kirliliğinin, karadaki hava kirliliği seviyesiyle karşılaştırılabilecek oranda yüksek olduğunu ortaya koyan çalışmalar bulunmaktadır (Villalba ve Gemechu, 2011; Zhao ve diğerleri, 2013; Fan ve diğerleri, 2016). Gelecek öngörüleri ise, gemi kaynaklı salımların, gelişen uluslararası deniz ticaretinin etkisiyle önemli ölçüde artacağını ve gerekli önlemler alınmadığı takdirde, gemi kaynaklı hava kirliliğinin daha da kötüleşeceğini bildirmektedir (Shell, 2013; Song, 2014). Gemilerden kaynaklı salımların liman veya açık deniz bölgeleri kapsamında hesaplandığı ve makine öğrenmesi algoritmaları ile tahmin edildiği çalışmalar da literatür de yer almaktadır (Styhre ve diğerleri, 2017; Simonsen ve diğerleri, 2018; Wang, ve diğerleri, 2018; Yang ve diğerleri, 2019; Le ve diğerleri, 2020; Liu ve Duru, 2020; Le ve diğerleri, 2020; Farag ve Ölçer, 2020; Zhu ve diğerleri, 2021; Kim ve diğerleri, 2021; Moreira ve diğerleri, 2021).

Enerji santralleri ve karayolu taşımacılığı gibi diğer büyük emisyon kaynakları, genel olarak artan devlet denetimleri sebebiyle, denizcilik faaliyetlerinden kaynaklanan salımların aksine, son yıllarda düşüş eğilimi göstermektedir. Bu bilgi, gemi kaynaklı egzoz salımlarının, özellikle limanlara yakın alanların atmosferik çevresi üzerindeki etkisini daha önemli bir hale getirdiğini açıkça ortaya koymaktadır. Bu sebeple, gemi kaynaklı salımların hava kalitesi üzerindeki etkilerini değerlendirmek ve etkili kontrol stratejileri geliştirebilmek için kapsamlı gemi egzoz salım envanterlerinin geliştirilmesi hayati önem taşımaktadır (Chen ve diğerleri, 2016).

Bu kirlilik sorunlarına karşı, bir dizi liman işletmesinin, son yıllarda hem gemilere hem de limanlara hitap eden, salımları azaltmayı amaçlayan programlar uygulamaya başladığı ve bu amaç üzerine yeni politikalar yürütmeyi planlamakta oldukları bilinmektedir (Gibbs ve diğerleri, 2014). Devlet yönetimleri de, gemilerin egzoz salımları ile ilgili minimum teknik standartları belirleyen önlemler alabilmektedir. Bu önlemler, düşük sülfürlü yakıtlara geçiş, enerji verimliliği sağlayan sistemlerin kullanımı veya salım miktarlarını kontrol altına alan egzoz gazı temizleyicileri (scrubber) ve EGR (egzoz gazı resirkülasyonu) gibi sistemlerin gemilere entegre edilmesi vb. uygulamaları içerebilmektedir.

Uluslararası Limanlar Birliği (IAPH) iş birliği ile Rotterdam, Anvers, Amsterdam, Le Havre, Hamburg ve Bremen liman yetkilileri, 100'den 100 puanla 0 ile 100 arasında değişen gemilere puan vermek üzere Çevresel Gemi İndeksi'ni (ESI) geliştirmiştir. Sıfır emisyonlu bir gemiye karşılık gelmektedir. Belirli bir eşiğin üzerindeki puanlara sahip gemiler, katılımcı limanlarda port aidatlarında indirimden yararlanabilmektedirler (Lam ve Notteboom, 2014). Bu tür gönüllü planlar, gemi sahiplerine ve gemi işletmecilerine daha yeşil gemi teknolojisine yatırım yapmak için bir fiyat teşvik etmeyi amaçlamaktadır. Liman kullanıcıları daha yeşil olduğu için ödüllendirilirken, fiyat teşvikinin ek ücrete tabi olma maliyetini karşılayıp karşılayamayacağını değerlendirmek daha önemlidir. Liman operasyonları ile ilgili emisyonları azaltmak için, birçok liman, fosil yakıtla çalışan tesislerin / araçların elektrikle çalışan veya hibrit olarak değiştirilmesi baskısına sahiptir. Örneğin, Long Beach limanı yenilenebilir enerji kaynaklarına ve kendi kendine üretim sistemlerine geçişi kolaylaştırmak için yeşil liman politikasını uygulamıştır. Böylece dizel partikül

emisyonlarını, azot oksitleri, sülfür oksitleri ve sera gazlarını sırasıyla %85, %50 ve %97 oranlarında azalttığı ortaya konmuştur (Cui ve Notteboom, 2017).

Bu çalışmanın amacı, örnek bir marina içerisindeki yatların yanaşma ve kalkış manevraları sırasında ortaya çıkan salım miktarlarının hesaplamasıdır. Bu çalışmayı gerçekleştirmek için referans bir marinadan yatların yıllık ortalama giriş-çıkış verileri, boyut ve makine bilgileri alınmıştır. Marinada yatların 3 knot hızla giriş çıkış kuralına uydukları varsayılmış, buna göre yakıt tüketimleri, makine yükü ve salım hesaplamaları yapılmıştır. Ayrıca teorik hesaplar marinadaki 3 millik alanı kapsayacak şekilde gerçekleştirilmiştir. Bir yıl içerisinde yatların referans marinada ürettiği salım miktarları hesaplanmış bu miktarı azaltmak için yapılabilecek uygulamalar tartışılmıştır.

## 2. Yöntem

Çalışmada, referans bir marina için bir yıl içerisinde giriş yapmış 363 adet yatın boyutları ve ana makine bilgilerine dair veriler toplanmıştır. Yatların ortalama boyutlarına ve makine gücüne sahip bir yat üzerinden salım hesaplamaları yapılmış ve toplam giriş çıkış sayısıyla çarpılarak yıllık ortalama yatlardan kaynaklı salım miktarları elde edilmiştir. Ortalama yat boyu 12,5 m, baş-kıç merkez hattına dik olarak ufki yönde dik olarak teknelerin en geniş mesafeleri ortalaması ise 3,91m'dir. Bu boyutlarda bir yatın maksimum 15 knot gibi bir hızda seyir yapabilmesi için ortalama ana makine gücü 230 kW olarak saptanmıştır. Bu özelliklere uygun olan piyasadaki yat makineleri incelenmiş ve yakıt tüketimi eğrilerinin benzerlik gösterdiği gözlemlenmiştir. Bu çalışma için piyasada yaygın bir kullanımı olan dört zamanlı, altı silindirli YANMAR 6LPA-STZP2 serisi ana makine baz alınarak hesaplamalar yapılmıştır. Tablo 1'de bu dizel makinenin özellikleri gösterilmektedir.

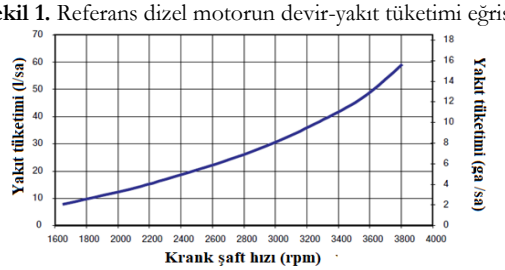
**Tablo 1.** Referans dizel motorun özellikleri

| | |
|---|---|
| **Yapılandırma** | 4 zamanlı, dikey, su soğutmalı |
| **Krank şaftta maksimum çıkış gücü** | 225 kW (Yakıt pompasında yakıt 25 °C)<br>232 kW (Yakıt pompasında yakıt 40 °C) @3.800 rpm |
| **Silindir** | 6 tane sıralı, her silindir için 4 valfli |
| **Yakıt Özellikleri** | Yoğunluk 0,84 kg/l, Kalorifik değer 42.700 kJ/kg |

**Kaynak:** YANMAR (2022)

Referans marina sahası içerisinde deniz araçlarının 3 deniz milidir. Bu da 5,55 km/sa gibi bir hıza denk gelmektedir. Çeşme liman sahasını çıkmak için bir yat yapılan hesaplamalar sonucu, ortalama 1,2 km yol kat etmelidir. Liman sahasında ana makinenin %25 yükte 2.400 devirde çalıştığı kabul edilmiştir. Bu çalışmada marinadan 3 deniz mili açığa kadar, yatlardan kaynaklı salımlar incelenecektir. Bu da 5,5 km gibi bir mesafeye denk gelmektedir. Liman sahası sonrası 4.3 km'lik yolda yatların tam yola çıktığı ve dizel makinenin MCR'de yani %85 yükte, 3.500 devirde çalıştığı kabul edilmiştir. Şekil 1'de referans ana makinenin devir sayısına göre yakıt tüketimi eğrisi görülmektedir.

**Şekil 1.** Referans dizel motorun devir-yakıt tüketimi eğrisi




**Kaynak:** YANMAR (2022)

Şekil 2' de harita üzerinde marina sahası ve seyir alanı olarak belirlenen bölgeler gösterilmiştir.

**Şekil 2.** Referans alınan marinada belirlenen seyir ve marina bölgeleri


Gemilerden kaynaklı salımı hesabı yaparken, tüketilen toplam yakıt miktarından yola çıkılarak hesap yapılmıştır. Salım katsayıları kullanılarak toplam salım miktarlarına ulaşılmıştır. Tablo 2'de kullanılan katsayılar gösterilmektedir.

**Tablo 2.** Deniz tipi dizel yakıt için salım katsayıları (g salım/ g yakıt)

| **Kirletici** | **$CO_2$** | **$CH_4$** | **$N_2O$** | **$NO_x$** | **VOC** | **CO** | **$PM_{10}$** | **$SO_2$** |
|---|---|---|---|---|---|---|---|---|
| **Katsayı** | 3.206 | 0.00006 | 0.00015 | 0.0961 | 0.00308 | 0.00277 | 0.00097 | 0.01 |

**Kaynak:** Kuzu ve diğerleri (2021); Trozzi (2010); IMO (2014)

Salımların hesaplanmasında ise Formül 1 kullanılmıştır (Kuzu ve diğerleri, 2021).

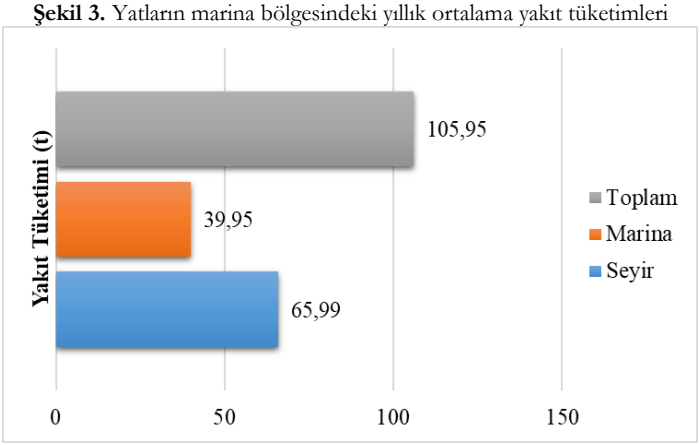
$$E_k = \sum_k FC * EF \quad (1)$$

Formülde salım miktarları $E_k$ ile gösterilmiş olup, k kirletici tipidir. $FC$ toplam yakıt tüketimi $EF$ ise kirleticinin salım katsayısını simgelemektedir.

## 3. Bulgular ve Tartışma

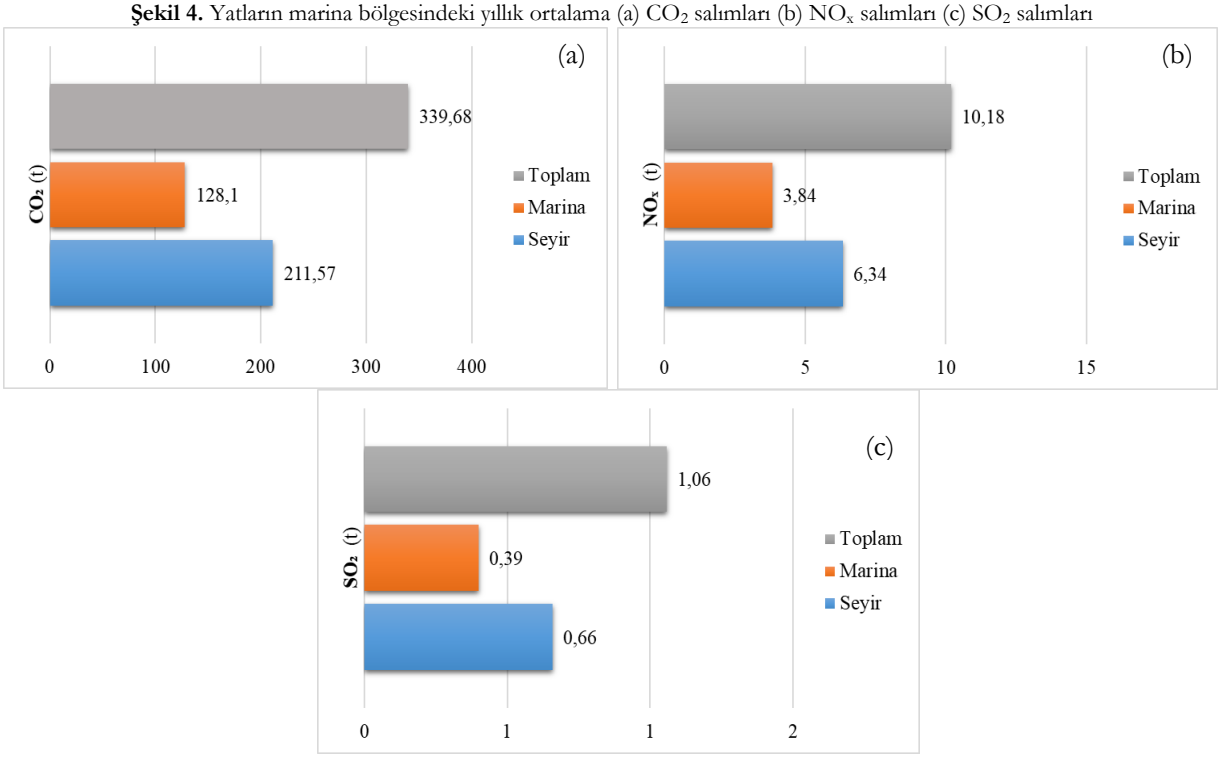
Baz alınan dizel makine 2.400 devirde yani liman sahasında saatte 18,8 l yakıt tüketmektedir. 3.500 devirde yani liman sahasını çıktıktan sonra ise saatte 44,85 l yakıt tüketmektedir. Bu değerleri referans yakıtımızın yoğunluğu olan 0,89 kg/dm3 ile çarparsak liman sahasında saatte 16,7 kg, açık denizde ise 39,9 kg yakıt yaktığı görülmektedir. Bir yatın liman sahasında ortalama 13 dakika, açık denizde ise ortalama 9 dakika geçirdiği hesaplanmıştır. Bu hesaplar ışığında bir yat liman sahasında 3,62 kg yakıt yakarken açık denizde 5,99 kg yakıt yakmaktadır. Marinadan alınan avara jurnallerinin incelenmesi sonucunda marinaya toplam giriş-çıkış sayısının bir yıl için ortalama 11.022 olduğu tespit edilmiştir. Bu veriler sonucunda Formül 1 kullanılarak egzoz salımlarının hesabı yapılmıştır. Şekil 3'te yatların referans marinada harcadıkları yıllık olarak ortalama yakıt tüketimleri gösterilmiştir.

**Şekil 3.** Yatların marina bölgesindeki yıllık ortalama yakıt tüketimleri



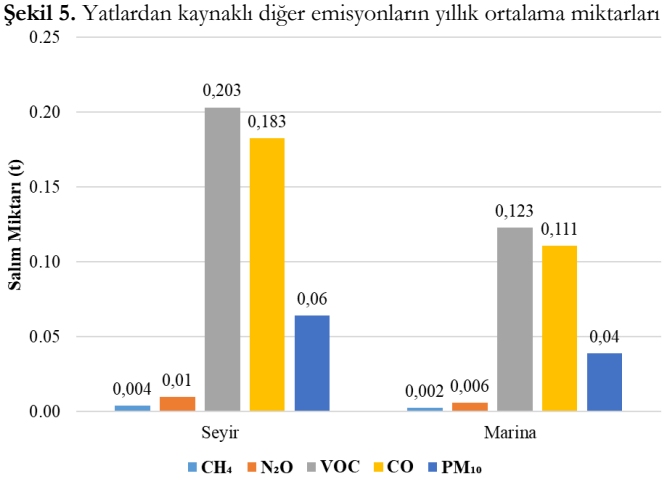

Şekil 4(a)'da bir yıllık süreçte referans olarak ele alınan marinada yatlardan kaynaklı ortalama $CO_2$ salım miktarları gösterilmektedir. Şekil 4(b)'de yıllık ortalama $NO_x$, Şekil 4(c)'de ise $SO_2$ gazı salımları gösterilmiştir.

**Şekil 4.** Yatların marina bölgesindeki yıllık ortalama (a) $CO_2$ salımları (b) $NO_x$ salımları (c) $SO_2$ salımları




Şekil 5'te daha az miktarda ortaya çıkan $CH_4$ (metan), $N_2O$ (nitröz oksit), VOC (uçucu organik karbon), CO (karbon monoksit) ve $PM_{10}$ (<10µ partikül madde) salımları marina ve yat bölgesi için ayrı yarı gösterilmiştir.

**Şekil 5.** Yatlardan kaynaklı diğer emisyonların yıllık ortalama miktarları



## 4. Sonuçlar

Referans marinada 3 millik (5,5 km) açığına kadarki bölgede yatlardan kaynaklı kirletici gaz miktarları hesaplanmıştır. Hesaplar yapılırken 1,2 km'lik alan marina sahası olarak alınmış, geri kalan 4,3 km ise açık deniz bölgesi olarak adlandırılmıştır. Marina bölgesi olarak kabul edilen 5,5 km'lik bölgede yatların yıllık ortalama 105,96 t yakıt harcadıkları hesaplanmıştır. Marina sahasında 128,1 t, açık denizde 251,57 t olmak üzere toplam 339,67 t ortalama karbon salımı gerçekleştiği hesaplanmıştır. Yıllık ortalama 10,18 t $NO_x$ gaz salımının bu bölgede yapıldığı hesaplanmıştır ve bunun %37,7'si marina sahası olarak belirlenen 1,2 km'lik alan sınırlarında gerçekleşirken geri kalanı seyir alanı olarak kabul edilen 4,3 km'lik bölgede üretildiği saptanmıştır. Marina bölgesindeki yatların yıllık ortalama 1,06 t $SO_2$ gazı ürettiği hesaplanmıştır.

