

ORGANIZING THE COUNTRY'S DREDGING VESSELS BASED ON DATA MINING TECHNIQUES BASED ON ARTIFICIAL NEURAL NETWORKS AND BAYESIAN NETWORKS IN IBM MODELER SOFTWARE

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Abstract

Dredging is often done by a special floating device called a dredger. The important goals in dredging are usually obtaining more water depth or extracting materials that have special value or use. Consideration of risk management is based on data mining techniques in the IBM Modeler environment. The method used in this research is the quantitative analysis method based on data mining techniques in the IBM Modeler environment. This research is of an exploratory type, and for this reason we do not hypothesize. The information required for this research is obtained by using field techniques, library, Observations and interviews and technical meetings held with experts have been obtained. The main findings of the research for organizing the country's dredging vessels, considering risk management, are as follows: By implementing the results of this study in the Ports and Maritime Organization, the performance of "reducing dredging operation time in various ports (I1)" equals 0.07; "risk control aimed at enhancing security in ports (I2)" equals 0.10; "improving maritime traffic conditions index (I3)" equals 0.06; "allocation based on the number of existing dredgers and their capacity (I4)" equals 0.17; "allocation based on the environmental conditions of the region (I5)" equals 0.07, and "allocation based on reducing the costs of dredging projects in ports (I6)" equals 0.13. These contribute to a 25% improvement in the organization of the country's dredging vessels with risk management considered. Dredging is a relatively costly technique. However, employing suitable and efficient equipment can reduce these costs. Among the main challenges are the allocation of dredgers, the release of toxic substances, and environmental damage.

Keywords: Data Mining Techniques, Artificial Neural Networks, Bayesian Networks, Dredging Vessels, IBM Modeler Software.

INTRODUCTION

Dredging is one of the essential requirements for safe transportation and maritime navigation. In marine environments, the dredging process is often limited to port basins and access channels (Ahmadi, 2022). Early dredging systems consisted of a pile and a large bucket. The pile would anchor the vessel in place, while materials from the seabed were manually collected into the bucket and then moved to the shore or deeper waters (Fatemi-Nejad and Ghiathi, 2021).

Given the complex process of sedimentation and erosion in rivers, and the significant role of river morphology changes in management and dredging projects, there is an urgent need to understand these morphological changes. One way to address this is through river dredging. However, dredged river sections often face immediate challenges of sediment re-accumulation and bed and bank erosion. Therefore, accurate dredging calculations and understanding its effects are essential to minimize these issues (Molakhah and colleagues, 2023).

In other words, dredging is an inevitable action in ports and coastal oil basins, ensuring the safe movement of vessels within basins or access channels. Although dredging is the result of a combination of technical, economic, and environmental factors, economic considerations hold particular importance, often overshadowing technical and specialized issues (Mirzaei and Dezfuli, 2023).

One of the fundamental challenges facing ports is sedimentation in basins, access channels, and changes to the shoreline and seabed after the construction of ports. A primary requirement for accommodating vessels in ports is ensuring the necessary water depth for docks and waterways leading to them. To maintain the required draft depth, periodic dredging of the port basins and their entrances is essential (Radkhah and Igdari, 2021).

Since dredging operations generate suspended particles, the highest concentration—approximately 500 mg/L—occurs near the dredger, creating sediment deposits up to 18 cm thick (Ban & Bebić, 2023). The tidal current pattern during transitions from ebb to flood and vice versa is accompanied by the formation of two vortices upstream and downstream of the breakwater entrance and one vortex at the breakwater entrance itself. Due to the fine-grained nature of these particles, this process results in the transfer of suspended sediments from dredging operations to the inner and outer areas of the basin, leading to sedimentation in these zones. Since the sediment thickness near the breakwater entrance during dredging is less than 2 cm, these sediments are eroded by currents and vortices and transported further away (Fatemi-Nejad and Ghiathi, 2021). Dredging projects, in each phase—excavation, transport, and disposal—impact various forms of marine life due to physical changes to the seabed or the potential release of pollutants. Dredging operations have numerous negative effects on the environment, the most significant of which include (Shoushterizadeh et al., 2018):

This study examines the organization of the country's dredging vessels, considering risk management, using data mining techniques within the IBM Modeler environment.

Theoretical Foundations and Research Background

“Dredgers” are vessels designed for dredging access channels, dock areas, rivers, basins, and coastal waters. Dredging is one of the most crucial activities in the maritime industry. It serves the following purposes (Luter et al., 2021; Chou et al., 2024):

- Facilitating safer navigation by maintaining an adequate distance from the seabed and reducing underwater traffic.
- In some cases, dredging is used to extract oceanic treasures such as shells and mollusks, aiding in the discovery of these fascinating marine species.

