ARAB ACADEMY FOR SCIENCE, TECHNOLOGY AND MARITIME TRANSPORT

College of Engineering and Technology

Construction and Building Engineering Department

PRIORITIZING OF DIFFERENT CRITERIA FOR THE ENHANCEMENT OF PORT RESILIENT INFRASTRUCTURE

By

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DECLARATION

I certify that all the material in this thesis that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this thesis reflect my own personal views, and are not necessarily endorsed by the University.

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Abstract

Port infrastructure systems are facing an increasing number of disruptions such as global trade growth, increasing vessel sizes, the impacts of climate change, shifting demands and new jobs, and new constraints. As a result, this research develops and verifies a port resilient infrastructure decision model based on the decision-makers point of view of different ports in Europe and the Middle East as well as the Advisory Center of the Ports & Logistics which represents the private sector, the aim of the study is to determine the most important criteria that enhance port resilient infrastructure. Thus, the research will help in a better understanding of the port's resilience infrastructure effect on the sustainable prosperity of both social and economic aspects while considering the environmental situation by balancing four major aspects: physical, environmental, economical, and digital. The research used the methodology Analytical Hierarchy Process (AHP) to analyze the model, the necessary data used in AHP was collected using a questionnaire.

The results indicate that there are some variations in views and expectations among the decision-makers in the different ports, where European ports consider that the physical criterion represented in planning and design is the most important criterion for enhancing the resilience of the port's infrastructure, while the ports of the Middle East consider that enhancing the economic criterion represented in the efficient use of resources will enhance the resilience of the port's infrastructure, while the Advisory Center for Ports and Logistics consider (representative of the private sector) that enhancing the digital criterion represented in digital optimization will help strengthen the port's resilient infrastructure. Therefore, the global priorities of all responses were integrated to determine the common global priorities of each of European ports, the ports of the Middle East, and the private sector. The results showed that planning & design, and efficient use of resources is the most important criteria for port resilient infrastructure that can be used in developing port infrastructure strategies and plans. While ecological-friendly infrastructure and technical innovation appear not to have a significant impact on ports' infrastructure resilience.

Also, sensitivity was analyzed to see the extent of the impact increase of the local weights on global priorities. Where the results showed the stability of global priorities in most cases when compared with the initial results, except for some minor effects on the order of global priorities, which can be bypassed, so the results can be considered acceptable.

Based on decision-makers' responses from the questionnaires, the magnitude of benefits (economic, social, and environmental) resulting from the resilient infrastructure projects implemented in the ports are from high to very high. This will encourage stakeholders to invest in this type of projects.

Planning & design has been applied as the most important priority to enhance the port infrastructure resilient on the Aden Container Terminal and compared with the proposal submitted by the Aden Port Authority, where the result of the comparison was our proposal has a larger storage capacity, longer berths, and a greater number of ships compared to the proposal submitted by the Aden Port Authority.

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List of Abbreviations

Symbols	Nomenclatures
ACT	Aden Container Terminal
AECOM	American Engineering Company
AFSCA	Asian Freight and Supply Chain Award
AGVs	Automated Guided Vehicles
AHP	Analytical Hierarchy Process
AI	Artificial Intelligence
AMP	Alternative Marine Power
APP	Adaptive Port Planning
ARMG	Automatic Rail-Mounted Gantry cranes
CFS	Container Freight Station
CHE	Cargoes Handling Equipment
CI	Consistency Index
CIS	Commonwealth of Independent States
CR	Consistency Ratio
DGPS	Differential Global Positioning System
DGNSS	Differential Global Navigation Satellite System
DP	Dubai Ports
DRR	Disaster Risk Reducing
EDI	Electronic Data Interchange
EMS	Environmental Management Systems
ESPO	European Sea Ports Organization
EU	Europe Union
FCD	Floating Car Data
GHGs	Greenhouse Gas
GM	Green Marine
GNSS	Global Navigation Satellite System
GPS	Global Positioning Systems
GRI	Global Reporting Initiative
HDVs	Heavy-Duty Vehicles
ICT	Information and Communication Technologies
IMO	International Maritime Organization
IoT	Internet-of-Things
IPMS	Integrated Ports Management System
ISO	International Organization for Standardization

List of Abbreviations (Cont'd)

Symbols	Nomenclatures
IS	Information Systems
IT	Information Technologies
ITSs	Intelligent Transportation Systems
KPA	Kenya Port Authorities
LPR	Laryngopharyngeal reflux
MCDA	Multi-Criteria Decision Analysis
MPA	Maritime and Port of Singapore Authority
MSL	Mean Sea Level
NIAC	National Infrastructure Advisory Council's
OCR	Optical Character Recognition
OGVs	Ocean-Going Vessels
OSITRAN	Organization Supervisory for investment in infrastructure transport
PIS	Port Infrastructure Systems
PIANC	World Association for Waterborne Transport Infrastructure
PLA	Port of Los Angeles
POLA	Ports & Logistics Advisory
PoR	Port of Rotterdam
PSA	Port of Singapore Authority
RDL	Royal Decree Legislative
RFID	Radio Frequency Identification
RI	Randomized Inconsistency
RTGs	Rubber Tire Gantry cranes
SDGs	Sustainable Development Goals
STS	Ship-To-Shore Cranes
TEUs	Twenty-foot Equivalent Units
TOS	Thoracic outlet syndrome
ULCV	Ultra Large Container Vessels
UNCTAD	United Nations Conference on Trade and Development
UN	United Nations
US	United States
WPSP	World Port Sustainability Program
WLAN	Wireless Local Area Network
YPA	Yemen Ports Authority