Bu rakamların aşağı çekilmesi için yatlarda yenilenebilir enerji sistemlerinin kullanımının yaygınlaşması gerekmektedir. Yatlara entegre edilecek güneş panelleri yakıt sarfiyatının azaltılmasına katkıda bulunabilmektedir. Ana güç ünitesi olarak yakıt pilleri ile entegre edilen bir sistem tasarımı da yakıt tüketiminin ciddi anlamda düşmesine ve çevresel etkilerin minimuma indirilmesinde önemli bir katkı sağlayacaktır. Gelecek çalışmalarda salım hesaplarının doğruluğunu arttırmak adına bu çalışmanın kısıtlarını ortadan kaldıracak verilere ulaşıp, daha detaylı bir salım envanteri çıkarılması planlanmaktadır. Yatların boyutları ve ana makine özelliklerinin girdi olarak kullanılacağı bir regresyon uygulamasıyla gelecek periyotlardaki yakıt tüketiminin tahmin edilmesi de gelecek çalışma planları içerisindedir.

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*Research Article*

# Study on the Water Transport System in the Northern Region of Dhaka; the Capital City of Bangladesh

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## Abstract

All the megacities in the world suffer from traffic jams at a certain period of the day but in the case of Dhaka with the addition of traffic jams, it also faces total traffic chaos and mismanagement. At different times, the Government of Bangladesh took different initiatives to mitigate this issue but the result was futile. Now various megaprojects are underway to reduce the burden on the roads. The northern region of Dhaka city is a focal point of various megaprojects of the government to diversify the accommodation for the city dwellers which will lead to the requirement of various modes of transportation. Mostly unused waterways in and around the northern region can play a significant role here to diversify the transportations. There are ample opportunities to develop a waterways network. The study aims at the development of a sustainable water transport system for the northern region of Dhaka city based on questionnaire surveys on total traffic movement hourly variation, movement during weekdays and weekends, physical surveys on the proposed route, etc. A steel body waterbus has been proposed for this route and it has been found that the proposed waterbus can ensure the movement of substantial portions of the people along this region and its surroundings without any hassle and traffic jam. The development of the water transport network will ensure affordable journey in the Northern Region of Dhaka city.

## 1. Introduction

Rapid and ongoing urbanization in Bangladeş has resulted in an extreme level of traffic congestions. Now, it is the most intolerable and burning issue for the country. This level of traffic congestion is hampering the economic growth and development of the country. According to research, the average speed of vehicles in Dhaka city has slowed down to only 4.5 kilometers per hour now from 21 kilometers per hour only in a decade (Saif, 2020). The city's traffic congestion eats up to 5 million man-hours every day. In another research, the annual loss due to traffic jams is estimated between Tk. 200 billion (1 USD=85.00 Tk.) and Tk. 370 billion and the average loss stands at Tk .370 billion a year (Correspondent, 2018). In the northern region of Dhaka city, several government and private planned townships are now either being under construction or at the planning phase to reduce the pressure of population in Dhaka city by creating opportunities for residential accommodation. "Purbachal new Town Project" is the biggest planned township among them, comprising the area of 6150 acres located in the north-eastern side of Dhaka (Rajuk, 2020). Now, residents of these townships still have to travel to the center of Dhaka on daily basis for different purposes, which will cause a ripple effect on the already overwhelmed road transportation system. The government undertook different policies to address this issue. One of them is "Mass Rapid Transport System (MRT)", work on MRT LINE 1 from Hazrat Shahjalal International Airport to Kamalapur Railway Station has already been started which will connect Purbachol with Notun Bazar too (Byron and Adhikary, 2019). Now, the northern region of Dhaka city also has a vast network of waterways which to this day still remains mostly unused for public transportation.

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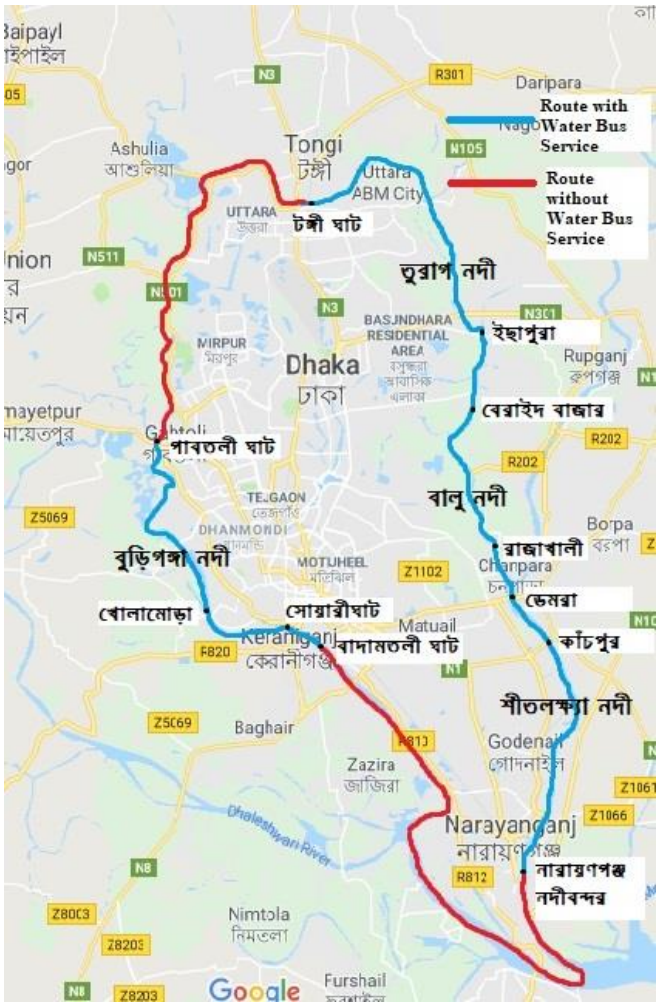
That is why with proper planning, by building water transportation systems in these untapped waterways integrated with already existing public transportation systems can substantially improve the traffic condition in this region.

The city of Dhaka has a unique advantage of encircling the river Buriganga, Turag, Tongi, Balu, Sitalakhya, and Dhaleswari covering 110km shown in Figure 1. They have been playing a significant role in the carriage of goods and passengers particularly on the south, southeast, northeast, and west belt of the city. The water route from Munshiganj via Fatulla to Sadarghat and further to Mirpur is operable for carrying passengers and goods by various types of vessels motor launches, engine boats, and country boats. These circular waterways have a big potential to use it for the movement of goods and passengers. Unfortunately despite having huge potential, until now it is not possible to utilize it fully. A rather very limited portion of it is capacity is used now. The circulating waterways of Dhaka city are also linked with many khals/canals along with a few well-recognized lakes and water bodies (Gulshan, Banani, Baridhara, Moghbazar, and Dhanmondi, etc.). Historically, these khals and water bodies seem to have good transport links with the peripheral river contributing to the attractive environmental features of the city. But since the late 1940s with the rapid expansion of the city, ever-growing population, accelerated housing and business growth there had been a continuous tendency to infill the water bodies and khals for building structures, roads, and sewerage systems resulting in the complete or partial closure of almost all the khals and water bodies and today these intra cities khals (water bodies) hardly contribute anything to the transport to the transport network or environment, rather cause environmental pollution. The only surviving 6/7 canals and 4/5 water bodies are also in the grip of encroachment of the builders and developers due to the absence of well-defined policy and plan for city development and strong commitment for implementation of the plans and policies.

**Figure 1.** Current Water Transport Routes with Water Bus service in Dhaka City




The present study is focused on studying a route on the northern side of Dhaka. The name of the route is the Rampura-Khilgaon-Uttara route and it has been used in recent times for the movement of goods. It has not been utilized for passenger transportation in recent times. No significant research has been done in this particular route regarding the implementation of a water transportation system. Due to the recent development of housing projects,

many people are living in this area and they need to move to different parts of the city every day. So, the proposed route could be used as an alternate route for not only passengers but also for goods.

## 2. Rationale

Though the Rampura-Khilgaon-Uttara route is a complete waterway, it has not been utilized for passenger transportation in recent times. No significant research has been done in this particular route regarding the implementation of a water transportation system.

Proposed Rampura Bridge- Khilgaon - Uttara waterway includes a significant number of residential housing projects on both sides. Most of the housing projects do not have the facilities of continuous bus services from Rampura Bridge and Khilgaon.

Banasree and Aftabnagar site right near to Rampura canal portion (Rampura Bridge- Khilgaon Trimohini). They are one of the most populous regions of Dhaka city. Along the waterway, at a distance of about 10 Kilometers from Rampura Bridge 'Ruposhi Bangla Model Town' and 'Kaptotakkha Green City' housing projects sit right next to the Balu River. Traveling to these projects will take no longer than 35 minutes with the proposed waterbus at a speed of 10 Knots from Rampura Bridge but now at this moment, they have no continuous roadway transportation mode which causes both wastes of time and money. It requires almost 1 hour and 20 minutes to reach these projects through the shortest available roadway transportation modes. Right next to them at a distance of 13 Kilometers from Rampura Bridge, there is Beraid Boat Ghat. Beraid is also a densely populated area. No continuous bus service is available between these two points either. Using 100 feet Madani Avenue Road is the fastest route possible, it takes more than 50 minutes at usual traffic conditions. But using a waterbus will take about 40 minutes. Anondo Police Housing Society is located 16 kilometers apart from Rampura Bridge through the waterway. It will take around 55 minutes to reach the 300 ft road by waterway and an additional 0.5 Kilometer has to be traveled through another transportation mode to arrive at the destination while in roadways, it requires more than 1 hour and 30 minutes via Progoti Sarani - Debogram Road - Purbachal Express Highway.

Using a waterbus, it will take around 1 hour to reach Balu Bridge of Purbachal Express Highway. From this point, it will take another 25 minutes to reach Bashundhara Residential Area located next to Beraid. Through road transportation network it will take 30 minutes to reach Bashundhara Residential Area from Rampura Bridge but on the other hand from Khilgaon Trimohini the distance of Balu Bridge is around 13 Kilometers along the waterway but using road transportation from Khilgaon to reach Bashundhara Residential Area via Bir Uttam Rafiqul Islam Avenue and Madani Avenue will take 1 hour and 20 minutes at usual traffic condition, which makes the waterway more feasible from Khilgaon region.

Purbachal Residential Model Town is the biggest planned township in Bangladesh. The project area is located in between the Shitalakhya and the Balu River at Rupgonj thana of Narayanganj District and Kaligonj Thana of Gazipur District, in the northeastern side of Dhaka. From Balu Bridge of Purbachal Express Highway, it will take 20 minutes to reach Purbachal Residential Model Town and with roadway transportation, it does not have any continuous bus service and to reach the location via Progoti Sarani - Debogram Road - Purbachal Express Highway it will take no less than 1 hour and 30 minutes at usual traffic condition and reaching the location from Khilgaon will take much longer time but using waterway it will take even less amount of time than of traveling from Rampura Bridge.

Tongi is a thana (police station) within the Gazipur Sadar Upazila along with Joydebpur and is located immediately north of Dhaka. Many of the people who live in Tongi commute to Dhaka each day, mainly by bus. From Rampura Bridge it is located at a distance of around 27 Kilometers along the waterway and will take almost 1 hour and 30 minutes to reach the destination using waterbus whereas from Khilgaon it will take around 1 hour and 10 minutes. Continuous bus services are available in this route and it takes around 1 hour and 30 minutes from Rampura Bridge but from Khilgaon it takes almost 2 hours to 2 hours and 15 minutes at normal traffic conditions, which makes waterbus a feasible alternative to the bus.

The project of Rupayan City Uttara is the country's first mega gated community and is located at the end of Sonargaon Janapath, Uttara. This is also at the ending point of the proposed waterway at a distance of around 28.5 Kilometers from Rampura Bridge along the waterway and it will take 1 hour and 35 minutes via waterbus and additional 10 minutes via road transportation medium to reach the project, from Khilgaon Trimohini it will take around 1 hour and 10 minutes. Whereas in case of road transportation via Bir Uttam Rafiqul Islam Avenue -

Progati Sarani Road - Noyanogor Road it takes 1 hour and 30 minutes at average traffic condition and from Khilgaon region it takes around 2 hours to reach the project.

From the above discussion, it is conspicuous that these developing projects along the proposed waterway can be well integrated and interconnectivity can be more time-efficient with the development of a waterway transportation system. Waterway transportation might be marginally costlier than the road transportation system but the time efficiency it has over the road transportation system makes it a feasible alternative. Additionally, it is immutable to any traffic jam which frequently plagues the roadway transportation network at that situation even the above-mentioned times look like a distant goal. It will also reduce the burden from the existing networks and will work as a supplementary medium to better integrate the different locations and increase their efficiency.

## 3. Methodology

This research work reviews the overall transport scenario of the northern region of Dhaka city especially the Rampura-Khilgaon-Uttara area. The water bodies in the periphery of this particular part of the city have been examined along with the existing water transport activities going on in these waterways. This study includes data collection from various sources such as

i) Questionnaire survey on the movement of passengers in the routes identified
ii) Survey to understand the expectation and demand of the potential passengers on the character and quality of service
iii) Physical survey of the routes to identify the actual scenario with present status especially for the route starting from Rampura Bridge to Balu river junction
iv) Data collection from secondary sources such as earlier study reports, data, information, and statistics from BIWTA regarding particulars of the route from Balu river junction to Uttara.

The questionnaire-based survey has not only considered the total traffic movement but also the hourly variation, movement during weekends, etc. have been assessed.

Based on the data, information, statistics, opinions gathered during the survey, outline design of the various alternative crafts has been prepared. The various limitations such as draft restriction, maneuvering constraints, etc., have been considered in this study. The speed requirement has also been determined. The procurement cost of the vessels has been estimated. The operating cost, repair and maintenance cost, financial costs, and other costs have also been estimated. These data, information, and estimated figures have been used to perform an economic analysis of the alternative vessels operating in the routes in terms of IRR, NPV, B/C ratio.

### 3.1 Survey

#### 3.1.1 Route and Particulars

This specific route stretches from Rampura Bridge to Khilgaon to Uttara (Sumiya et. Al., 2018). It connects some of the busiest transportation hubs in the Northern Region of Dhaka city. Detailed particulars at several points along the waterway according to several physical surveys and hydrographic charts collected from the BIWTA are mentioned in Table 1. In Figure 2, the complete route is shown, an orange line indicating the waterway whereas a blue sailing symbol shows all the proposed stoppages along the waterway.

#### 3.1.2 Existing facilities and present scenario of public transport

Public buses can carry about 40 passengers on average. Approximately 200 buses depart for Uttara per hour from Khilgaon and Rampura with a combined maximum capacity of carrying approximately 136000 passengers per day. At 70% of overall capacity, 95200 passengers travel daily. As all the passengers do not travel the whole roadway, it is considered in present analysis that an average of 25% of passengers travels for the region concerned which amounts to approximately 23800 passengers per day from Khilgaon to Uttara. With a fleet of 25 waterbuses (each one having a capacity of 40 passengers), 4000 passengers (approximately 17%) can be diverted at maximum capacity.

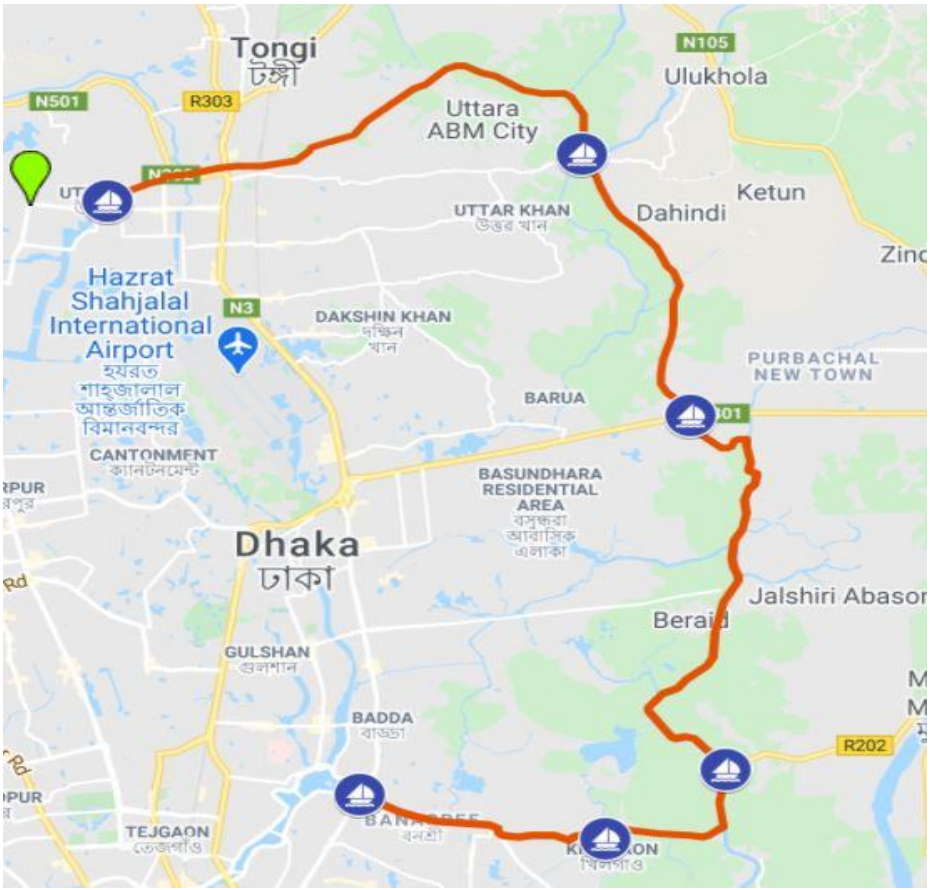
At present, access through road vehicles (public and private) is the only mode of transport for the passengers moving in and out of the Rampura-Khilgaon-Uttara area. Local bus service (Great Turag), Counter bus service (Raida, Anabil, Victor Classic, Asmani, Akash, etc.) and Air-Conditioned bus service (Iqbal, Green Dhaka) are available as common public transportation whereas CNG, Ridesharing apps (UBER, PATHAO, OBHAI, etc.) are there for personal use.