- Dredging is an essential requirement for channeling networks of bridges, dams, or other civil engineering structures in water. It removes the necessary volume of underwater mud and other materials, enabling flawless marine construction.
- Dredging is vital for maintaining a pollution-free marine ecosystem. It helps in environmentally friendly disposal of pollutants and harmful sediments without damaging marine life.
- In addition to supporting aquatic flora and fauna, dredging also facilitates recreational activities.

In the case of anchor dredgers, the vessel anchors at the designated location and, using pipes, digs channels up to 20 meters deep and 75 meters in diameter. Through suction power, sand, mud, and silt are drawn into the dredger. On the other hand, in trailing suction hopper dredgers, the excess sediment and silt are returned to the seabed (Kuhbezan, 2020).

Overall, minimizing the environmental impacts of dredging and achieving maximum efficiency in operations requires a focus on environmental parameters. Dredging operations, which are extensive in their geographical scope, have various environmental impacts, including physical, chemical, and physiological effects. The dredging process combines excavating seabed soil and removing or extracting it from the dredged area.

Establishing a risk management protocol within the culture of a maritime organization, using a set of tools and standardized models combined with training, can significantly reduce additional costs over time. Maintaining an archive of organizational history and records allows for better preparation and utilization of past experiences when facing risks in coastal projects. Moreover, by assessing organizational perspectives to gain greater awareness of risks, an organization can better control them, leading to improved planning, policies, and decision-making (Hedayatifar, 2023).

Research Background

A. Domestic Research Background

1. Mirzaei and Dezfuli (2023)

This study compares the technical and economic aspects of various dredging techniques in ports, using Imam Khomeini Port as a case study. Presented at the National Conference on New Approaches to Overcoming Challenges in the Construction Industry, the research examines mechanical and hydraulic dredging techniques in terms of construction and execution management, including costs, time, quality, and necessary machinery and equipment.

2. Sharifi et al. (2022)

This research aims to optimize berth allocation under the consideration of fuel consumption for vessel movement. Terminal managers and shipping lines factor fuel costs into their decisions about vessel allocation operations. The study focuses on Shahid Rajaei Port, providing a mathematical model tailored to its physical and operational characteristics. The model is solved using the Advanced Epsilon Constraint (AEC) method. Due to the complexity

of the proposed mathematical model, the Non-dominated Sorting Genetic Algorithm II (NSGA-II) was also used for solving real-world problems. The results and statistical analyses demonstrate the effectiveness of the proposed multi-objective mathematical optimization model in reducing vessel waiting times and fuel consumption.

3. Afshari and Mirzapour (2022)

This study highlights that, in addition to container vessels commonly addressed in the literature, bulk cargo also constitutes a significant share of international trade. Different types of bulk cargo require different types of vessels, and not all bulk carriers can be serviced at every terminal berth. Therefore, this research develops a mixed-integer programming model to allocate multiple berths to vessels at bulk terminals, aiming to minimize the total costs of waiting time, operations, and berth allocation. Considering the influence of various factors on vessel arrival and service times, these parameters were modeled as triangular fuzzy numbers, and the Jimenez method was used for defuzzification. To validate the model, numerical examples were solved using IBM ILOG CPLEX 12.10 software, and the results were presented.

B. Foreign Research Background

1. Martin et al. (2024)

This study, conducted by the Technical University of Denmark (DTU), analyzed the continuous berth allocation problem with multiple ports using the Adaptive Large Neighborhood Search (ALNS) algorithm.

The key objectives of the continuous berth allocation in Denmark include: constructing multiple ports and reclaiming quay lands; creating pathways for underwater pipelines and cables; and maintaining and improving the waterways of ports and marine channels. The benefits of berth allocation in Denmark's coastal regions include: providing safe access between the sea and ports (access channels), increasing the depth and capacity of port quays, and promoting maritime transportation.

2. Tunçel et al. (2023)

This research, carried out by the Department of Maritime Transportation Engineering and Management at Istanbul Technical University, evaluated the risks associated with anchor dredging for cargo vessels using an extended fuzzy Bow-Tie approach combined with SLIM (Success Likelihood Index Method) and Comprehensive Quantitative Risk Assessment (QRA).

The study highlighted that anchor dredging plays a significant role in Turkey's maritime transport. Over the past three decades, dredging projects for ports, estuaries, and rivers in Turkey have seen significant growth. Utilizing the QRA method to assess risks has improved the quality of anchor dredging operations for cargo vessels.

Key benefits of dredging in Turkey's coastal areas include: enhancing the marine environment, extracting agricultural resources, coastal protection, and land reclamation.