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الأكاديمية العربية للعلوم والتكنولوجيا والنقل البحري

كليـــة الهندســـة والتكنولوجيـــــــا

قسم هندسة التشييد والبناء

تحديد أولويات المعايير المختلفة لتعزيز البنية التحتية المرنة للموانئ

إعداد

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الملخص

تواجه أنظمة البنية التحتية للموانئ عدداً متزايداً من الإضطرابات مثل نمو التجارة العالمية، وزيادة أحجام السفن، وتأثيرات تغير المناخ، وتغيير الطلبات والوظائف والقيود الجديدة. نتيجة لذلك، يتم في هذا البحث التحقق من نموذج قرار البنية التحتية المرنة للميناء استنادًا إلى وجهة نظر صانعي القرار في الموانئ المختلفة في أوروبا والشرق الأوسط وكذلك المركز الإستشاري للموانئ والخدمات اللوجستية الذي يمثل القطاع الخاص، هدف الدراسة هو تحديد أهم المعايير التي تعزز البنية التحتية المرنة للميناء. وبالتالي، يساعد هذا البحث في فهم أفضل لتأثير البنية التحتية المرنة للميناء على الإزدهار المستدام للجانبين الإجتماعي والإقتصادي مع مراعاة الوضع البيئي من خلال موازنة أربعة جوانب رئيسية: المادية والبيئية والإقتصادية والرقمية. يتم في البحث إستخدام عملية التسلسل الهرمي التحليلي (AHP) كمنهجية لتحليل البيانات، التي يتم جمعها من أصحاب القرار بالموانئ والقطاعات الخاصة المستهدفة بإستخدام الإستبيان.

وتشير النتائج إلى وجود بعض التباينات في وجهات النظر والتوقعات بين متخذي القرار في الموانئ المختلفة، حيث تركز الموانئ الأوروبية على المعيار المادي المتمثل في التخطيط والتصميم لتعزيز مرونة البنية التحتية للميناء، بينما ترى موانئ الشرق الأوسط أن تعزيز المعيار الإقتصادي المتمثل في الإستخدام الفعال للموارد سيعزز مرونة البنية التحتية للميناء، في حين أعتبر مركز الإستشارات للموانئ واللوجستيات (ممثل القطاع الخاص) أن تعزيز المعيار الرقمي المتمثل في تحسين الرقمنه سيساعد على تعزيز البنية التحتية المرنة للميناء. لذلك، تم تكامل الأولويات العالمية لجميع الإستجابات لتحديد الأولويات العالمية المشتركة لكل من الموانئ الأوروبية وموانئ الشرق الأوسط والقطاع الخاص. أظهرت النتائج أن التخطيط والتصميم والاستخدام الفعال للموارد أهم المعايير للبنية التحتية المرنة للميناء والتي يمكن إستخدامها في تطوير إستراتيجيات وخطط البنية التحتية للموانئ. بينما لا يبدو أن للبنية التحتية الصديقة للبيئة والإبتكار التقني تأثير كبير على مرونة البنية التحتية للموانئ.

أيضاً تم تحليل الحساسية لمعرفة مدى تأثير زيادة الأوزان المحلية على الأولويات العالمية. حيث أظهرت النتائج إستقرار الأولويات العالمية في معظم الحالات عند مقارنتها بالنتائج الأولية، باستثناء بعض الآثار الطفيفة على ترتيب الأولويات العالمية والذي يمكن تجاوزه، لذا يمكن إعتبار ان النتائج مقبولة.

بالإضافة إلى ذلك، فإن مقدار الفوائد (الإقتصادي والإجتماعية والبيئية) الناتجة عن مشاريع البنية التحتية المرنة المنفذة في الموانئ عالية إلى عالية جداً. سيشجع ذلك أصحاب المصلحة على الإستثمار في هذا النوع من المشاريع.

تم تطبيق التخطيط والتصميم كأهم أولوية لتعزيز مرونة البنية التحتية للميناء في محطة حاويات عدن ومقارنة بالمقترح المقدم من هيئة ميناء عدن، حيث كانت نتيجة المقارنة أن إقتراحنا لديه سعة تخزين أكبر، أرصفة أطول، وعدد أكبر من السفن مقارنة بالمقترح المقدم من هيئة ميناء عدن.