In the case of sitting and air-conditioned service, at peak hours (8-10 A.M.,5-8 P.M.) it takes around two hours to reach Uttara from Khilgaon whereas at off-peak hours it takes around one hour and fifteen minutes. In the case of local bus service, at peak hours (8-10 A.M.,5-8 P.M.) it takes around three hours to reach Uttara from Khilgaon and at the off-peak hour, it takes around two hours.

**Table 1.** Detailed locations and particulars of the selected route.

| Selected Route | Different Segments | Total Length [km] | Breadth [m] | Depth [m] |
|---|---|---|---|---|
| Rampura Bridge-Khilgaon-Uttara | Rampura Bridge to Trimohini. (Hydrographic Chart unavailable) | 4.40 | Highest – 24.39<br>Lowest – 7.32 | 2.44-3.05 in August<br>1.52-2.13 in December |
| | Trimohini to Balu river junction. (Hydrographic Chart unavailable) | 2.20 | Highest –34.76<br>Lowest – 9.33 | 3.66-4.27 in August,<br>2.44-2.74 ft in December. |
| | Balu river (UptoKayetpara) | 1.20 | Highest – 60.98<br>Lowest – 54.57 | 3.96-5.49 |
| | Balu river (Kayetpara to Ichapura) | 8.00 | Highest – 64.33<br>Lowest – 56.40 | 4.27-5.49 |
| | Turag River | 0.012 | Highest – 57.93<br>Lowest – 39.63 | 3.66-4.57 |

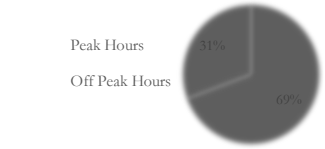
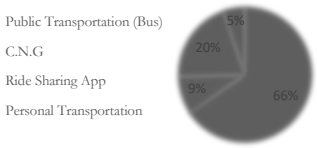
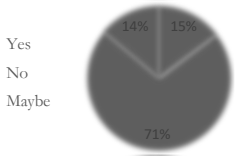
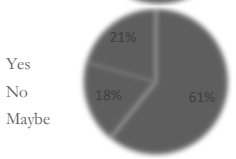
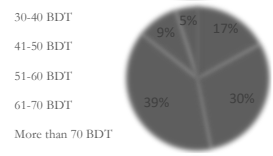
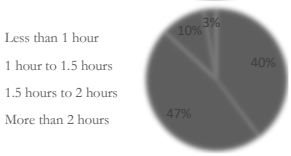
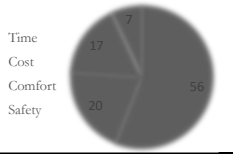
**Figure 2.** Selected Route.



### 3.1.3 Passengers' survey

According to a questionnaire-based survey by present authors on 100 randomly selected passengers, 66% of the respondents use public transportation systems on regular basis and 61% of the respondents will consider using waterbus in this route if properly implemented. A significant percentage of the passengers in this route can be diverted by ensuring less travel time with almost similar cost. A detailed parameters considered for this questionnaire-based survey with survey results are shown in Table 2.

**Table 2.** Detailed locations and particulars of the selected route.

| Sl. No. | Parameters | Survey Results |
|---|---|---|
| 1 | Travel Time |   |
| 2 | Mode of Transport |   |
| 3 | Satisfaction with current facilities |   |
| 4 | Consideration of Waterbus |   |
| 5 | Expected Cost to be incurred |   |
| 6 | Expected Time to travel |   |
| 7 | Priority |   |

## 4 Design criteria for selecting particulars and speed of the waterbus

The displacement type monohull craft is considered in the present study. This is one of the oldest types, the simple design, and technology of building such type vessel is well known. It can also be constructed in places other than conventional shipyards. Hull form and configuration have been designed based on minimum resistance and low wash for its operating speed. The craft possesses good stability which will provide a fear-free, comfortable ride. It should have good maneuverability and be capable of negotiating sharp bends as well as obstacles quickly and efficiently so that the craft can be operated in confined and/or congested areas also. The boat is designed to run at a moderate 10-knot speed to avoid huge waves which may cause high bank erosion in narrow canals and rivers and may also cause damage to flora and fauna.

The capacity of the waterbus is kept same like average passengers no. i.e., 40 were found from the survey. For the fixing principal particulars of the waterbus, passenger comfort is considered and seats are arranged in seven rows wherein each row, there are six seats except the front (bow) row which has four seats and a space equal to 1 m for walking. The breadth of each seat is 0.45m. Then six seats need (6 × 0.45) = 2.7 m space which enables passengers to move comfortably inside the water bus. Allowing other spaces, the breadth of the boat is taken as 4.50 m. The length of each seat is 0.45m and the space between two rows is 0.35 m in the longitudinal direction. So, total seating space = (0.45 × 7) + (0.35 × 6) + 0.9 (wash cabin) + 0.9 (space between front rows and collision bulkhead) = 7.05 m. Steering space is 2.0 m and space for the engine is 2 m. Peak Tank space is 1.8 m. So, the total space required in the longitudinal direction is 12.85 m. Therefore, the length of the ship is taken as 13 m. Since, as per survey data, the minimum depth of the route is 1.5 m, the draft of the boat is taken as 0.80 m.

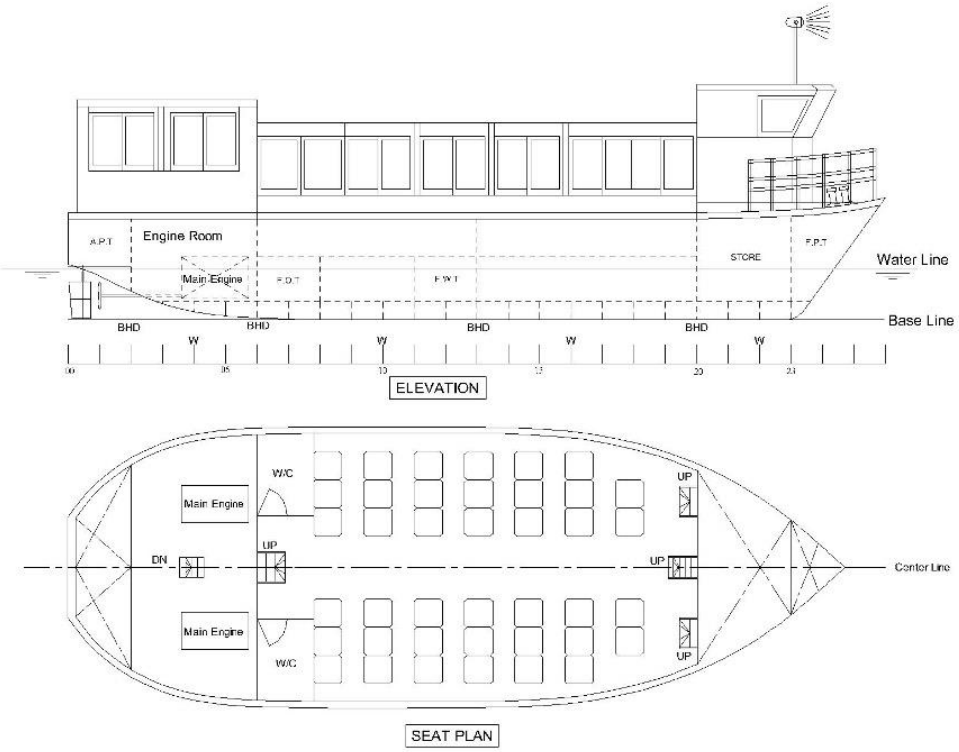
Considering the travel time required by road transports, the safety of the smaller boats and households at the riverbank of the waterways, the average speed is taken to be 10 knots. The travel time required by road transports in the proposed area is about 105 minutes at peak hours. At 10 knots speed, the required travel time by waterbus for a trip is about 90 minutes. The principal particulars of the proposed waterbus are described in Table 3.

**Table 3.** Principal Particulars of the Waterbus

| Particulars | Value | Unit |
|---|---|---|
| Length Overall | 13.00 | Meter |
| Length Between Perpendiculars | 11.95 | Meter |
| Breadth Mld | 4.50 | Meter |
| Depth Mld | 1.70 | Meter |
| Draft | 0.80 | Meter |
| Speed | 10 | Kn. |
| Capacity | 40 | Nos. |

Figure 3. shows the General Arrangement (GA) of the waterbus, which is designed for the Rampura Bridge-Khilgaon-Uttara route.

**Figure 3.** General Arrangement of Waterbus



## 5 The initial cost for waterbus with economic analysis

### 5.1 Initial cost

Depending on the hull materials, the construction cost of the waterbus may be varied. In the present study, 3 different hull materials have been considered for the construction of monohull-type water buses. Hull materials considered here are steel, aluminum, and GRP. A market survey for the construction of this waterbus had been conducted to get the total construction cost of the waterbus. It is to be mentioned here that depending upon technological know-how availability cost is varied among the 3 hull materials considered in the present study. Table 4 shows the lightweight, deadweight, and engine power of the boat made of three different hull materials considered in the present study.

**Table 4.** Lightweight, deadweight, and engine power of the boat made of three different hull materials

| Particulars | Hull materials | | | Unit |
|---|---|---|---|---|
| | Steel | Aluminum | GRP | |
| Lightship | 19.40 | 12.50 | 12.30 | Ton. |
| Deadweight | 5.51 | 5.48 | 5.48 | Ton. |
| Displacement | 24.91 | 17.98 | 17.78 | Ton. |
| Draft at full load | 0.80 | 0.54 | 0.53 | Meter |
| Resistance at 10 Kn. | 8.33 | 6.63 | 6.59 | KN |
| Engine Power | 2 × 63.50 | 2 × 50.50 | 2 × 50.00 | HP |

### 5.2 Projected economics of operation

To have a quick look into the possible economic performance of the vessels in this particular route, the projected economic analysis has been prepared and presented here. It is to be noted that though the factors affecting the economics as well as the transport demands are the same in a particular route, three vessels of the same size but different hull materials have been considered and the projected economic performances are evaluated separately. However, the following assumptions are common in all cases.

(i) When an individual vessel starts commercial operation, it generally operates at a rate lower than the full capacity. In the present study, it is considered that all vessels operate at 100% load.
(ii) The annual escalation rate is as in Table 5.
(iii) The rates of depreciation of hull and machinery have been assumed to be 2%
(iv) It is also assumed that the operator will acquire the vessels with no down payment (100% on loan).
(v) Ship life is considered 20 years and at the end of project life scrap value is considered 20% of the invested cost.

The following economic indices of performance have been presented for each type of vessel in individual routes

- Internal Rate of Return (IRR)
- Net Present Value (NPV) of the investment based on 10% discount rate and
- The benefit-cost ratio (BCR) is based on a 10% discount rate.

**Table 5.** Annual rates of escalation

| Items | Increase (%) |
|---|---|
| Hull Maintenance | 1.0 |
| Engine and Machinery Maintenance cost | 2.0 |
| Fuel and Lubricating oil cost | 5.0 |
| Insurance, Registration, Port charges etc. | 1.0 |
| Passenger fare | 5.0 |
| Crew wages | 5.0 |

The projected economic performances based on the IRR, NPV, and B/C ratio of vessels operating in the route are given in Table 6. The analysis is carried assuming the fare rate is 75 taka per person.

**Table 6.** Economic performance of Water Taxi for different hull materials

| Items | Hull materials of Water Taxi |
|---|---|

| | Steel | Aluminum | GRP |
|---|---|---|---|
| Length (m) | 13.00 | 13.00 | 13.00 |
| Breadth(m) | 4.50 | 4.50 | 4.50 |
| Depth(m) | 1.70 | 1.70 | 1.70 |
| Vessel cost (Tk.) | 38,02,000 | 54,91,000 | 55,35,452 |
| Eng. Power (HP) | 127 | 101 | 100 |
| Capacity (nos) | 40 | 40 | 40 |
| Speed (Knot) | 10 | 10 | 10 |
| NPV (Tk.) | 2508 | 12311 | 13962 |
| BCR | 1.035 | 1.202 | 1.24 |
| IRR | 15.20% | 36.94% | 39.46% |

1 USD = 85.00 Tk.

From the economic analysis, it appears that the Aluminium boat and GRP boat are more economically viable and this is due to less power is required for these two boats and hence operating cost is lower than steel hull water bus. On the other hand, the initial cost of a steel body water bus is less and it is 30% cheaper than an Aluminium boat and GRP boat. Considering the social perspective of Bangladesh, the initial cost usually dominates regarding the choice of the ship. Again from a repair and maintenance point of view steel body water bus is the most favorable one.

## 6 Conclusion

Different megacities around the world adopted multiple approaches to building an integrated transportation system in and around the city where waterways played a crucial role. At present different projects are underway to develop the connectivity between Dhaka city and its outskirts. In the northern region of Dhaka, these untapped waterways can play a significant role to reduce the burden on-road transportation systems. In this study, a steel body waterbus has been found suitable considering initial cost, repair and performance point of view throughout its life of 20 years. It is expected that this type of waterbus can also provide a feasible alternative to other networks and integrating them can be a potential solution to the unbearable traffic jams this megacity is facing. A proposed designed waterbus can play a key role in mitigating these issues.

## 7 Limitations and Future Works

This study has been confined to the following aspects:

- Only monohull vessels have been considered in present study. Catamaran vessels may be included in the future to check the performance.
- The speed effects could be considered for evaluating the ship's performance analysis.
- Sensitivity analysis could be done.

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*Research Article*

# The Impact of COVID-19 Pandemic on Maritime Students' Perceptions of Their Profession

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*COVID-19, Maritime Education, Supply Chain, Maritime Transportation, Coronavirus*

**Abstract**

There is no doubt that the COVID-19 pandemic has formed a global impact in many sectors. It is a notable fact that the maritime industry, which is a respectable part of the global supply chain, is also affected by the COVID-19 pandemic. Along with these, it is though that there are radical changes in the education sector with the COVID-19 pandemic. That These changes exist, when combined with the changes of COVID-19 in the sector, is created a considerable impact on maritime students' perceptions of their profession. In this study, it is aimed to investigate the effect of COVID-19 on students' occupational perceptions. On this paper, the impact of the COVID-19 pandemic on maritime students' perceptions of their profession is investigated using the Five Point Likert Type Survey method. Recent developments resulting from COVID-19 have led to a renewed interest in maritime students' perceptions of their profession. Accordingly, the study provides a better understanding of maritime students' opinions in order to help maritime regulatory bodies construct future policies that best match seafarer needs.

## 1. Introduction

The pandemic of the coronavirus (COVID-19) has an impact on many aspects of the entire world, including public health, education, supply chain, and global trade, etc. Its spread has caused national economies and companies to examine the consequences, as governments attempt to stifle movement in order to prevent the virus from spreading. Furthermore, several comprehensive national lockdowns continue to cause supply chain disruptions by delaying or even completely halting the transfer of raw materials and finished goods (Praharsi et al., 2021). The maritime industry, as a backbone of international trade and the global economy, has been severely impacted by the spread of the COVID-19 pandemic, among others (Babica et al., 2019)

The maritime industry plays a key role in maintaining global supply chains and transporting more than 80% of global trade at particularly challenging periods (the COVID-19 pandemic) (Puteri Zarina et al., 2021) . 98,140 commercial ships with a capacity of 2.06 billion dwt move about 12 billion tonnes of cargo (IMO, 2021a). However, the COVID-19 epidemic continues to impose immense physical and mental pressure on the world's two million commercial seafarers. A large percentage of seafarers spend extended amounts of time at sea during their contracts, with tours of duty spanning several months (Yazır et al., 2020)(Millefiori et al., 2021). A roughly equal proportion of seafarers have been unable to board ships and work for a living. Furthermore, because seafarers are unable to visit to land (shore leave), repatriate and replace crews, or get medical treatment, they face a humanitarian disaster that jeopardizes the safety and future of shipping (IMO, 2021b). On the other hand, seafarers who are physically and mentally exhausted are expected to continue working on ships. At the same time, they are vital to the safe, efficient, and sustainable marine transport and contribute significantly to the conservation of the fragile maritime environment.

The safety of ships is highly reliant on the well-being of seafarers, who are on the front lines of decision-making and risk-taking to guarantee that ships are managed properly and safely (Radic et al., 2020). In this perspective, seafarers have been considered as a core of maritime transportation future (IMO, 2021a). Besides, according to the most recent BIMCO/ISF study from 2015, there will be a shortage of officers by 2025 (BIMCO, 2016). Therefore, the focus of this research is on seafarers' perceptions of the COVID-19 epidemic, which offers

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significant difficulties in terms of the human aspect of shipping, such as the safety and security of life on board ships, as well as seafarers' well-being. The assessment of seafarers' perception of the COVID-19 pandemic is of paramount importance in the development of the global supply chain and maritime transportation future. Its key advantages are that it emphasizes deduction and assists the decision-maker in identifying present difficulties, allowing for apparently more reasonable and even-handed decisions.

The articles should clearly state the problem, motivation, aim and significance of the study in the introduction part. The article structure is expected to has a flow as introduction, methodology, theory/calculations, application results, discussion and results, references and appendix.

## 2. Evaluation of COVID-19 Pandemic Impacts on Maritime Education and Maritime Students' Perception of Profession

For evaluation of COVID-19 pandemic impacts on maritime education and maritime students' perception, maritime training will be evaluated primarily with quality indicators, then the impact of the COVID-19 pandemic on maritime training will be evaluated. Evaluation of COVID-19 pandemic impacts on maritime education and maritime students' perception will be achieved by combining these assessments and new items.