3. Bai et al. (2021)

This research, conducted by the State Key Laboratory of Hydraulic Engineering Simulation and Safety at Tianjin University in China, analyzed the efficiency of trailing suction hopper dredgers (TSHD) using a stacking strategy and the Dredging Project Management Framework (PMFD). The study focused on maintaining existing depths based on sedimentation rates and other influential parameters while creating initial hydrographic maps. The use of TSHDs in China is determined by factors such as regional depths, dredger draft, existing obstacles, seabed composition, and hardness. The key benefits of dredging in China's coastal areas include: increasing the depth and capacity of rivers, lakes, and port basins; filling underwater or onshore pits; and supporting coastal protection and land reclamation

RESEARCH METHODOLOGY

Data mining refers to a set of techniques applied to large and complex databases to discover hidden and interesting patterns within the data. Data mining techniques are typically computationally expensive. The interdisciplinary science of data mining involves tools, methodologies, and theories used to uncover patterns in data, and it is a crucial step in knowledge discovery. There are several reasons why data mining has become such an important area of study (Sadeghian, 2023):

1. Explosive Growth of Data: The rapid growth of data across a wide range of fields in industry and academia is supported by:
 - Cheaper, virtually unlimited storage devices, such as cloud storage.
 - Faster communications with higher connection speeds.
 - Improved database management systems and software support.
2. Rapid Increase in Computational Power: The rapid advancement in computational power facilitates the processing of large datasets.

The method used in this study is quantitative analysis based on data mining techniques in the IBM Modeler environment. This research is exploratory, and as such, it does not focus on hypothesis testing. The required information for this study is collected through field techniques, library research, observations, interviews, and technical sessions held with experts. In operations research, mathematical modeling, particularly mathematical models, is mainly used.

Given the vast and varied nature of available data, data mining techniques help extract information from these datasets. Data mining techniques include a wide range of methods, from regression to complex pattern recognition techniques with high computational costs, rooted in computer science. The primary goal of learning (data mining) techniques is prediction; however, prediction is not the only purpose of data mining. The steps involved in executing the data mining method are as follows (Sadeghian, 2023; Karimizadeh, 2023):

Table 1: steps of implementing the data mining method

Data preparation phase	It is said to be a process that the data specialist seeks to improve the quality and quantity of the primary data in order to clean it from the presence of junk, noisy and outlier data.
Machine learning phase	It is said that a data scientist entrusts the process of analysis and prediction to computers by teaching machine learning algorithms to the computer. The machine learning phase takes place after the data preparation phase. In the suggested courses below, all the preparation and machine learning algorithms have been taught.
Deep learning phase	Deep learning (also known as deep structured learning) is part of a broader family of machine learning techniques based on artificial neural networks.
Text mining phase	It is said to a process that the data under analysis is no longer structured, but unstructured and in the form of text, and a data science specialist with natural language processing algorithms. NLP seeks to extract useful knowledge from text.
Predictive analysis	Predictive analytics includes a variety of statistical techniques from data mining, predictive modeling, and machine learning that analyze current and historical facts to predict future or otherwise unknown events. All the predictive analysis algorithms are taught in the suggested courses below.

Indeed, data mining is one of the ten emerging fields that has brought about a technological revolution in this decade. This field today has a very wide range of applications in various management and industrial domains. Data mining knowledge is the process of discovering hidden knowledge within large datasets, and this is accomplished through algorithms and data mining software (Bashash-Alang and Noori, 2020).

Among these, the IBM Modeler data mining software is one of the leading data mining tools from IBM, widely used in data mining projects. With the features and algorithms provided by IBM Modeler, modeling and conducting data mining tasks are carried out in the most optimal way. Due to its user-friendly nature, ease of use, and time efficiency, IBM Modeler enjoys significant popularity and produces valuable results.

This software supports the entire data mining process within an organization based on the CRISP-DM standard, from start to finish, reducing data preparation and analysis time compared to other software (Sadeghian, 2023).

Data Analysis:

Data Analysis Based on Data Mining Techniques in IBM Modeler

In this study, to extract knowledge from the dataset of dredger fleet management in the country, with risk management in consideration, the first step involved extracting information from the database. The data for this research were based on a thousand-sample set of documents and reports from the Ports and Maritime Organization during the years 2018 to 2023, categorized seasonally.

The extraction of data from multiple sources was carried out after a qualitative case study and expert interviews, leading to the final model, which was based on the data items of the research, specifically:

- “Dredging Operations Management” component, using metrics such as:
 - Rent cost reduction for dredger equipment (V.A1)
 - Reduction in dredging operation costs for dredgers at different ports (V.A2)
 - Maximizing the number of dredging projects carried out by dredger vessels (V.A3)
 - Reducing dredging operation time at different ports (V.A4)
- “Risk Management in Coastal Projects” component, using metrics such as:
 - Reducing risks associated with dredger insurance and certificates (V.Bi)
 - Reducing risks associated with the capacity limitations of dredger vessels (V.Bii)
 - Risk control to improve security at ports (V.Biii)
 - Reducing risks related to maximum permissible wave height (tides) (V.Biv)
- “Traffic Management in Ports” component, using metrics such as:
 - Maintaining balance between dredging plans at ports and different vessels (V.Ca)
 - Applying maritime traffic services based on dredging depth (V.Cb)
 - Traffic control based on the location and purpose of each port (V.Cc)
 - Index of improvement in maritime traffic conditions (V.Cd)
- “Dock Allocation Management in Ports” component, using metrics such as:
 - Allocation based on reducing dredging project costs in ports (V.D1)
 - Allocation based on differences in dredging operation times at each port (V.D2)
 - Allocation based on environmental conditions of the region (V.D3)
 - Allocation based on the number and capacity of available dredgers (V.D4)