Satisfaction is one of the important quality indicators for education. Almost every educational institution measures this quality indicator regularly. There are also studies in the literature measuring the satisfaction of maritime students (Puteri Zarina et al., 2021)(Anita Gudelj, Jeļena Lić̦ere, Inga Zaitseva-Pärnast, 2021)(Reyes & Reyes, 2019). However, this indicator may vary even regionally and temporally. In Turkey, It is thought that Maritime students are satisfied for their education like the others country.

*H1: Maritime students are generally satisfied with the training they have received in Turkey.*

To be Mariner are need to take international profession education. Because it has international maritime qualifications. Also training standards for these qualifications are determined by international authorities. The determined education standards are also applied by the countries. In this way, the training continues in a loop. The awareness of the students, who are the outputs of maritime education institutions, of the trainings they have received and the qualifications they have gained has been used as a quality criterion (Kalnina & Priednieks, 2017). It is expected that seafarers who receive education in accordance with international standards will be aware of their qualifications before they graduate.

*H2: Maritime students graduate knowing their proficiencies of maritime profession*

COVID-19 has changed many things in our daily life. However Education planning needs to tolerate the changes that come with COVID-19. This planning is important for education has more practical training, such as maritime training. New technological developments have also been seen in the Turkish maritime education industry, which is experiencing difficulties with COVID-19 (Nas, 2021)]. Therefore, it is considered that maritime training planning is done well during the COVID-19 process.

*H3: Planning for maritime education was done well enough during the COVID-19 pandemic process*

The bad effects of COVID-19would be seen years later. It is only possible to comment and evaluate on this topic at the moment. There are studies investigating the effects of COVID-19 on Maritime education (Demirel, 2021)(Milić-Beran et al., 2021)(Ochavillo, 2020). Also, it is possible to make a comment that COVID-19 will have bad effects on Maritime education.

*H4: COVID-19 pandemic has worse effects on maritime education*

With the COVID-19pandemic, health and supply chain related problems have emerged in maritime transportation, as Imo also reported (World Customs Organization, 2020). Personnel Exchange Problems, Operational Problems, Problems Related To Quarantine Conditions and Workload By Increasing Health Measures are problems brought

by COVID-19 (Article et al., 2022). Students who will enter the industry in a few years are expected to be aware of these problems.

*H5: Maritime students are familiar with the problems posed by the COVID-19 pandemic in maritime*

The maritime industry, maritime vocational education and personal life experiences have an impact on the maritime profession perceptions of maritime students COVID-19 affected all of them. It is expected that the changes in education with COVID-19, the problems experienced in the maritime industry and the health problems that the students may experience together with them could cause a change in the perception of the profession of maritime students.

*H6: The COVID-19 pandemic has had an impact on the maritime students' perceptions of profession*

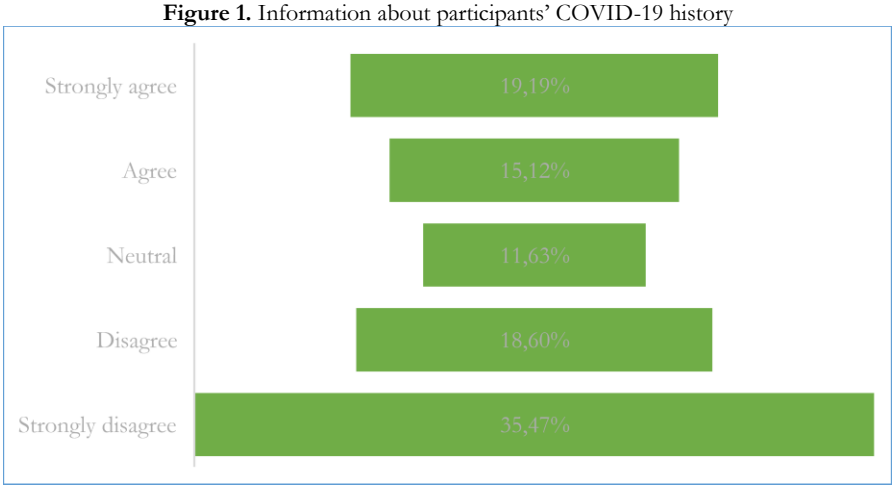
In this study, there is evaluation of the impact of the COVID-19 pandemic on maritime education and maritime students' perception of profession. Therefore there is studied on H1,H2,H3,H4,H6.

## 3. Method and Material

### a. Data Collection

After the hypotheses are defined, scales suitable for the hypotheses are determined: Evaluation of education, Perceptions of profession, COVID-19 and education and COVID-19 and perceptions of maritime profession. "Five point Likert type survey" method is used to research the hypotheses. Shown in Appendix, Five point Likert type survey occur with 47 statements from strongly agree (5) to strongly disagree (1).

**Figure 1.** Information about participants' COVID-19 history




Target group of our study is maritime students of high school, associate degree, bachelor degree, advanced degree. We are making investigations for Turkey. In our study, convenience sampling, one of the nonprobability sampling methods, has been used. The survey is implemented to the participants via internet (Karaca, 2021). A questionnaire was applied to 172 participants from different levels. Our sampling group is it. The categorical distribution of the participants' demographic and about their maritime training information is given in Table 1. Considering the capacities of maritime education institutions in Turkey, it is possible to say that our sample group represents target group. Information about their COVID-19 history is also given in Figure 1. The majority of our participants and their family did not have health problems due to COVID-19.

The majority of our participants are male, undergraduate students and their ages is between 18-23. The classes are almost equally spaced according to information.

**Table-1.** The categorical distribution of the participants' demographic and about their maritime training information

| Age (Number of student) | Sex | Student | Class |
|---|---|---|---|
| 13-17 (18,60%) | Man (93,02%) | Student of high school (21,51%) | Preparatory (16,86%) |
| 18-23(70,35%) | Woman (6,98%) | Student of associate degree (6,40%) | 1st year (22,09%) |
| 24-30(9,30%) | | Student of bachelor degree (69,77%) | 2st year (18,02%) |
| 30+ (1,74%) | | Student of advanced degree (2,32%) | 3st year (17,44%) |
| | | | 4st year and more (25,58%) |

## i. Analysis

The scales used in this study is determined firstly so the existing scales in the literature are not used. For this reason, reliability and validity analysis of the scales are carried out. For This analysis, IBM SPSS Statistics 20 is used. For Reliability analysis, Cronbach's coefficient alphas is used. Value of number of items, mean, variance, standard deviation and Cronbach's Alpha is given for all scales in table 2 for reliability analysis. Results are acceptable.

**Table-2.** Reliability analysis results for every scale

| Scale | Number of items | Mean | Variance | Standard deviation | Cronbach's Alpha |
|---|---|---|---|---|---|
| **Evaluation of education** | 6 | 19,8 | 32,520 | 5,703 | ,827 |
| **Perceptions of profession** | 12 | 35,99 | 79,269 | 8,903 | ,817 |
| **COVID-19 and education** | 16 | 44,92 | 160,859 | 12,683 | ,862 |
| **COVID-19 and perceptions of maritime profession** | 13 | 38,44 | 101,546 | 10,077 | ,851 |
| **Total** | 47 | 138,43 | 1152,223 | 33,944 | ,948 |

For Validity Analysis, Factor Analysis is used. Value of number of items, KMO value, Cumulative (%) rotation and number of component. KMO values are acceptable, Cumulative (%) rotation is reasonable given for all scales in table 3. Scales includes various components but number of items and participants are not sufficient.

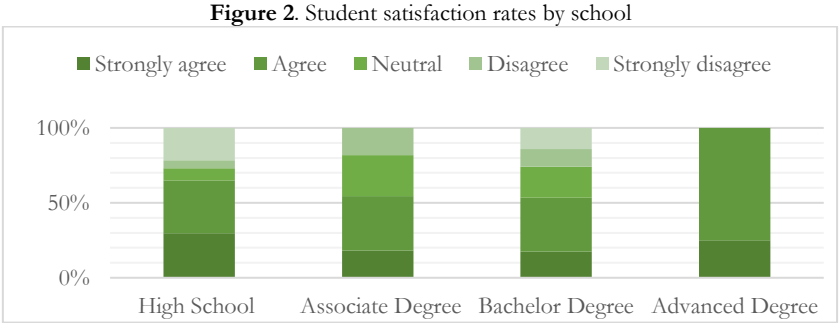
**Table-3**. Validity analysis results for every scale

| Scale | Number of items | KMO value | Cumulative (%) rotation | Number of component |
|---|---|---|---|---|
| **Evaluation of education** | 6 | ,836 | 74,394 | 2 component |
| **Perceptions of profession** | 12 | ,837 | 66,795 | 3 component |
| **COVID-19 and education** | 16 | ,824 | 65,739 | 4 component |
| **COVID-19 and perceptions of maritime profession** | 13 | ,828 | 67,986 | 3 component |
| **Total** | 47 | ,883 | 69,095 | 9 component |

## 4. Finding and Results

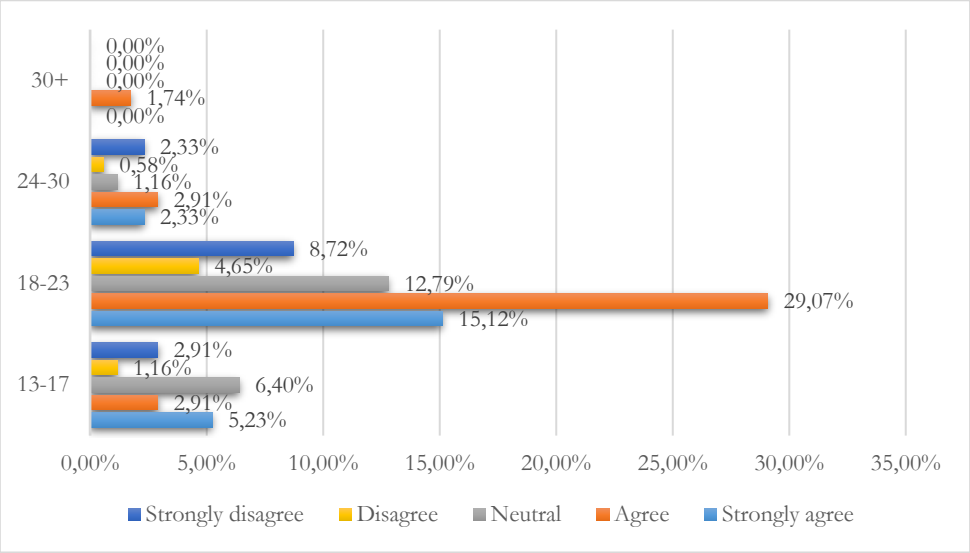
In this section, findings and results regarding the survey outputs is presented.

**Figure 2**. Student satisfaction rates by school



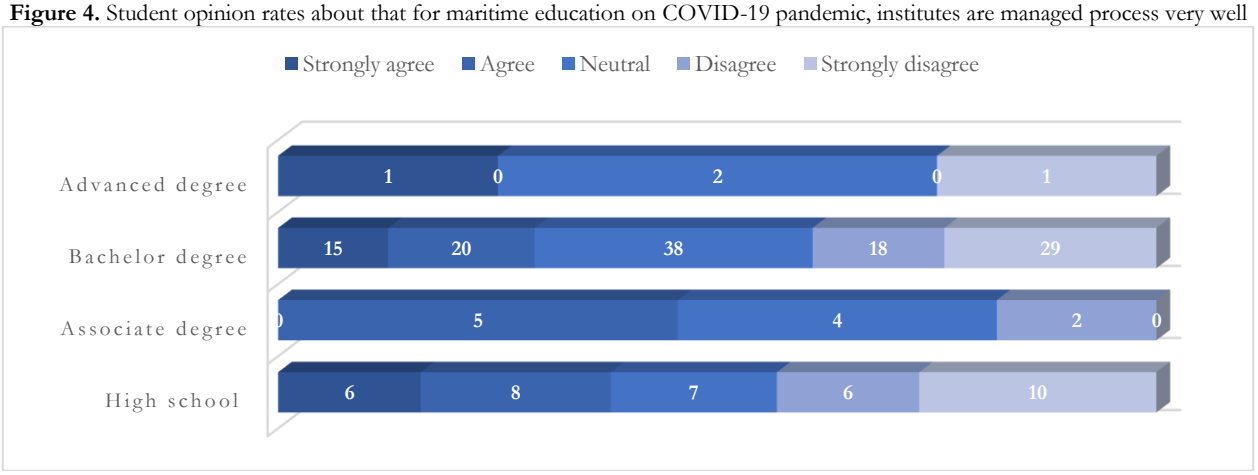

Student satisfaction rates by school is shown in Figure 2. According to this figure that Students are generally satisfied with their education.

**Figure 3**. Student professional awareness rates by school




Student professional awareness rates by school is shown in Figure 3. According to this figure that Students are generally aware of their professional qualifications. It is noticed that the youngest students are undecided on this question because they are new to maritime training.

**Figure 4.** Student opinion rates about that for maritime education on COVID-19 pandemic, institutes are managed process very well




Student opinion rates about that for maritime education on COVID-19 pandemic, institutes are managed process very well is shown Figure 4. When the answers of undergraduate and high school students with a higher number of participants are evaluated, it is seen that the rates are evenly distributed. We can say that the opinions of the students on this subject are evenly distributed. In short, it can be said that students are undecided about educational institutions manage very well the COVID-19 Pandemic process.

Student opinion rates about that for COVID-19 has worse effect for maritime education is shown Figure 5. According this figure, It can be said that students are undecided about the fact that maritime education is badly affected by COVID-19.

**Figure 5**. Student opinion rates about that for COVID-19 has worse effect for maritime education

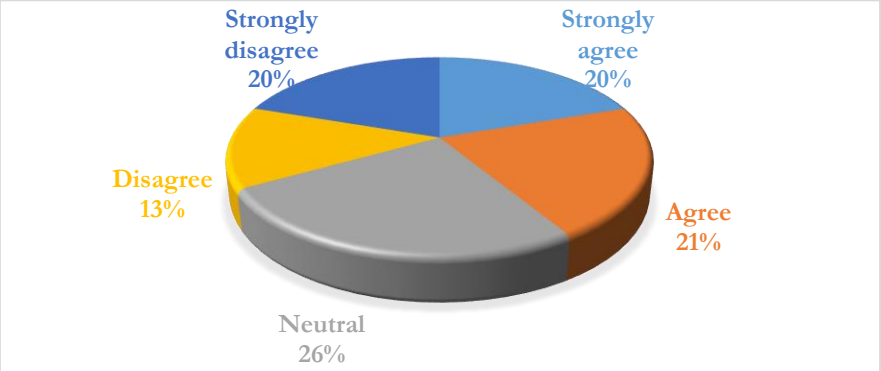
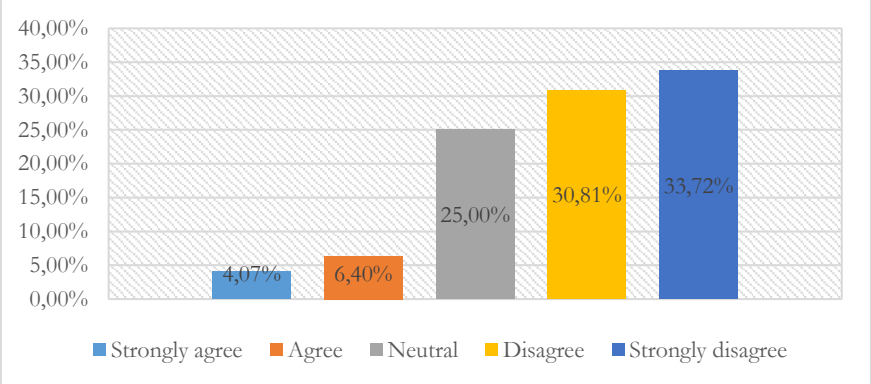



**Table-4.** Student opinion rates about problems in maritime industry occurred with COVID-19

| | Personnel exchange problems | Operational problems | Problems related to quarantine conditions | Workload by increasing health measures |
|---|---|---|---|---|
| **Strongly agree** | 29,65% | 9,88% | 13,95% | 12,21% |
| **Agree** | 19,19% | 25,00% | 23,26% | 13,95% |
| **Neutral** | 25,00% | 34,30% | 31,40% | 26,74% |
| **Disagree** | 8,72% | 15,70% | 13,95% | 25,00% |
| **Strongly disagree** | 17,44% | 15,12% | 17,44% | 22,09% |

With COVID-19 pandemic, it is occurred problems maritime industry. It is possible to divide these problems into four categories: Personnel exchange problems, operational problems, problems related to quarantine conditions and workload by increasing health measures. Student opinion rates about problems in maritime industry occurred with COVID-19 is given Table 4. Students generally strongly agree that there are personnel exchange problems, but strongly disagree with there is a problem about workload by increasing health measures. About there are operational problems and problems related to quarantine condition, students mostly agree.

**Figure 6**. Student opinion rates about that for not practising maritime profession in the event of similar pandemic




Student opinion rates about that for not practising maritime profession in the event of similar pandemic is shown Figure 6. This figure showed that the pandemic did not affect the profession perceptions of maritime students. Most of students gave a clear answer to the question that they would not do their job in the event of a similar pandemic but There are also undecided students.

## 5. Conclusions

The spread of the COVID-19 pandemic, among other things, has had a significant influence on the marine sector, which is a backbone of international trade and the worldwide economy. More importantly, the COVID-19 epidemic continues to put enormous physical and emotional strain on the world's two million commercial mariners. Therefore, there has been increased interest in maritime students' opinions of their profession. The current research is specifically designed to evaluate the maritime students' perceptions to support and assist regulators to design future regulations in a manner that best suits seafarer needs. The study's findings contribute to the maritime literature in various ways. Firstly, the study enhancing our understanding of maritime students' perceptions. The second contribution of this study is to encourage focused regulatory activity by providing a clear understanding of the current situation. Finally, when the findings of this study and the literature are compared, Although the effects of COVID-19 on the maritime profession have been explained in the literature, it has been demonstrated by this study that maritime students are not fully aware of these effects. Despite the fact that the current study only included a small sample of participants, the findings suggest that future crises should be handled more delicately, considering the international challenges that seafarers have to deal with. This issue is extremely relevant in the context of the projected officer shortages. It would be inspiring to see future research that looked at the worldwide perspective.