Based on the reports and documents of the research, a dataset was created, considering a thousand-sample set for managing dredger fleets in the country with risk management. After determining the type of data and the value ranges of the research variables, it was identified that the data type was executed by defining new attributes through mathematical and logical operations on existing attributes.

Using the data audit section, for managing the dredger fleet in the country with risk management, it was confirmed that the number of valid data based on 24 data points (time series T1 to T24) was in an optimal state. The corrected information in the databases was provided based on an average above 70 for the data items.

Table 2: Corrected information in the database based on average data mining

Data item	Valid Data	Average Data mining	Maximum Data	Minimum Data
Reducing risk related to insurance and dredging certificates (V.Bi)	24	80.583	147	65
Maintaining the balance of dredging plans between ports and different vessels (V.Ca)	24	80.417	147	65
Reducing the cost of dredging operations of dredging vessels in various ports (V.A2)	24	80.167	122	31
Committing dredging costs (V.A1)	24	78.083	121	59
Reducing dredging operation time in different ports (V.A4)	24	76.25	168	31
Allocation according to the environmental conditions of the region (V.D3)	24	75.25	214	31
Traffic control based on the location and type of use of each port (V.Cc)	24	70.75	105	34
Allocation according to the difference in dredging operation time in each port (V.D2)	24	58.917	97	27
Maximizing the number of dredging plans carried out by dredging vessels (V.A3)	24	57.333	80	36
Risk control aimed at increasing security in ports (V.Biii)	24	54.333	97	33
Reducing the risk related to the maximum permissible wave height (tide) (V.Biv)	24	54.167	97	33
Application of marine traffic service based on dredging depth (V.Cb)	24	54.167	97	33
Maritime traffic improvement index (V.Cd)	24	54.167	97	33
Reducing the risk related to the limitation of the capacity of dredging vessels (V.Bii)	24	53.917	77	41
Allocation according to cost reduction of dredging projects in ports (V.D1)	24	48.417	73	27
Allocation according to the number of existing dredges and their capacity (V.D4)	24	48.417	73	27

By analyzing the data auditing section for organizing dredging vessels in the country while considering risk management, it was determined that all research data (24 data items) were 100% valid (24 out of 24 data). The following indicators had the highest average values in the

first phase of the study's data mining process:

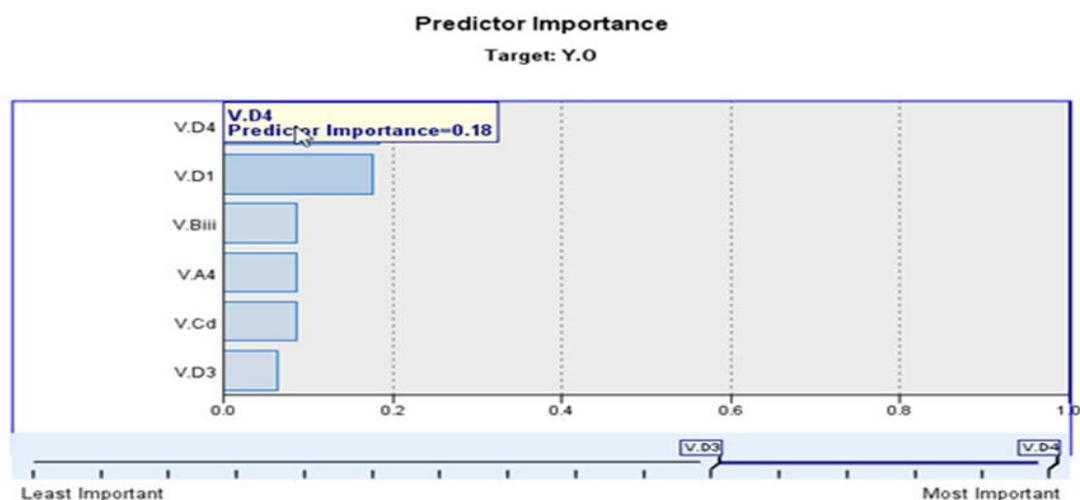
- Reduction of risks related to dredger insurance and certifications (V.Bi) with a data mining average of 81
- Maintaining balance in dredging projects across different ports and vessels (V.Ca) with a data mining average of 80.5
- Reducing the operational costs of dredging vessels in various ports (V.A2) with a data mining average of 80
- Allocation based on regional environmental conditions (V.D3) with a data mining average of 75

Subsequently, to complete the data mining process, IBM Modeler software was utilized with the artificial neural network (ANN) data mining technique to identify patterns in the research execution. In the data partitioning phase, the data were divided into training data (80% of the dataset) and testing data (20% of the dataset). Initially, the training data underwent simulation to determine the optimal model, which was then tested in the second phase:

Field	Value
Partition field:	Partition - Training&Testing
Partitions:	<input checked="" type="radio"/> Train and test <input type="radio"/> Train, test and validation
Training partition size:	80
Testing partition size:	20
Validation partition size:	10
Total size:	100%
Label:	Training
Value:	"1_Training"
Label:	Testing
Value:	"2_Testing"
Label:	Validation
Value:	"3_Validation"

Figure 1: Research data partitioning (Partition)

The output of artificial neural networks (ANN), for more precise analysis in the implementation of the research, is shown in the diagram below.



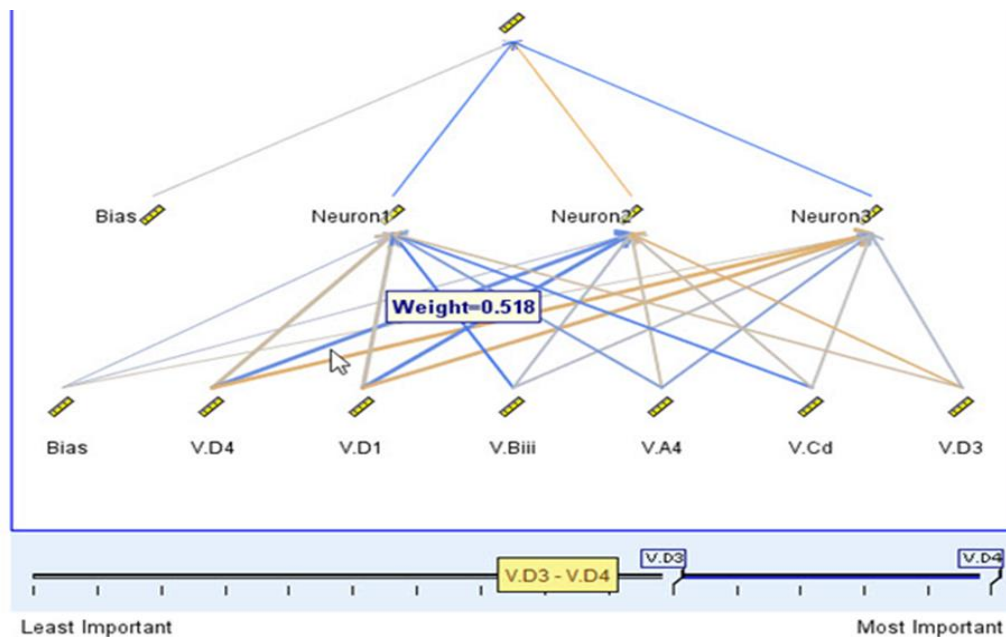


Figure 2: The importance of predictors based on ANN data mining algorithm

By analyzing the output of artificial neural networks for more precise analysis in the implementation of the research, it was determined that the blue colors represent positive estimates in the research model. These correspond to the main predictors of the model, which are:

- Allocation based on the number of available dredgers and their capacity (V.D4) for the component “Port Berth Allocation Management,” with a predictor weight of 0.18;
- Allocation based on reducing dredging project costs in ports (V.D1) for the component “Port Berth Allocation Management,” with a predictor weight of 0.16;
- Risk control aimed at increasing security in ports (V.Biii) for the component “Coastal Project Risk Management,” with a predictor weight of 0.14;
- Reduction of dredging operation time in different ports (V.A4) for the component “Port Dredging Operations Management,” with a predictor weight of 0.13;
- Marine traffic conditions improvement index (V.Cd) for the component “Port Traffic Management,” with a predictor weight of 0.12;
- Allocation based on regional environmental conditions (V.D3) for the component “Port Berth Allocation Management,” with a predictor weight of 0.10.

Through more precise analysis in the execution of the research, utilizing data mining techniques, it was found that these predictors can assist in organizing dredge fleets in the country with a risk management approach, achieving an accuracy rate of over 90%. This was done by applying data mining techniques and modeling the brain’s processing features in the

organization of dredger fleets, approximating common computational methods with biological processing methods.