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*Deniz Taşımacılığı ve Lojistiği Dergisi*
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*Research Article*

# The Effect of Freight Rates on Fleet Productivity: An Empirical Research on Dry Bulk Market

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**Abstract**

Fleet productivity increases in two directions. First one is achieved by increasing the speed of the vessels in the market conditions where high freight rates are observed, this increases the amount of cargo per unit capacity they carry at the unit time. The other one is related to the short run inelastic supply curve in shipping because of the time to build effect. When the demand increases occur, the amount of cargo carried per unit capacity increases since the increase in supply is limited in the short run. In this context, it is determined the relationship between freight rates and the amount of cargo carried per unit capacity in this study. The Baltic Dry Index (BDI) was selected as a measure of the freight rates, and the tonnage carried per DWT from the portion of the total cargo tonnage carried by the sea to the dry cargo fleet capacity during that year was selected as an indicator of the fleet productivity. The dataset used in the study consists of annual observations covering the period from 1985 to 2020. Correlation and regression methods were used to determine the econometric relationship between the variables. As a result of the study, a significant strong relationship was found between freight rates and productivity in the positive direction. According to the developed model, a 10% increase in the freight rate causes an increase of about 1.3% in fleet productivity.

## 1. Introduction

Maritime transport is today still the most efficient way for transporting larger volumes of cargoes in an acceptable price across the oceans and without maritime transport, the development of the modern industrialized world would be impossible (Heidbrink, 2011; 49). Despite this important role, the maritime market is sensitive to macroeconomic conditions. Because, the demand for shipping services is a derived one and the main driver behind this derived demand is the world merchandise trade (Tamwakis, 2011; 52). So, even small fluctuations in the world economy are strongly felt in this market. Therefore, the effective use of the maritime fleet, which is the capital of the shipowners, varies according to the situation in the economy.

In general, the productivity of the fleet may increase due to two reasons; the first is the increase in demand for maritime transport due to revival in the economy and the second is the increase in the short-term transport capacity by increasing ship speeds (Karakitsos and Varnavides, 2014; 43). Both of which are mainly due to inelastic short-run supply curve in the maritime market. In addition to these, factors such as the increase in the average size of the ships, the developments in cargo handling speed in the ports, the opening of alternative waterways also affect the productivity of the fleet (Ma, 2020; 121). In addition, another productivity factors are the amount of cargo and navigating distance in the context of the productivity of shipping in relating to fleet productivity. So, shipping productivity can be affected by various factors such as economy, politics, geographical borders, war, and weather conditions, etc. (Duru, 2010; 167). However, in this study, we focused more on two factors, which are demand increase and speed increase, due to data constraints and simplification of the relationships.

It would be useful to first address the inelastic supply curve in the short run. The supply of shipping services can be categorized as short-run and long-run. If the stock of the fleet is fixed, it is called short-run, if the stock of the fleet is variable, it is called long-run (Karakitsos and Varnavides, 2014; 42). As can be seen in Figure 1, the freight rates are elastic until the 80% of the fleet up to the point of use, but when the next 20% of the limit is passed, it

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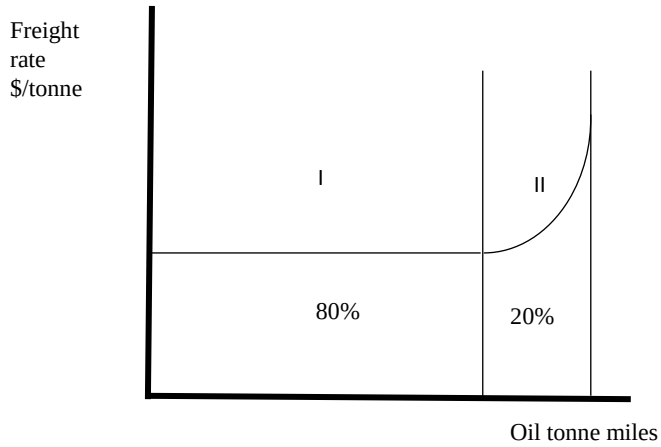
begins to become inelastic, and freight demanded by shipowners starts to increase rapidly (Glen and Christy, 2010; 379). The other version of this model, including demand lines, is presented in Figure 2.

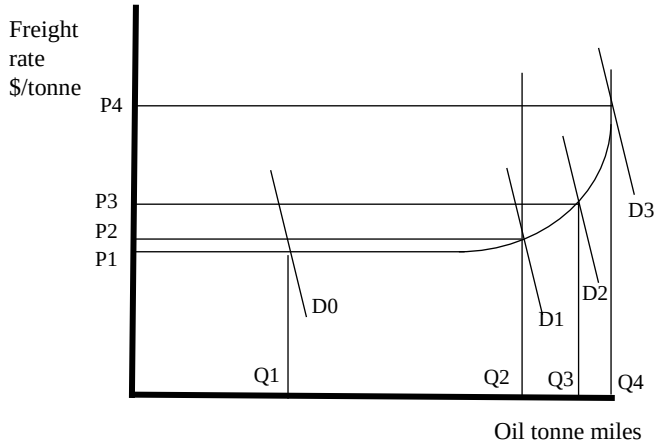
**Figure 1.** Short Run Supply Curve for Shipping Services




**Source:** Glen and Christy (2010; 379).

According to Figure 2, there is an insignificant increase in freight rates from $P_1$ to $P_2$, although there is a very large increase between $D_0$ and $D_1$. Later in the upright, a small increase in the amount causes a large increase in freight, for instance, when there is an increase from $D_2$ to $D_3$, freight rates increase much more from $P_3$ to $P_4$ (Glen and Christy, 2010; 381). This situation is a result of the fixed capacity of the fleet in the short run. Since shipbuilding times can vary between 1 and 4 years on average depending on factors such as ship type, congestion in shipyards, freight market conditions, the supply of new ships to the market remains limited (Tsolakis, 2005). This situation causes the freights to increase very much even with the slight increase in demand. This causes the freight markets to follow continuous cycles and be very volatile (Stopford, 2009; 104). Although these volatilities may seem like a disadvantage, they also provide important profit opportunities for ship owners.

**Figure 2.** Modeling Shipping Demand and Supply in the Short Run



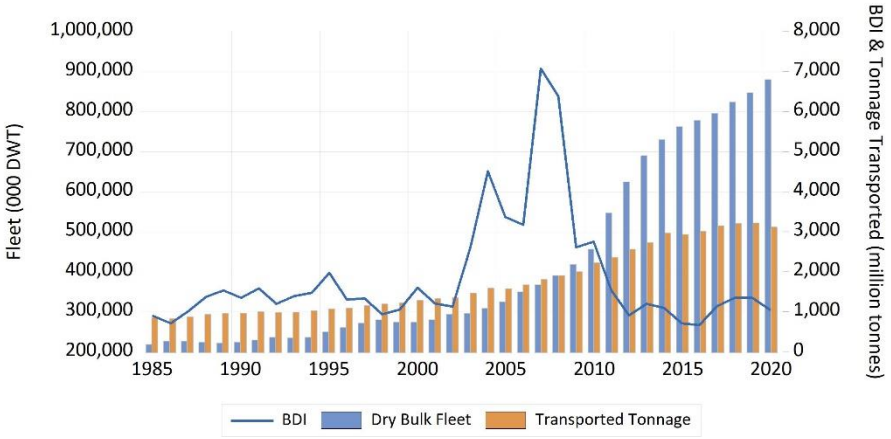

**Source:** Glen and Christy (2010; 381).

Due to this inelastic supply curve, there is an increase in freight rates in case of demand increase. At this point, it is inevitable that this increase in demand will also increase the transportation productivity of the fleet. In addition, ship owners who wish to benefit more from higher freight rates increase their voyage speeds, since lower speed means less cargo is delivered (Stopford, 2009; 244). This further increases the amount of cargo carried per unit time per dwt since the bunker cost from the speed increase may be lower than the freight income from carrying more cargo. According to all these, it is quite natural that there is a positive relationship between fleet productivity and freight rates.

The graphical representation of the dataset used in the analysis is presented in Figure 3 and was thought to facilitate the understanding of the above-mentioned relationship. The graph includes the fleet, the tonnage carried and the BDI variables. When the tonnage carried is considered as demand, it is clearly seen how the difference between

the supply (fleet) and demand has been opened after 2008. Of course, many factors affect freight rates, however this difference between supply and demand has also caused a sudden collapse in freight rates due to the oversupply in the market. This difference is also mathematically indicative of a decrease in the amount of cargo carried per dwt (productivity). Hence, a positive relationship between fleet productivity and freight rates is inevitable. However, no study employing empirical test for this relationship has spotted in the literature. This lack has also generated the motivation for this study. There are studies that indirectly support this relationship rather than directly modeling the issue. A limited number of studies have been conducted that have identified a positive relationship between world GDP and freight rates (e.g. Başer and Açık, 2019; Akbulaev and Bayramli, 2020; Michail, 2020; Özer et al., 2020; Efes, 2021), and a positive relationship between freight rates and ship speed (Wen et al., 2017; Açık, 2021). In both cases, productivity will increase as freights increase due to higher demand and ship speeds increase due to higher freight rates. Therefore, the relationship between freight rates and productivity is inevitable.

**Figure 3.** Transported Tonnage, Dry Bulk Fleet and BDI Variables




**Source:** UNCTAD (2021); Bloomberg (2021).

The fleet productivity can be tracked in several ways. Some of these measurements are ton-miles performed per dwt and tonnage carried per dwt. For the fleet productivity measurement in this study, the total amount of dry bulk cargo carried in the world and the dry bulk fleet volume variables were used due to the data limitation. The cargo carried was divided into the fleet volume and the amount of cargo carried per dwt was obtained, and so the fleet productivity variable was generated. For freight rates, BDI variable, which has become one of the primary indicators on the cost of shipping in the world since its establishment (Lin and Sim, 2013) and has reflected the changes in dry bulk freight transport as a component indicator (Angelopoulos, 2017), was used. In the model established, other factors affecting the freight rates were assumed to be fixed in order to be able to see the relationship between the two variables clearly. As a result of the research, the relationship between freight rates and fleet productivity was empirically tested and the positive relationship was confirmed. Thus, the relationship, which has been theoretically discussed many times in the literature, has been empirically tested and verified. As a result, it is recommended that fleet expansion policies be at a more sustainable level for both ship and cargo owners, as the difference between demand and supply growth rates directly affects fleet productivity and hence transport costs.

The remainder of the study was organized as follows; the methods used in the study were introduced in section two; the results obtained from the analysis were presented in section three; then lastly, the findings were interpreted and discussed in the conclusion section.

## 2. Methodology

The methodology used in the study consist of two methods; correlation analysis and regression analysis. Correlation analysis was used to determine the direction and strength of the relationship, and a regression analysis was used to determine the causal relationship. Both methods are briefly introduced in the following sections. The method section should be added here, after that subsections (second and third level headings), if any, should be included.

### 2.1. Correlation Analysis

Correlation analysis helps us determine the degree of the relationship between two or more variables (Sharma, 2005:3). The correlation does not show causality but shows the direction and strength of the movements of the variables. Correlation coefficients range between 1 and -1, and coefficients equal to 1 or -1 means that data points lying exactly on a straight line (Chang, 2014; 78). Two methods are used for correlation calculations; Pearson's correlation and Spearman's correlation. While the two methods give similar results, their use varies according to the distribution of the variables. Pearson correlation coefficient assumes that the data are normally distributed while Spearman correlation can be used in circumstances where data investigation is not normally distributed (Osborne, 2008; 39).

Evaluation of the correlation analysis depends on the degree and direction of the correlation coefficient. The closer the absolute value of the correlation coefficient is to 1, the stronger the relationship. Generally, correlation coefficients are classified into 5 groups; the coefficient between 0.00-0.20 is called very weak; the coefficient between 0.20-0.40 is called weak; the coefficient between 0.40-0.60 is called moderate; the coefficient between 0.60-0.80 is called strong; and lastly, the coefficient between 0.80-1.00 is called very strong (Soh, 2016; 40).

Although correlation analysis is simple, it is a useful method and has been used as a research method in some studies dealing with the BDI variable. When the correlation analyzes about the BDI are examined in the literature, several studies are found in which different factors are examined as indicated in Table 1.

**Table 1.** Correlation Analysis used with BDI

| Authors | Variables Associated with the BDI | Findings |
|---|---|---|
| Ruan, et al. (2016) | Crude oil prices | Cross-correlations between BDI and crude oil prices are significantly multifractal. |
| Kärrlander, (2010) | MSCI metals and mining index | There is a statistically significant correlation between BDI and the MSCI metals and mining index. |
| Xiong and Hu (2021) | Chinese soybean prices | There is a very low correlation between BDI and Chinese soybean prices. |
| Derindere Köseoğlu, (2011) | GDP | There is a positive correlation between BDI and world GDP between the years of 1986 and 2008. |
| Bakshi, et al. (2011) | Global stock returns, commodity returns, and industrial production growth | There is a significant relation between BDI and subsequent global stock returns, commodity returns, and industrial production growth. |

Correlation analysis is a useful method; however, it is insufficient to explain how much a change in one variable causes a change in another variable. One of the most basic methods to answer this question is regression analysis. Therefore, we preferred regression analysis in addition to correlation analysis in the research.

### 2.2. Regression Analysis

Regression analysis aimed at discovering how one or more variables affect other variables. The affected variables are called dependent or response variables while affecting variables are called independent variables, predictor variables or regressors (Sen and Srivastava, 1990; 1). Regression analysis allows researchers to quantify how the average of one variable systematically varies according to the levels of another variable (Gordon, 2015; 5).

The following equation (1) shows the contents of a simple linear regression. The dependent variable is represented by $Y_t$, while independent variable represented by xi. $\beta_0$ and $\beta_1$ variables are the coefficients of the equation. $\beta_1$ gives the slope of the regression line, and if it is positive, it indicates a relation in the same direction, otherwise it indicates a relation in the opposite direction. The part unexplained in the model is aggregated into $\epsilon_t$ and forms the error terms of the model. Error terms are important for the process of developing consistent and unbiased regression models. So that after the model is estimated, there are many tests on the error terms.

$$y_t = \beta_0 + \beta_1 x_t + \epsilon_t \quad (1)$$

## 3. Findings and Results

Descriptive statistics of the data used in the study are presented in Table 2. The first two columns of the table belong to the "loaded tonnage" and "fleet" values used in the productivity calculation. Loaded cargo tonnage is divided by the total fleet to reach transported ton value per dwt during the year. That is, equation (2) was used and the productivity value (ton per dwt) was obtained.

$$Productivity = \frac{Transported\ Cargo}{Fleet} \quad (2)$$

The descriptive statistics of the Baltic Dry Index, another variable used in the study, are also included in the table. The BDI and productivity variables were used in econometric analysis in the direction of the study, so logarithms were taken in advance. Taking logarithms of the variables makes discrete data continuous and facilitates processing of the data. Then, the unit root test was performed on logarithmic variables and the results are presented in Table 3.

**Table 2.** Descriptive Statistics for Raw and Converted Data

| | Loaded (Million tons) | Fleet (000 dwt) | BDI | Prod |
|---|---|---|---|---|
| Observations | 36 | 36 | 36 | 36 |
| Mean | 1742.389 | 1742.389 | 1855.269 | 4.322947 |
| Median | 1413.500 | 1413.500 | 1352.720 | 4.302556 |
| Maximum | 3218.000 | 3218.000 | 7070.256 | 5.136999 |
| Minimum | 834.0000 | 834.0000 | 673.1200 | 3.545880 |
| Std. Dev. | 826.5914 | 826.5914 | 1458.558 | 0.412472 |
| Skewness | 0.655624 | 0.655624 | 2.331261 | 0.176528 |
| Kurtosis | 1.908704 | 1.908704 | 8.004411 | 2.084102 |
| Jarque-Bera | 4.365447 | 4.365447 | 70.17486 | 1.445277 |
| Probability | 0.112734 | 0.112734 | 0.000000 | 0.485470 |

**Source:** Bloomberg (2021); UNCTAD (2021).

In the time series analyzes, deviations and inconsistencies arise in estimates in the case of the series containing the unit root. For this reason, the Augmented Dickey-Fuller (Dickey and Fuller, 1969) unit root and KPSS (Kwiatkowski et al., 1992) stationarity tests were applied to BDI and productivity variables and the results are presented in Table 2. According to the ADF test, the unit root null hypothesis was rejected at the level for both variables. The KPSS test was also applied as a supporting test and the null hypothesis of the test indicates that the series are stationary. The results show that the null hypothesis is accepted, and, unlike the ADF test, the series are stationary in level. Since difference taking operations in series can cause loss of information, we hereby decided that the series are stationary based on the results of the KPSS test. Therefore, the series are I (0). After this phase, correlation analysis was started to determine the directional relationship between the variables.

**Table 3.** Unit Root and Stationarity Test Results

| | | Level | | First Difference | |
|---|---|---|---|---|---|
| Test | Variable | Intercept | Intercept & Trend | Intercept | Intercept & Trend |
| ADF | BDI | -2.09 | -2.01 | -2.84* | -2.84 |
| | Prod. | -0.78 | -0.79 | -5.00*** | -5.96*** |
| KPSS | BDI | 0.13* | 0.12** | 0.10* | 0.04 |
| | Prod. | 0.19* | 0.19*** | 0.45** | 0.08* |

ADF CVs -3.65 for ***1%, -2.95 for **5%, -2.62 for *10% at Intercept, -4.27 for ***1%, -3.56 for **5%, -3.21 for *10% at Trend & Intercept. Schwarz automatic lag selection was used at maximum 3 lags. KPSS CVs 0.74 for ***1%, 0.46 for **5%, 0.35 for *10% at Intercept, 0.22 for ***1%, 0.15 for **5%, 0.12 for *10% at Trend & Intercept. Barlett Kernel spectral estimation method and Newey-West bandwidth were used.

Correlation analysis was used to determine whether there was a directional relationship between the movements of the variables. The different analysis method applied according to the distributions of the variables. When Table 1 was examined, it was determined that both of the Ln BDI variable and the Ln Productivity variables were normally distributed. Thus, Pearson method was more suitable but both Pearson and Spearman analysis methods

were used, and results are presented in Table 4. According to the results, significant strong degree correlations were found between the two variables in the positive direction. But this analysis only shows the direction and strength of the relationship, but not the causal relationship, therefore, a regression model was adopted.

**Table 4.** Results of the Correlation Analysis between Variables

| | Ln BDI | |
|---|---|---|
| | **Pearson** | **Spearman** |
| Ln PRODUCTIVITY | 0. 7929<br>(7.588)<br>0.0000* | 0.7958 (7.664)<br>0.0000* |

Significance levels = * 1%

The regression model of our study was presented below. The BDI, which is the independent variable, represents the revenues of the shipowners, and the dependent variable is the PRODUCTIVITY reflecting the transferred tonnage per dwt in the fleet. The hypothesis we have established is that there is a positive relationship between shipping revenue and productivity. Then, the model was established and predicted this way.

$$LnPRODUCTIVITY_t = Ln\beta_1 + \beta_2 LnBDI_t + \varepsilon_t$$

The results of the estimated regression analysis are presented in Table 5. According to the results, the F statistic indicating the significance of the model is significant at 1% confidence level (0.000003<0.01), and the independent variable BDI is also significant at %1 confidence level. The coefficients of the model show the elasticity of the productivity with respect to the revenue, and according to the results, the 1% increase in the revenue causes an increase of 0.133% in the productivity. R-squared value showing the explanatory power of the model is relatively low, but it is good for the differenced variables used models. The value is 62, which means that 62% of the changes in the dependent variable are explained by the independent variable. On the other hand, this moderate value may be due to the irrelevance of the selected variables, or structural break and outliers in the model may decrease explanatory power. Thus, it is useful to examine some stability tests and graphs from the regression equation.

**Table 5.** Regression Equation Results of Model

| **Dependent Variable: Ln PRODUCTIVITY** | | | | |
|---|---|---|---|---|
| **Variable** | **Coefficient** | **Std. Error** | **t-Statistic** | **Prob.** |
| C | 0.4828 | 0.1290 | 3.7406 | 0.000* |
| Ln BDI | 0.1331 | 0.0175 | 7.5888 | 0.000* |
| R-squared | 0.6287 | F-statistic | | 57.5913 |
| Adjusted R-squared | 0.6178 | Prob (F-statistic) | | 0.000* |

Significance levels = * 1%

We first looked at the actual, fitted, residual graph showing the relationship between the estimated value and the actual value. It was included in the appendix section, and according to the graph, there were small deviations but no big deviation were spotted, which means our model fits well. The second visual we examined is the influence statistics and according to these statistics deviations did not exceed the critical value so much and there were no large deviations that could be solved with the dummy variables. All these graphs are presented in the appendices. All of these tests indicated that the model fitted well satisfactorily.

Some tests are applied to residuals of the model to test the stability of the model in regression estimations. The most important of the conditions that the residuals must provide for the model to be consistent and stable are no autocorrelation, no serial correlation, homoscedasticity and normal distribution. The Ljung & Box (Ljung and Box, 1979) test for autocorrelation was performed and the results are presented in Table 6. The null hypothesis of this test is that there is no autocorrelation in the residuals and according to the results the null hypothesis was rejected in all 16 lags.

**Table 6.** Autocorrelation and Partial Correlation Check for the Residuals of the Model

| **Lags** | **AC** | **PAC** | **Q-Stat** | **Prob** | **Lags** | **AC** | **PAC** | **Q-Stat** | **Prob** |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.709 | 0.709 | 19.649 | 0.000 | 9 | -0.011 | 0.158 | 29.813 | 0.000 |
| 2 | 0.439 | -0.129 | 27.390 | 0.000 | 10 | 0.020 | -0.025 | 29.833 | 0.001 |
| 3 | 0.216 | -0.089 | 29.327 | 0.000 | 11 | 0.085 | 0.100 | 30.227 | 0.001 |
| 4 | 0.077 | -0.011 | 29.581 | 0.000 | 12 | 0.072 | -0.110 | 30.522 | 0.002 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 5 | 0.030 | 0.050 | 29.619 | 0.000 | 13 | -0.063 | -0.208 | 30.759 | 0.004 |
| 6 | -0.006 | -0.046 | 29.621 | 0.000 | 14 | -0.255 | -0.248 | 34.818 | 0.002 |
| 7 | -0.012 | 0.014 | 29.628 | 0.000 | 15 | -0.317 | 0.110 | 41.366 | 0.000 |
| 8 | -0.061 | -0.101 | 29.807 | 0.000 | 16 | -0.365 | -0.208 | 50.459 | 0.000 |

The results of the remaining tests are presented collectively in Table 7. The LM test is used for the serial correlation test and the null hypothesis is that there is no serial correlation. The null hypothesis in our model was rejected according to the F statistic used in small samples. The white test (White, 1980) was used for the heteroscedasticity in the residuals and the null hypothesis of this test is that there is no heteroscedasticity. According to the results the null hypothesis could not be rejected and the residuals were homoscedastic. The final test is the Jarque-Bera test, which tests whether the residuals are normally distributed, and the null hypothesis of this test is that the residuals are normally distributed.

**Table 7.** Robustness Checks for Residuals of the Model

| **Test Name** | | **Results** | | |
|---|---|---|---|---|
| Breusch-Godfrey Serial Correlation LM Test | F-statistic | 27.31832 | Prob. F(2,32) | 0.0000 |
| | Obs*R-squared | 22.70309 | Prob. Chi-Square(2) | 0.0000 |
| Heteroskedasticity Test: White | F-statistic | 0.119089 | Prob. F(3,27) | 0.8881 |
| | Obs*R-squared | 0.257968 | Prob. Chi-Square(3) | 0.8790 |
| | Scaled explained SS | 0.251892 | Prob. Chi-Square(3) | 0.8817 |
| Jarque-Bera Normality Test | Skewness | -0.0840 | Jarque-Bera | 0.0962 |
| | Kurtosis | 3.1893 | Probability | 0.9530 |

According to the results of the tests we applied to the residuals of the model, autocorrelation and serial correlation problems were determined. For this reason, the standard errors were recalculated by re-running the model with the HAC (Newey and West, 1987) covariance estimation method, and the results are presented in Table 8. The new results indicated that there was no change in the significance of the variables in the model, and a 1% change in freight rates causes a 0.13% change in productivity of the fleet.

**Table 8.** Regression Equation Results of Robust Model

| **Dependent Variable: Ln PRODUCTIVITY** | | | | |
|---|---|---|---|---|
| **Variable** | **Coefficient** | **Std. Error** | **t-Statistic** | **Prob.** |
| C | 0.4828 | 0.1449 | 3.3314 | 0.0021* |
| Ln BDI | 0.1331 | 0.0188 | 7.0473 | 0.0000* |
| R-squared | 0.6287 | F-statistic | 57.5913 | 0.000* |
| Adjusted R-squared | 0.6178 | Wald F-stat. | 49.6653 | 0.000* |

Significance levels = * 1%

## 4. Conclusion

The operational behavior of commercial ships is basically shaped by the balance between supply and demand. In cases where the demand is high, the ships may want to increase their work per unit time by increasing their speed since the freights are high. Because in such an environment, the cost incurred by increasing the speed is lower than the gain obtained by carrying more cargoes. Thus, more cargo is carried per unit time. On the other hand, ships rarely sail fully loaded. According to this measurement called the fleet utilization rate, the utilization rates of the ships vary a lot. Especially in recent decades, flexibility in cargo selection has decreased due to the specialization of ships. Ships specialize in certain cargoes to reduce per unit transportation cost. Thus, it is no longer possible to carry cargoes of different types in a single ship type. As a result, the increase in demand can positively change the amount of cargo carried per unit time by affecting both the speed of the ships and the utilization rates of the specialized ships. The increase in demand is felt in the market, reflected in the freights, as maritime transport has a derived demand structure. Thus, the positive relationship between fleet productivity and freight rates is clearly evident when the literature is examined, but no empirically tested study has been spotted. So, in this study it was tried to test the econometric significance of this relationship and it was contributed to the literature by using limited dataset.

The variable obtained from the portion of the total carried dry bulk to the total fleet capacity was used as a productivity variable. The result gave us the amount of dry bulk cargo carried per dwt. For the freight rate variable, the BDI value converted to the annual data is used by taking the average of the daily values of the index. By this

way, the data set was formed by annual observations covering the years 1985 and 2020. For the determination of the econometric relationship, correlation and regression analysis was performed. As a first step in the application, it was determined that the series were stationary according to the implemented unit root analysis. This can be interpreted as the series carry the shocks they are exposed to temporarily and tend to return to their average values in the long run. Then, a positive relationship between the two variables was confirmed according to the obtained results by using econometric analysis. Correlation analysis showed strong positive significant correlations (0.792 and 0.795) between the two variables. Regression analysis showed that the 1% increase in the revenue causes an increase of 0.13% in productivity, and according to the R-squared value, 62% of the changes in the dependent variable (productivity) is explained by the independent variable (freight rate).

In the literature, there is no empirical study that directly examines the relationship between productivity and freight rates. However, in parallel with our results, there are studies confirming the positive relationship between GDP and freight rates. There are studies in this direction for several maritime markets (e.g. Başer and Açık, 2019; Akbulaev and Bayramli, 2020; Michail, 2020; Özer et al., 2020; Efes, 2021). As a simple logic, the increase in economic activities also increases the demand for maritime transport, causing an increase in freight levels. This rise is due to the shortage of supply in the supply-demand balance. In such a case, the utilization rates of the ships increase, and their productivity also increases. On the contrary, as the demand for maritime transportation decreases, ship utilization rates decrease and productivity decreases. In addition, it has been determined in the literature that freight rates positively affect the speed of ships while modeling ship speeds (Wen et al., 2017; Açık, 2021). Of course, such a situation arises with the effect of increasing freight rates after increasing demand. Due to the speeding ships, the cargo carried per unit time increases, and therefore the productivity increases. Our study forms a complementary structure with these studies and deals with the same story from different angle.

It is seen in the research that there is a strong positive relationship between the productivity of the fleet and the freight level in the market. In this case, according to the balance of supply and demand in the market, while the increase in productivity causes the transfer of extra resources from the cargo owners to the ship owners, the decrease in productivity may cause the transfer of extra resources from the ship owners to the cargo owners. Like a zero-sum game, this may cause losses between the parties, depending on market conditions. In this respect, the surplus resources paid also affect the welfare level of society, as they also affect the export and import costs of the countries. As a result, more sustainable implementation of fleet expansion investment policies can contribute to a more predictable freight market condition. This uncertain situation can be brought under control by applying some regulations to the dry bulk market, which is prone to perfectly competitive conditions.

One of the most important limitations of the study is the annual frequency of the data. Better results could be obtained with more frequent data sets. Further studies may examine this relationship in other maritime markets such as liquid bulk and container. In addition, other factors affecting freight rates can be added to the model, and the model can be varied.

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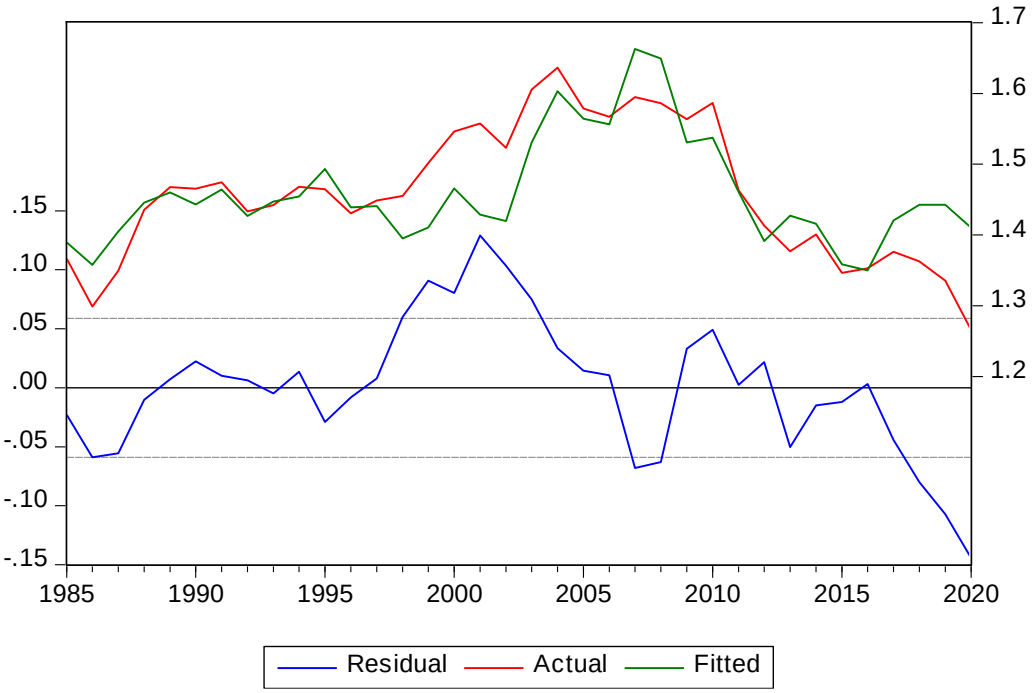
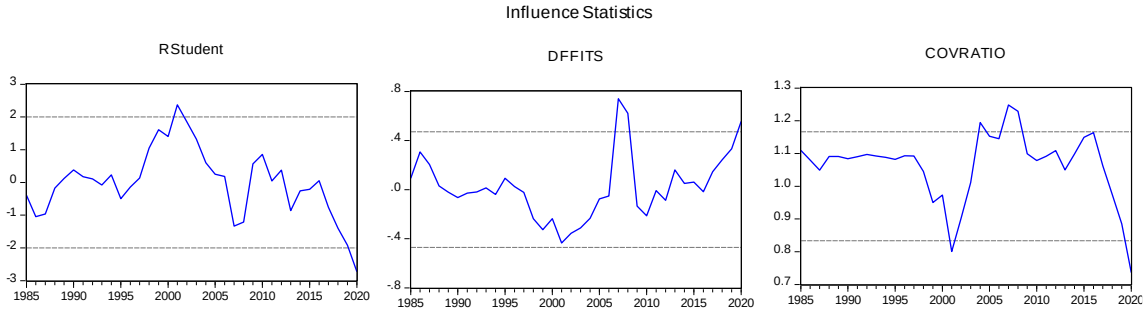
## Appendices

**Appendix 1.** Actual, Fitted and Residual Values of the Model




**Appendix 2.** Influence Statistics of the Model



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# Investigation of Turkish Ports Within the Scope of Port Location Selection and Green Port

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**Abstract**

Ports are closely related to the economy of both the country and the neighbouring countries, especially the region they are located in. Countries whose economic power is based on maritime trade should attach great importance to the selection, construction and development of new ports in order to meet the increasing import and export volume and market demands in the developing and changing world trade with technology. Otherwise, it will be difficult for countries to compete economically in the market, especially in their foreign trade. Climate, raw materials, energy, transport, land, market, strategic situation etc. the selection of a port location to be made by considering the criteria will make great contributions to the development of the regional economy. In addition, it is thought that making the most suitable choices for the environment, considering the concept of a green port, which is still a popular topic, with a proactive environmentalist approach in its construction, will also play a role in encouraging the protection of the ecosystem in which the port is located throughout its lifetime. In this study, Turkey's main ports were examined by using a comprehensive literature review, taking into account the concept of green ports.

## 1. Introduction

From past to present, ports have a very important place in maritime transport. Ports that serve ships carrying cargoes subject to maritime transport are built by making huge infrastructure investments. After a port is built, it carries out its economic activities for many years. One of the most critical processes for the port investments to reach the planned targets is the correct selection of the port location. Since ports are multidimensional structures, there are many and different types of criteria to be considered in site selection.

Port strategy and legal processes, especially the approach to environmental safety and security practices, have been common study topics in this area in recent years (Adams et al., 2009; Canbulat, 2014; .Teerawattana and Yang, 2019).

The aim of this study is to reveal the criteria taken into account in the selection of port location in the literature, to determine the methods used in port location selection and to examine how ports are evaluated in the context of green ports. Thus, it is aimed to contribute to the planning of port facilities, which are planned to be built in the coming periods, as more accurately as possible.

Due to the environmental problems seen recently, more environmentally friendly port activities and the concept of green port have emerged. For this reason, the evaluation of ports within the scope of the concept of green port has been examined in detail under a separate heading from port location selection.

Turkey is a country with a total coastline of 8,333 km. As of 2020, there are 180 port facilities and piers operating under 71 Port Authority in Turkey (DGM Statistics Bulletin, 2020). These facilities are generally located in or near the centers of cities. For this reason, pollution arising from ships and port operations will primarily affect urban life negatively. In addition, they have the potential to cause damage to the ecosystem by causing irreparable

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pollution problems in the seas. Therefore, it is aimed to reduce the negative effects of ports on the environment by taking a proactive approach with the concept of green port and establishing an effective management system that includes the preference of renewable energy and recyclable materials within the scope of sustainable and environmentally friendly development, with an effort to protect nature and reduce pollution. The main components of the green port policy are; ecosystem protection and improvement, reducing emissions affecting air quality in ports, cleaning port and coastal waters, cleaning the port floor, cooperation with stakeholders and organizing necessary trainings, carrying out port site design, management practices and operations, establishing port design, operation and management systems within the scope of sustainability (Türklim, 2013). In this context, in the light of the export and import data provided by the Ministry of Transport, the Ministry of Commerce and the customs directorates, Turkey's important port regions have been evaluated in the context of the choice of port locations and the concept of green ports.