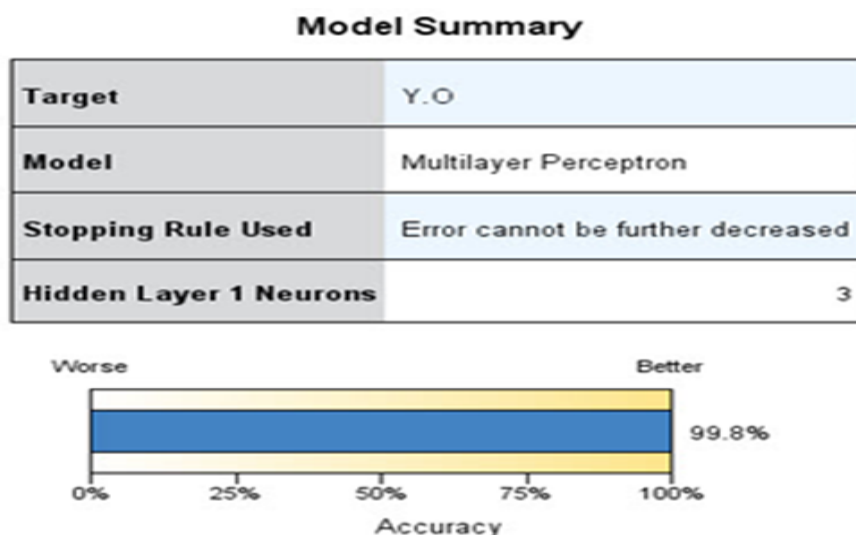
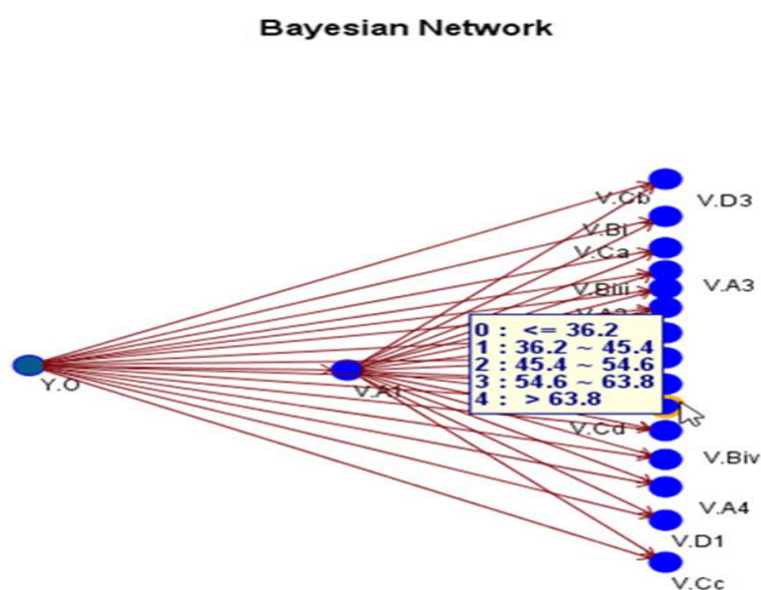


Figure 3: Accuracy information of artificial neural networks (ANN)

Finally, based on the over 90% accuracy in executing the data mining of the research, it was determined that the main predictors in organizing the dredger fleets in the country with a risk management approach are: allocation based on the number of available dredgers and their capacity; allocation based on reducing dredging project costs in ports; increasing security in ports; reducing dredging operation time in different ports; and the marine traffic conditions improvement index. Furthermore, here is the output of the Bayesian Networks (BNN) to infer and estimate the probabilistic relationships between the main variables presented.



**Conditional Probabilities of
V.A4**

Parents		Probability			
V.A1	Y.O	<= 72.1	> 72.1	2	3
<= 90	188	0.00	1.00	0.00	0.00
> 90	195	1.00	0.00	0.00	0.00

**Conditional Probabilities of
V.Biii**

Parents		Probability			
V.A1	Y.O	<= 52.2	> 52.2	2	3
<= 90	188	1.00	0.00	0.00	0.00
> 90	195	0.00	1.00	0.00	0.00

**Conditional Probabilities of
V.Cd**

Parents		Probability			
V.A1	Y.O	<= 52.2	> 52.2	2	3
<= 90	188	1.00	0.00	0.00	0.00
> 90	195	0.00	1.00	0.00	0.00

**Conditional Probabilities of
V.D4**

Parents		Probability				
V.A1	Y.O	<= 36.2	36.2 ~ 45.4	45.4 ~ 54.6	54.6 ~ 63.8	> 63.8
<= 90	188	1.00	0.00	0.00	0.00	0.00
> 90	195	1.00	0.00	0.00	0.00	0.00

Figure 4: Output of Bayesian Networks (BNN)

Based on the Bayesian Network (BNN) calculations, the probabilistic relationships between the main variables have been analyzed, and it can be inferred that:

- The probabilistic relationship between reducing dredging operation time in different ports (V.A4) for the “Port Dredging Operations Management” component and the research objective function (Y.O) was calculated to be 72%.
- The probabilistic relationship between risk control aimed at increasing security in ports (V.Biii) for the “Coastal Project Risk Management” component and the research objective function (Y.O) was determined to be 52%.
- The probabilistic relationship between the marine traffic conditions improvement index (V.Cd) for the “Port Traffic Management” component and the research objective function (Y.O) was calculated to be 52%.
- The probabilistic relationship between allocation based on the number of available dredgers and their capacity (V.D4) for the “Port Allocation Management” component and the research objective function (Y.O) was measured to be 64%.