In this part of the study, the selection and importance of the port location and the concept of green port are mentioned and information about the purpose of the study is given. In the second section, the studies on port location selection were compiled and the most important criteria and methods in these studies were tried to be determined. The advantages and disadvantages of the multi-criteria decision methods used in these studies are given. In the third section, information is given about eco-ports, green port policies, environmental improvement targets of important ports in developed countries within the scope of green ports, international legislation on green ports, environmental performance evaluation methods of ports according to the green port concept and green port studies in Turkey. In the fourth section, some important ports of Turkey are evaluated in terms of location selection and green port concept. In the fifth section, it has been concluded that the port area of interest in the port location selection affects the criteria and analysis method to be used, and information about Turkey's position and situation in the academic studies and field applications on green ports in the world. In addition, a port to be built with a general site selection road map, which is tried to be reached in the study, accelerates the economic, infrastructure, superstructure development of the region, country and neighboring countries, as well as sustainability in terms of ecosystem and green harbor as a result of medium and long-term strategies for climate and environment-friendly development. Considering the importance of studies on this subject and the importance of studies on this subject, it is revealed that more contributions should be made to the literature.

## 2. Port Location Selection

Two types of questions arise regarding the location selection of ports: (1) which criteria should be taken as a basis for port location selection? (2) in which methods should the determined criteria be processed and the most suitable port location should be decided? Therefore, in this section, previous studies were compiled to seek answers to both questions, and the criteria and methods that were mostly taken into account were tried to be determined. Since the determined criteria and the chosen method directly affect the decisions taken, it is very important to make these two critical decisions correctly.

### 2.1. Port Location Selection Criteria

The application of multi-criteria analyses is an important development in port site selection studies. Although it contributes a lot, it is focused on the expectations of the senders (Slack, 1985).Port costs are an important criterion for companies in large-volume transportation where it is essential to benefit from economies of scale (Wiegmans et al., 2008).

Various studies have been carried out regarding the selection of port location in different geographies of the world and criteria specific to the region have been determined. For example, Hasanzadeh et al. (2013) determined ecological, economic and social criteria in their study for the location selection of the oil pier in the Persian Gulf. Zavadskas et al. (2015) For port location selection in the East Baltic Sea, access to the port by rail, access to the port by road vehicles, industry interest in the port, space use efficiency, preservation of natural coastal areas, impact of rail access on existing settlements, construction cost, port expansion capacity, ease of access of ships to the port, competition with other ports in the Baltic Sea, storage capacity, port area operational efficiency criteria. In another study, three topographic criteria such as tide level, land use and coastline change were used for port location selection on the Thi Vai river in southeastern Vietnam (Nguyen et al., 2021).

For different regions of Turkey, many studies have been conducted on port location selection for various port types. These studies are listed below in chronological order:
In the study conducted to determine the most suitable place for Ro-Ro transportation on the European Side of

Istanbul, the criteria were taken into consideration such as public benefit, distance from city traffic, environmental compatibility, proximity to loading/unloading points, land transportation connection and total costs (Yıldırım, 2006).

Two factors affecting port location selection; can be expressed as regional and local factors. Regional factors that affect port location selection, proximity to international maritime traffic, (Hinterland), incentives, taxation practices, proximity to energy sources, regional wage policy, integration with other transportation modes, strategic and political situation of the region, if any status of other ports, proximity to the market, expansion possibilities, economic suitability for industrial development and industrial investments, labor force, climate, land costs, etc. can be counted as. As local factors, ground surveys of the region are one of the most important items in the port location selection. In these studies, previous geological findings and maps, geophysical methods and technologies are used. While a soft ground on which dredging can be made is preferred, the bearing capacity of the ground on which the port structures will be built should be sufficient. In terms of marine factors, the current and the associated shallowing possibilities (heels, etc.), tides, tsunami probability, changes in water level (bathymetry) should be evaluated very well. For İstanbul Silivri port, economic factors, transportation opportunities, topographic features of the region, geological and geomorphological factors and mineral deposits of the region were examined as site selection factors (Koldemir, 2008).

The criteria determined for the port location selection for Ro-Ro transportation in the Marmara Region are regional factors (feasibility, future maritime trade potential of the region, land transportation, military reasons, political reasons) and local factors (topography and bathymetry, dredging, wave characteristics, water depth, geological factors, icing, stream, sociological factors, other ports in the region, economic factors, meteorological factors) were evaluated in two categories (Yaran, 2009).

Karaca (2009) used economic feasibility study (establishment location analysis, port hinterland, marketing dimensions, transportation opportunities, geological structure, meteorological situation, traffic demand forecast), technical feasibility study (structures of ports on the sea and land sides, port equipment) and financial feasibility study (port investment cost, port operating cost, net present value criterion, benefit/cost ratio, internal efficiency method) in the selection of port location in her study.

According to the study conducted using the port hinterland, the structural features of the port and the transportation system preference factor, it has been revealed that the Gebze-Derince port area is the most suitable location in terms of combined transportation (Erdem, 2012).

İzmit region came to the fore in the port location selection, which was made considering regional factors (proximity to international maritime traffic, hinterland, incentives, climate, labor supply, land and railway connection) and local factors (bathymetric characteristics, construction costs according to the terrain, prevailing wind). Kavlakçı, 2014).

In another study on ports, regional factors such as economic viability, future maritime trade potential of the region, availability of land transportation, military and political reasons, topographic and bathymetric information, dredging, wave characteristics, tidal wave, tsunami, wind waves, water depth, geological local factors such as factors, icing effect, stream and solids transport along the coast, sociological factors, experiences that can be obtained from other ports and sea structures in the region, economic and meteorological factors with Legal factors such as laws, regulations and communiques regarding the coast, coastal facilities and ports in Turkey have been taken into account (Öner, 2015).

For the container port in Izmir and its vicinity, cost, sustainability, performance and physical conditions has been considered as the main criterion as the factors affecting the establishment location (Özel, 2018).

Cost, sustainability, performance and physical conditions was used as the main criteria in the study on port location selection in the Western Black Sea region (Pekkaya and Bucak 2018).

In the study conducted on the port need in the Kapıdağ Peninsula, geomorphological features, socio-economic status, earthquake risk of the region, road and rail transportation, bathymetric features, climatic features with the status and capacities of the existing ports in the region were taken into account (Erdönmez, 2019).

As in this section, when various studies on port location selection are examined, the criteria most commonly taken as a basis for port location selection are presented in Table 1.

**Table 1.**Port location selection criteria.

| Main Criteria | Sub Criteria | Explanation |
|---|---|---|
| Regional Factor | Proximity to Market | The distribution of the demands in the region according to the services to be provided by the port operators is very important for the effective and economic performance of the services. |
| Regional Factor | Transportation and Transportation Facilities | Transport factors and cost are very important in the cost calculation of services. Therefore, transportation possibilities should be evaluated well in the construction of the port area. In the service cycle of the port, the integration of the highway, airway and railway with its hinterland is extremely important for the goods to reach their exit and departure points. |
| Regional Factor | Labor and Regional Wages | When choosing a port, it is necessary to pay attention to the fact that there are many working days, that it is qualified and cheap. |
| Regional Factor | Expansion Possibilities | Warehouses and stockyards in the port area should be designed to serve handling speeds that may change in the future. |
| Regional Factor | Proximity to Energy Sources and Traffic Nodes (Strategic Situation) | Proximity to energy sources and traffic nodes will make it easier to compete by reducing service time and cost in the port's service cycle. |
| Regional Factor | Incentives, Tax Practices, Investment Suitability, Political and Military Situation, Bureaucratic Practices | The support, exemptions and facilitating practices of the region or country where the port is planned should be analyzed well for the cost and construction process. The political and military conjuncture should be well evaluated in terms of future projections of the port. |
| Local Factor | Climate, Meteorological Situation | The climatic conditions of the region to be established for the construction of the port should be analyzed. (Min-max and average temperature values, wind force, humidity, precipitation, frequency of natural disasters, currents and tides, geophysical condition of the seabed) |
| Local Factor | Ground Properties, Geological Condition, Land Costs etc. | First of all, topographic and bathymetric data should be analyzed well. (The fact that the region is mountainous, the sea is shallow, if there is a current, the possibility of heeling etc.) |
| Local Factor | Marine Factors | In the place where the port will be built, the undercurrent and shallowing situations should be well analyzed against the situations that require high cost such as waves formed by the winds, tides, earthquake waves and tsunami probability, dredging. |

### 2.2. Port Location Selection Methods

In this section, analysis methods used in port location selection are compiled. When various studies are examined, some of the methods used in port location selection are presented in Table 2. When the studies are examined, it is understood that multi-criteria decision-making methods are used almost entirely in port location selection, and these methods are rarely accompanied by geographic information systems.

Due to the advantages that AHP provides to the user, its usage area is seen as a common method. According to Tüminçin (2016), the advantages of AHP are; Because it divides the problem into simple structures, it is easy to understand the content, complex, multi-criteria and multi-person problems can be structured hierarchically, complex problems can be simplify, qualitative and quantitative criteria can be handled together, the consistency of the decision maker's judgments can be tested, consensus can be easily reached and the results obtained can be reliable. determined as high rate. According to Karabacak (2012), the disadvantages of AHP are listed as making it difficult to create comparison matrices if the number of criteria and alternatives is high, requiring a clear definition of criteria, and comparisons taking a long time if the decision maker is a group.

**Table 2.**Methods Used in Port Selection.

| Writer | Subject | Method |
|---|---|---|
| Slack(1985) | Containerization, Inter-Port Competition and Port Selection. Maritime Policy and Management | Deadwood (DW) Survey |
| Yıldırım (2006) | Ro-Ro port location selection for İstanbul | AHP |
| Wiegmans et al., (2008) | Port and Terminal Selection by Deep-Sea Container Operators. Maritime Policy & Management | Decision Making Theory |
| Koldemir(2008) | The Importance of Regional Economy, Coastal Geology and Geomorphology in Selecting a Port Location in the Marmara Region: Silivri Port | Case Study |
| Yaran (2009) | Ro-Ro port location selection in Marmara Region | Analytical Network Process |
| Karaca (2009) | Site selection for ports | Feasibility Studies |
| Hadipour et al. (2012) | Pier site selection in coastal areas | Geographic Information Systems |
| Erdem (2012) | Port location selection for combined transport | Fuzzy AHP |
| Hasanzadeh et al. (2013) | Oil pier site selection in the Persian Gulf | Analytical Network Process |
| Kavlakçı (2014) | Determination of the most suitable port area alternative | Fuzzy AHP / Fuzzy TOPSIS |
| Zavadskas et al. (2015) | Port location selection in the East Baltıc Sea | AHP / ARAS-F |
| Öner, 2015) | Ports and Turkey Practice in Maritime Trade | Feasibility Study and Literature Research |
| Pekkaya and Bucak(2018) | Regional Port Establishment Site Selection with Multi-Criteria Decision-Making Methods: An Application in the Western Black Sea Region | PROMETHEE, TOPSIS and VIKOR |
| Özel (2018) | Determination of container port location around İzmir | VIKOR |
| Erdönmez (2019) | Port Locating Process in New Port Construction: The Case of Kapıdağ | Expert Consultation |
| Nguyen et al. (2021) | Port location selection on the ThiVai river in southeastern Vietnam | Geographic Information Systems / AHP |

The advantages of the TOPSIS method can be listed as follows. It is one of the best ways to indicate the change in rank among alternatives when a non-optimal alternative is proposed. Since it gives the closest result to the positive ideal solution and the farthest to the negative ideal solution, it is based on a logical idea compared to other simple weights. It is an intuitive method that is easy to implement and simple to understand. The method is the best and most successful method in order change. After the evaluation of the distances to the ideal point between the minimum and maximum values that the determined criteria can take, ranking can be realized thanks to the TOPSIS method. The method is a method with increasing or decreasing utility tendency of each criterion among the alternatives. It is used in many areas because it provides an important support to decision makers. The method has some advantages as well as some disadvantages. The effect of uncertainty on decision criteria is an important problem encountered in the decision-making process. In the method, it is necessary to assign an initial weight for each of the criteria. The results obtained in the method can sometimes contradict the basic ideas. If the weights of the criteria are too small, the distance between the criteria and the negative ideal solutions may increase (Kallo, 2015; Özdemir, 2015: 134; Koyuncu ve Özcan, 2014). The ARAS method was developed by Zavadskas and Turskis for the solution of multi-criteria decision making problems. In the method, the optimum values and the utility function values of the decision options are compared (Zavadskas & Turskis, 2010: 159-172; Shariati vd., 2014: 411; Özbek, 2018a:35).

VIKOR can be used to make a decision or rank alternatives in case of conflicting criteria. The decision maker is responsible for approving the final solution. At the same time, they can add their own preferences to the final solution (Kuzu, 2015). The decision maker can also weight the criteria with his own judgment. An initial weight must be assigned for each of the criteria. In addition, it is necessary to know not only the weights of the determined criteria, but also whether they are a benefit or a cost element. The method identifies compromise solutions that help the decision maker reach the final decision in the ranking and selection of alternatives. It gives not only a single ordering, but also the compromise solutions of the orders. The decision maker can see the best alternative or alternatives. It is an easy-to-understand method with simple results, which has been used in many fields in recent years. Feasibility studies are based on the investigation of the project's technical, financial and economic data in

order to determine the economic potential and practical feasibility of a project. Feasibility studies should be done before the final investment decision is made and implementation projects are prepared. Its biggest advantage is to provide predictability and to help final decision makers take the right decision by examining all aspects of an investment idea, by making comprehensive analyzes and evaluations accompanied by relevant data and information. Its disadvantage is that the results it will reveal in an incomplete evaluation have the potential to overshadow advantageous investments and may mislead decision makers.

ANP is a method that helps to model and solve decision problems that cannot be modeled hierarchically. In the ANP method, first of all, a network structure related to the problem should be created. While creating the network structure, the internal and external dependencies between the criteria in the problem should be determined correctly. Then, as in the AHP method, pairwise comparisons and then consistency analyzes are performed. Local priorities obtained as a result of pairwise comparisons are combined in a supermatrix structure to obtain global priorities. By taking many exponents of the supermatrix, the limit supermatrix is obtained and a more effective decision is made than AHP by choosing the alternative with the highest importance weight (Çakın E. 2013).

Geographic Information System (GIS); Complex social, economic, environmental etc. on the world. It is a set of hardware, software, personnel, geographical data and methods that perform the functions of collecting, storing, processing, managing, spatial analysis, querying and presenting large volumes of geographic data to assist users in decision-making processes based on space/location for the solution of problems. With Geographical Information Systems, studies are carried out on database creation, querying, statistical and geographical analysis and their display. In addition to these studies, the advantages of Geographic Information Systems are; to reveal spatial and other spatial information in a holistic way in a single system, to include the most appropriate structure for querying and analysis of geographic information, by creating maps and spatial information in digital form. To provide diversity in extracting and displaying new and complex data from existing information (Ünaldık 2019).

## 3. Green Port

Eco-ports have become the main environmental initiative of the European port sector to address current environmental challenges. The overall aim of eco-ports is to raise awareness of environmental challenges, ensure regulatory compliance and set a high environmental management standard (Sotiris, 2017). Supporting this situation, port operations, which include environmental approaches, have been at the forefront in the policy determination processes. In addition to institutions that take an active role in determining policies such as governments, international or national organizations, maritime companies, like port owners and shipowners, are eager to make their organizations environmentally friendly "green port" (Canbulat, 2014).

The main components of the green port policy are as follows: improving air quality, improvement of energy consumption, noise pollution, deep dredging (seabed celaning and deepening), improvement of water quality, compliance and cooperation with local administrators, optimization of port development, disposal and recycling of waste from ships, planning of port waste management and dust pollution in port (Köseoğlu ve Solmaz, 2019).

Green port practices that emerge within the scope of sustainable and environmentally friendly development are based on volunteerism. With this policy, it is aimed to reduce the negative effects of ports on the environment by establishing an effective management system that includes the preference of renewable energy and recyclable materials, with an effort to protect nature and reduce pollution. The main components of the green port policy are; ecosystem protection and improvement, reducing emissions affecting air quality in ports, cleaning port and coastal waters, cleaning the port floor, cooperation with stakeholders and organizing necessary trainings, carrying out port site design, management practices and operations, establishing port design, operation and management systems within the scope of sustainability (Turklim, 2013).

It is possible to see the applications of green ports in the ports of the developed world. For example, the Port of Rotterdam is one of the largest port operators in the world in terms of annual handling capacity. It is the port that started the first concrete studies against exhaust gas emissions in 2007. In order to combat climate change, the Rotterdam Climate Initiative has established the Rotterdam Climate Initiative-RCI. Goals; To reduce CO2 emissions to half of 1990 levels by 2025, prepare for climate change and strengthen Rotterdam's economy. Another example is the Port of Amsterdam, which started to use wind and solar energy in order to prevent air pollution and save energy, and built biodiesel facilities in the port areas. In the Port of Hamburg, on the other hand, in 2011, the vehicles carrying the port personnel were converted to electric vehicles instead of diesel, and they set successful

examples in terms of carbon emissions and energy efficiency. It has been reported that they aim to convert all diesel-powered port equipment to electric motors in order to reduce carbon emissions by 40% by 2020 (Turklim, 2013). At the point reached today, exhaust emissions still exist as an environmental threat. Today, a significant part of port equipment (MHC, RTG, etc.) is powered by electricity. However, the exhausts of land vehicles coming to the port to take cargo continue to affect the air quality (Turklim, 2021).

### 3.1. Current International Legislations Regarding Green Port

Policies should protect and improve the marine ecosystem, reduce the emission intensity and values in the air, ensure the cleanliness of ports and coasts and spread awareness on green practices and approach, design, manage and operate port areas with the idea of being green, as well as reducing the negative impacts on the environment. and reducing energy consumption by increasing the use of renewable and environmentally friendly energy sources (Ateş and Akın, 2014; Anastasopouos et al., 2011; Türklim, 2013).

The expected impact from the Horizon 2020 tender is to achieve zero emission port operations by 2030. Accelerating the delivery of sustainable alternative fuels and electro-mobility in transport, energy storage, waste heat recovery in ports, promoting clean energy on-site, fuel production and distribution (especially clean hydrogen and electricity), as well as refueling and recharging possibilities. There are alternatives for fuel supply. These applications will also help improve energy-efficient and smart port operations, eco & smart logistics, low-emission intermodal integration, and reduce emissions impact for cities while improving cooperation with ports. All these results will enable ports and cities to commit and contribute to innovative solutions, including the development of follow-up actions (Görgün and Bardakçı, 2020).