CONCLUSION

One of the most important results of the present research is the exploration of the position of “Port Allocation Management” in organizing dredging vessels in the country, considering risk management. The “Port Allocation Management” component was determined based on indicators such as: allocation based on reducing dredging project costs in ports; allocation based on the difference in dredging operation time at each port; allocation based on environmental conditions of the region; and allocation based on the number of available dredgers and their capacity.

Specifically, allocation based on the number of available dredgers and their capacity (V.D4) for the “Port Allocation Management” component had a predictive weight of 0.18; allocation based on reducing dredging project costs in ports (V.D1) had a predictive weight of 0.16. The probabilistic relationship between allocation based on the number of available dredgers and their capacity (V.D4) for the “Port Allocation Management” component and the research objective function (Y.O) was measured to be 64%.

Another significant result of the present study is the exploration of the position of the “Coastal Project Risk Management” component in organizing dredging vessels in the country, considering risk management. The “Coastal Project Risk Management” component was determined based on indicators such as: reducing risk related to dredger insurance and certification; reducing risk related to the capacity limitation of dredgers; increasing security in ports; reducing risk related to the maximum allowable wave height (tidal waves).

In fact, risk control aimed at increasing security in ports (V.Biii) for the “Coastal Project Risk Management” component had a predictive weight of 0.14, and the probabilistic relationship between risk control aimed at increasing security in ports (V.Biii) for the “Coastal Project Risk Management” component and the research objective function (Y.O) was determined to be 52%.

Key aspects of this research include determining the indicators for organizing dredging vessels in the country, considering risk management, which include:

- The “Port Dredging Operations Management” component, based on indicators such as: categorizing dredger rental costs; reducing dredging operation costs for dredgers at different ports; maximizing the number of dredging projects performed by dredgers; reducing dredging operation time in different ports.
- The “Coastal Project Risk Management” component, based on indicators such as: reducing risk related to dredger insurance and certification; reducing risk related to the capacity limitation of dredgers; increasing security in ports; reducing risk related to maximum wave height (tidal waves).
- The “Port Traffic Management” component, based on indicators such as: maintaining balance in dredging projects between ports and dredgers; applying maritime traffic services based on dredging depth; controlling traffic based on the location and usage type of each port; marine traffic conditions improvement index.
- The “Port Allocation Management” component, based on indicators such as: allocation based on reducing dredging project costs in ports; allocation based on the difference in dredging operation time at each port; allocation based on environmental conditions of the region; allocation based on the number of available dredgers and their capacity.

Based on the conducted investigations, the major limitations of the study can be attributed to challenges encountered during the work, such as the absence of a similar model for organizing dredging vessels in the country with consideration of risk management.

The study could have been more comprehensive if variables had been analyzed more holistically based on its findings. Other limitations include issues related to research costs and time, and lack of access to more reports and documents from the Ports and Maritime Organization.

Finally, as the research was written based on documents from the Ports and Maritime Organization, another limitation of the study is the inability to generalize the results to other industries.

References

- 1) Jafari Yarki, Tanin, 2023. Risk Management and Value Engineering in Project Management. Publisher: Meyad Andisheh. Year of Publication: 2023.
- 2) Derakhshan, Ali, 2023. Review of Environmental Geotechnical Challenges (Dredging), Seventh International Conference on Applied Research in Science and Engineering.
- 3) Radkhah, Alireza, and Ighadari, Soheil, 2021. Study of the Physical and Ecological Effects of Dredging and Sand Extraction in River Systems, Seventeenth Congress of Soil Science of Iran and Fourth National Conference on Water Management in the Field of Soil Revival and Wise Water Governance, Karaj.
- 4) Sargazi, Sima, Mish Mast Nehi, Hassan, and Ahmadzadeh, Hamed, 2022. Dock Allocation Problem to Minimize Total Ship Service Time Under Uncertainty Conditions, 21st Iranian Fuzzy Systems Conference.

- 5) Sharifi, Sadegh, Hosseini, Seyed Farzad, and Zarei, Hassan, 2022. Docking Allocation Problem in Container Terminals Considering Fuel Consumption of Vessels, Case Study: Shahid Rajaei Port, Iran, Journal of Transportation Engineering, Vol: 13, Issue: 3.
- 6) Shafiei, Omid, 2021. Combining Equipment Allocation Problems and Cost-Time Balance with Multi-Criteria Genetic Algorithm. Publishers: Modares Educational Group (Affiliated with M. F. H. Simaye Golestan Afarinesh), Sanjesh and Danesh. Year of Publication: 2021.
- 7) Azizi, Bahram, 2023. Risk Management in Construction Projects (Principles, Tools, and Applications). Publisher: Raz Nehan. Year of Publication: 2023.
- 8) Fatemi Nejad, Mohammadjavad, and Ghiyasi, Reza, 2021. Study of Sediment Distribution During Dredging of Harbor Basins, Seventh International Conference on Mechanics, Construction, Industry, and Civil Engineering, Tehran.
- 9) Fardani, Mohammad Hossein, 2019. Best Allocation Model in Construction Projects. Publisher: Danesh and Tahqiq Moaser. Year of Publication: 2019.
- 10) Fazlollahi, Mohammadreza, 2020. Impact of Dredging Access Channel on the Performance of Container Ports under Tidal Effects, 11th National Civil Engineering, Architecture, and Urban Development Conference, Babolsar.
- 11) Karimi, Zahra, 2023. Risk in Projects or Risk Management in Projects. Publisher: Sanjesh and Danesh. Year of Publication: 2023.
- 12) Koh-Bazan, Shahin, 2020. Introduction to Dredging Vessels. Publisher: Asar Bartar. Year of Publication: 2020.
- 13) Mola Khah Khalilabad, Mohammad, and Mola Khah Khalilabad, Farzaneh, 2023. Determining Suitable Dredging Locations for Organizing Kordan River Using a Mathematical Model, Third International Conference on Architecture, Civil Engineering, Urbanism, Environment, and Islamic Art Horizons in the Second Revolution Statement, Tabriz.
- 14) Mirzaei Shashjvani, Vahid, and Dezfouli, Abdolkarim, 2023. Technical and Economic Comparison of Various Dredging Techniques in Ports: Case Study of Imam Khomeini Port, National Conference on New Approaches to Overcoming Barriers in the Construction Industry - Special Focus: Civil Engineering (Structures, Geotechnics, and Construction Management), Architecture and Urban Development, Ahvaz.
- 15) Negarestan, Hossein, 2018. Environmental Evaluation of Dredging Material Disposal: Case Study: Dredging Maintenance of Chababar and Amirabad Ports. Publisher: Ports and Maritime Organization. Year of Publication: 2018.
- 16) Hedayatifar, Mohsen, 2023. Techniques and New Methods in Risk Management of Civil Engineering Projects. Publisher: Jihad University of Amir Kabir Industrial University. Year of Publication: 2023.
- 17) Heidari, Mohsen, 2023. Key Success Factors in Firefighting Crisis Management with Structural-Interpretive Modeling for Determining Interactions of Its Factors. Publisher: Azar Barzin. Year of Publication: 2023.
- 18) Bashash Alanq, Ali, and Nasim Noori, 2020. Practical Data Mining Books in Technical and Engineering Fields - Humanities - Basic Sciences: Data Mining in SPSS Software (Volume 3). Publisher: Salehiyan. Year of Publication: 2020.
- 19) Danamzar'e, Hassan, and Kourosh Parand, 2023. Metaheuristic Algorithms with Emphasis on Genetic Algorithm. Publisher: Aron. Year of Publication: 2023.
- 20) Ghahramaninehr, Javid, and Paria Samadi Parvinenjad, 2023. Metaheuristic Algorithms in Solving Optimization Problems. Publisher: Pourhossein. Year of Publication: 2023.

- 21) Chou, Jui-Sheng, et al. 2024. Deep learning-based chatbot by natural language processing for supportive risk management in river dredging projects. *Engineering Applications of Artificial Intelligence* 12 January 2024
- 22) Guo, Liming, et al. 2023. Column generation for the multi-port berth allocation problem with port cooperation stability. *Transportation Research Part B: Methodological* 14 March 2023
- 23) Lin, Bowen, et al. 2024. A novel method for the evaluation of ship berthing risk using Automatic Identification System (AIS) data. *Ocean Engineering*. Volume 293, 1 February 2024, 116595
- 24) Luter, Heidi M. et al. 2021. Assessing the risk of light reduction from natural sediment resuspension events and dredging activities in an inshore turbid reef environment. *Marine Pollution Bulletin* 11 June 2021
- 25) Lv, Yaqiong, et al. 2024. Dynamic berth allocation under uncertainties based on deep reinforcement learning towards resilient ports. *Ocean & Coastal Management* 28 March 2024
- 26) Martin-iradi, Bernardo, et al. 2024. An adaptive large neighborhood search heuristic for the multi-port continuous berth allocation problem. *European Journal of Operational Research* 6 February 2024
- 27) Tunçel, Ahmet Lutfi, et al. 2023. An extended fuzzy bow-tie approach with SLIM to assess risk for anchor dredging in cargo ships. *Ocean Engineering* 4 July 2023
- 28) Vijayan, K. et al. 2021. Shock transmission through universal joint of cutter suction dredger. *Ocean Engineering* 21 May 2021