The Green Deal Communication advocates rail and inland waterways as sustainable modes of transport for transport. It was also emphasized in the Green Agreement that sea and short-distance sea transport can be as effective as rail and inland waterways in providing an alternative to road transport (Bedük F., Aydın M. E., 2012).

On the other hand, some technical studies related to the use of electricity, which have an important share as much as air pollution minimization and waste management policy in the green port establishment, are handled within the scope of eco-ports. As a matter of fact, cold-ironing is one of the applications that increase the air quality and reduce noise pollution in ports, but the lack of international standards and the use of different voltages and frequencies in the electricity supply systems of different countries create limitations in the use of this technology (Turklim, 2021). Therefore, the electricity supply network is one of the most important green port establishment criteria in the technological context. In addition, the use of LED lighting system in port equipment, the use of renewable energy resources such as solar energy, hydraulic energy, biomass, geothermal energy, tidal energy, wind energy and hydrogen energy are important technical details for the green port establishment.

By supporting the growth of the transportation sector as of 2050, the European Union has stated among its priority targets to reduce CO2 emissions from ships by 40%. An action plan has been created within the scope of the EU twinning project for the control of ship-sourced emissions in Turkey. The "Climate Change Action Plan, CCAP" aiming to reduce carbon dioxide emissions was accepted. Within the scope of CCAP, it is envisaged to increase the use of "alternative fuel and clean vehicles" until 2023, and to make legal arrangements that encourage foreign-flagged cargo and passenger ships using our ports to reduce their emission (Şenol S., 2020). Table 3 lists the international legislation regarding green port policies.

### 3.2. Environmental Performance Evaluation Methods of Ports in Accordance with The Green Port Concept

In the review article, which was prepared quite comprehensively on the studies on the green port in the world, qualitative analysis methods were used in 53% of the studies, mathematical analysis methods in 18%, statistical methods in 9%, multi-criteria decision-making methods in 8%, fuzzy logic methods in 6% and simulation in the remaining 6% methods have been used. Most of the studies were carried out for Turkish ports. These methods used are bibliographic research, fuzzy AHP, fuzzy DEMATEL, fuzzy logic, entropy analysis, factor analysis, content analysis, statistical analysis, mixed methods, literature research, mathematical calculations, panel data analysis, simulation, SWOT analysis, case analysis, data envelopment. are face-to-face studies. Green port criteria are air pollution, water pollution, soil pollution, noise pollution, sustainability, waste management and disposal, energy management, dust and odor management, cold ironing and slow steaming, incentive and penalty practices in port fees, modal shift and intermodality, dangerous making an emergency plan for loads, use of automation

systems, compliance with the legislation and participation in social responsibility projects, providing environmental awareness training to employees, taking OHS precautions, designing green ports and ships, monitoring environmental quality, paying attention to professional competence and making financial liability insurance. (Keske et al, 2020).

**Table 3.** Legislations ensuring the development of green port policy (Turklim, 2013; Köseoğlu and Solmaz, 2019).

| International Legislation | Purpose |
|---|---|
| 1949, Coast Protection Act | To allow and control sea-related works in waters suitable for maritime transport. |
| 1964, Harbours Act | Providing management for the sustainable development of ports, providing financial support for maintenance-repair and improvement. |
| 1972, London Convention | Convention on the prevention of pollution of the seas by wastes and harmful substances. |
| 1973/1978MARPOL, International Convention on the prevention of pollution from ships | Prevention of operational and accidental pollution in the seas. It includes rules for the control of petroleum, bulk toxic liquids, packaged toxic liquids, ship-derived waste, wastewater and chimney emissions. |
| 1987, Dangerous Goods Regulation in Ports | It includes regulations to control the transport, loading, unloading and storage activities of all dangerous goods. |
| 1990, Environmental Protection Act (EPA.) | To establish legal regulations for waste management and emission control. |
| 1992, Transport and Work Act, (TWA) | In addition to the 1964 Port Act legislation, it includes regulations that emphasize environmental problems and impose responsibilities on port authorities. |
| 2001, European Eco-Management and Audit Program, (EMAS). | It includes regulations for developing policies to improve and support the environmental and financial situations of businesses. |
| 2004, Environmental Management System Standard ISO14001:2004. | It includes regulations within the scope of effective use of natural resources, Reduction of damage to the environment and reduction of wastes arising from production. |
| 2012, ESPO Green guide (European Sea ports organisation) | Guidance on green port practices to member states, port stakeholders and managers, and the public. |
| 2015, ISO14001:2015 | An updated version of the environmental management system within the scope of changing and developing dynamics. |

### 3.3. Green Port Efforts in Turkey

These facilities are generally located in or near the centres of cities. For this reason, pollution arising from ships and port operations will primarily affect urban life negatively. In addition, they can cause serious pollution problems in the seas that are difficult to compensate and cause damage to the ecosystem. Many port facilities in Turkey are located close to the city centre. Accordingly, the impact of the port on the city (traffic density, exhaust emissions, noise, etc.) brings the people of the city and the ports face to face from time to time. Sea and air quality may decrease due to activities originating from ships and ports. In order to minimize this environmental risk, the ports take a series of precautions during both investment and operation phases.

Before mentioning the green port, practices operating in Turkey, it would be appropriate to give information about the locations and current status of the ports in Turkey. As of 2021, there are a total of 206 coastal facilities serving coastal facilities in Turkey. Although the forms and features of these facilities are different from each other, the service purpose is determined according to their features. 44% (90 units) of these facilities continue their activities in the Marmara region, 24% (50 units) in the Mediterranean region, 18% (36 units) in the Black Sea region and finally 14% (28 units) in the Aegean region is doing. If we need to specify the ports that serve maritime trade on a provincial basis, there are 35 in Kocaeli, 21 in Istanbul, 20 in Hatay, and finally 11 in Izmir. The characteristics, sizes and capacities of these ports are different from each other (Turklim, 2021). The fact that port activities are so intense in Turkey, which has the peninsula feature surrounded by seas on three sides, is of course expected and desirable considering the trade volume. A total of 484.1 million tons of cargo was handled at Turkey's ports in 2019, of which 224.8 million tons were loaded and 259.2 million tons were unloaded (Turklim, 2021). At this point, it is seen how essential it is for ports to operate as green ports. Green port practices, which are both environmentally friendly and contribute to the ports economically in the long run, are currently based on volunteerism in Turkey. Green port applications in Turkey started with the Green port / Eco port cooperation protocol dated 16.12.2014 signed between the General Directorate of Maritime Trade (DTGM) and the Turkish Standards Institute (TSE) within the body of the Ministry of Transport, Maritime Affairs and Communications (UDHB) (TSE, 2014). The protocol is currently still valid. Currently, the current name of the Ministry and the

Directorate officially is the Ministry of Transport and Infrastructure (UAB), the General Directorate of Maritime Affairs.

Esmer et. al. (2010) analyzed the lean and green dimension of a Turkish port through simulation and determined the optimal number of cargo handling equipment. Ateş and Akın (2014) presented the green port legislation and the certification process required for a green port in Turkey. In order for ports in Turkey to have a green port certificate, it is necessary to obtain the ISO 14001 certificate by the Ministry of Transport and Infrastructure of the Republic of Turkey (Bal, 2014).

It is observed that port operators, which are at the top in terms of cargo handling capacity in Turkey, adopt green port practices and are in the process of developing environmentally friendly practices. The ports of Asyaport, Aksaport, Marport, Borusan Lojistik, Ege Ports, Petkim Port, Bodrum Cruise Port, Solventaş Port, Ford Otosan Port, Evyap Port and Kumport, Kuşadası are the ports that are entitled to use the "Green Port" logo and title (IHA, 2015; Koşar Danışman and Özalp, 2015; Akgül, 2017; Satir and Dogan-Saglamtimur, 2018). Green port certificates issued by the Ministry of Transport and Infrastructure in Turkey are valid for five years as of the date of issue and must be renewed every year. Coastal facilities must apply for renewal within the scope of the relevant legislation two months before the expiry of the validity period of their certificates (UAB, 2021)"

12 of the ports located in the Sea of Marmara have a green port certificate (Yakan Dündar, 2020). Other ports should also continue to operate within the scope of green ports. For example, according to the study by Yalılı Kılıç and Adalı (2020), the noise level from ships at the passenger port in Bursa-Mudanya exceeds the green port criteria.

As a result of the work carried out within the scope of carbon footprint and green port in Limaş port operation, it has been seen that the transition to led lighting and the use of E-MHC are applications that are compatible with the green port understanding and increase the environmental quality in the port. Apart from this, for the continuation of the activities in the port with a more environmentally friendly approach; It has been evaluated that renewable energy sources such as solar energy should be used and that electricity and LPG should be used as an alternative to the use of diesel in vehicles other than mobile port cranes (Gültepe Mataracı, 2016).

It is to determine and prioritize the performance factors of green port applications by taking expert opinion with the DEMATEL method in enterprises that have received green port certificate in Istanbul. It has been determined that the most important of these criteria are "Sustainable Environmental Management", "Minimum Pollution" and "Minimizing Waste". On the other hand, it has been determined that the least important criteria are "Reducing Greenhouse Gas Emission", "Reducing Clutter in Transport Movements", "Noise Reduction", "Creating Better Transport Structures", "Managing Pressure in Nature", "Increasing Distribution Efficiency", "Reducing Accidents and Injuries" and "Reducing Land Transport Intensity at an Economical Level" respectively (Korucuk and Memiş, 2019).

As a result of their study, Köseoğlu and Solmaz (2019) identified incompatibilities in some of the criteria for being a green port in Turkey, according to international standards, and presented new regulation proposals for green ports in Turkey, criteria for being a green port and certificates.

## 4. Evaluation of Some Important Ports of Turkey in Terms of Site Selection and Green Port Concept

Aliağa Port has a national and international strategic importance in terms of its geographical location. According to the study, Aliağa Port is located on the route of the ships that organize expeditions between the ports of Turkey on the Mediterranean, Aegean, Marmara and Black Sea coasts in cabotage (domestic trade) transportation; In import, export and transit transportation, its connection with the ports of the Black Sea, Mediterranean and Western European countries, and its connection to the Indian Ocean Road by following the Suez Canal and the Red Sea increases its importance in maritime transportation (EroğluveBozyiğit, 2013). In addition to all these data, the fact that Aliağa Port is located in the center of the city constitutes the biggest negative aspect. The port affects the urban transportation negatively and also causes environmental and noise pollution when evaluated within the scope of green port.

Ambarlı Port, which is the port that handles the most containers in Turkey, is at an important point in terms of having the industrial power of Istanbul behind it and providing nourishing services to the Black Sea ports.

Industrial piers of public and private institutions are located in the Marmara Region, around Ambarlı and in the Gulf of Izmit. This is a factor that improves the location advantage for both Ambarlı and Kocaeli ports. The connection of Trans-European and Pan-European trade routes with Turkey is important for Marmara ports. At the same time, the fact that Haydarpaşa Port cannot be used actively pushes customers to this port. The acquisition of Kumport Port by Cosco Shipping in 2015 also increases the strength of this port in terms of commercial corridors. However, this port puts a heavy load on the Istanbul highway traffic, which is already busy due to its location. Access to Ambarlı Port can only be provided by sea and road. Since a railway infrastructure entering the port area is not available at the port, the connection between the railway and the hinterland, which is extremely important for the ports, could not be provided.

Asyaport Port was built in Tekirdağ to operate a container port and was put into service in 2015. With a depth of 18 meters, a dock of 2010 meters and a capacity of 2.5 million TEU, it is on the scale of world ports. Asyaport was planned and built as an international transit port (as a main port-hub port) (Piber, 2014).One of the important location advantages of the port is that it is in a position to prevent large ships coming from Europe, Africa, America or Arabia from getting stuck in the Bosphorus traffic. At the same time, it is in a position to relieve the possible congestion of Ambarlı Port and the ports in Kocaeli. Turkey's largest commercial and industrial cities such as Istanbul and Kocaeli are also located near the port.

Kocaeli Port is Turkey's industrial and port city due to its location. It includes terminals and industrial piers serving many different freight groups. In addition, being in the Pan-European and Trans-European corridors increases the competitiveness of the port. The shift of industrial establishments from Istanbul to Kocaeli is also a factor that increases the hinterland area. It is the third largest container handling port in Turkey. It connects Anatolia and Istanbul with its coast to the Black Sea and the Sea of Marmara, and its location in the gulf and transit passageways (Bayraktutan and Özbilgin, 2013). However, Kocaeli port is more congested than other ports in terms of road traffic density.

It is at an important point for trade in the Middle East region in the Eastern Mediterranean. With its strong hinterland connections, Mersin International Port is in good connection with the inner parts of the Turkey (Coşkuntuncelve Rad, 2015). Mersin Port is a main port for the industrial and agricultural power of the Eastern Mediterranean region. In addition to being on important sea route routes, Mersin Port is connected to industrialized cities of Turkey and neighboring countries such as Syria, Iraq and Iran by rail and land. According to Merk and Bağış (2013), Mersin Port has given more positive signals in recent years about being a main port, unlike most ports in the Eastern Mediterranean, due to its location. At the same time, it provides service with large capacities in a location very close to ports that are used extensively in international transportation such as Port Said and Haifa ports. This increases the location advantage of Mersin Port. However, besides these advantages, the port also has strategic disadvantages. As a result of the global conjuncture, both the pandemic and the constraints of the price-money system, the economies in the places where there is a marketing opportunity are shrinking. Thus, strategically emerging opportunities are limited by threats.

When Tatvan port is evaluated in terms of green port criteria, the conclusions are as follows: Lake Van is a closed lake, pollutants entering the lake are in a state of continuous accumulation. There may be a mixture of waste oils, domestic and hazardous wastes from the maritime transport of the Ferry Company, which has at least a century of history, into the lake. Pearl mullet, the only endemic fish living in the lake, is consumed as food by people in the basin. Pollutants participating in the food chain can reach people and threaten public health. In this respect, environmental practices should be implemented as soon as possible without wasting any time, and environmental impacts should be managed by creating projects and supports in order to achieve the title of green port (Ilık, 2020).

## 5. Conclusion

When the case studies are examined, it is seen that economic, social and environmental constraints affect the solution. On the other hand, protecting the environment for future generations and efficient use of resources can

be stated as a summary of environmental sustainability. Economic activities should not threaten natural ecosystems with limited resources and capacity. In this context, logistics centres, which save energy and resource use in the location selection model within the scope of green ports, are an important solution alternative for regions disadvantaged in terms of air pollution, traffic congestion and emissions. Thanks to the consolidation and connection of low-emission transport modes to be provided by logistics centres, greenhouse gas emissions caused by transportation and transportation activities will be reduced.

Based on the findings obtained, the criteria that will guide the construction of a new port can be reached from the said port investigations. As a matter of fact, while it cannot be expected that a port will have all the criteria at the same time, all of the port preference criteria have similar importance weights. In particular, the difference between port location, port fees and port infrastructure criteria is around 1.5%. This showed that there is no indispensable criterion for the selection of the main port within the scope of the study, and that all criteria must be found in the main port concept in a relationship. The importance weight of the proximity to the market and hinterland criteria was found to be 23.6%. Because proximity to the market and hinterland are related to how full the ship can leave the port at a point or how close it is to customer or industry needs. This criterion has been found to be the most important port selection criterion in many studies in the literature on port selection and the order of importance of port criteria. Right after this comes the port location criterion. This criterion is a criterion that directly affects the operational cost of the ship. The location of the port must give the ship a minimum deviation from its main course. At the same time, this criterion is closely related to proximity to the market and hinterland. As it can be understood from here, due to the technical and financial extra costs of the green port implementation, as well as the sanction burden of the green port implementation legislation, the location and proximity to the market criteria are much more decisive than ecological factors in the selection of the port establishment location.

On the other hand, when the relevant literature is evaluated; It can be said that there are few studies on which criteria should be considered in order for ports to receive green port certification, and besides, very different criteria are considered in these studies, that is, there is no unity. When this literature is examined in general; it can be said that the criteria of air pollution, water pollution, energy management and waste management come to the fore. It is natural for these criteria to come to the fore, as environmental issues are primarily considered in almost every sector that aims to alleviate the intensity of pollution, which is increasing day by day. In future studies, the potential of ports to be green ports can be evaluated. From this point of view, it can be suggested as a suggestion for ports that do not have green port certification to consider successful green port examples as role models. In addition, it can be said that the use of Multi-Criteria Decision Making (AHP, VIKOR, TOPSIS, ELECTRE etc.) techniques will give more accurate results, since it is a subject that requires consideration of both numerical and non-numerical criteria for studies to evaluate green port performances. In this context, it can be stated as another suggestion that ports should perform benefit, opportunity, cost and risk analysis and this can be resolved by the Analytical Network Process-Benefit, Opportunity, Cost and Risk (ANP-BOCR) method. In addition, the DEMATEL Method, which is frequently used in considering the relationships between the criteria, may be one of the techniques that researchers may prefer. However, it can be stated that the studies are generally published in journals such as "The Asian Journal of Shipping and Logistics, Transportation Research Part" and "Research in Transportation Business & Management" and that researchers may turn to these journals. As a result, the ever-decreasing resources and increasing pollution have brought the concept of sustainability to a more important dimension. The concept of sustainability, which is based on meeting the needs of the present generation without ignoring the needs of future generations, has made the ecological environment a priority and a demanded criterion in almost every sector. Green port and green logistics activities aiming to protect the environment can be given as examples. In this context, when environmental sustainability awareness is considered, the necessity of increasing the number of studies related to it emerges.

"In this study, a heterogeneous expert group consisting of experts from different interests and professions was formed. As a further study, the similar problem is addressed by the Regime Switching Fuzzy Analytical Hierarchy Process (RS-FAHP), which requires several homogeneous groups of experts to determine how results change depending on the perspective of different expert groups. On the other hand, analyzing the port location regardless of the terminal type may be the biggest limitation of the study. In this context, a study has been planned to determine the most suitable port location with its influencing factors, taking into account each terminal type such as container, liquid bulk, dry bulk and passenger."

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