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“Shaping the Next Generation of Port Industry Through Technology And Automation ”

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Provost
Regional Maritime University

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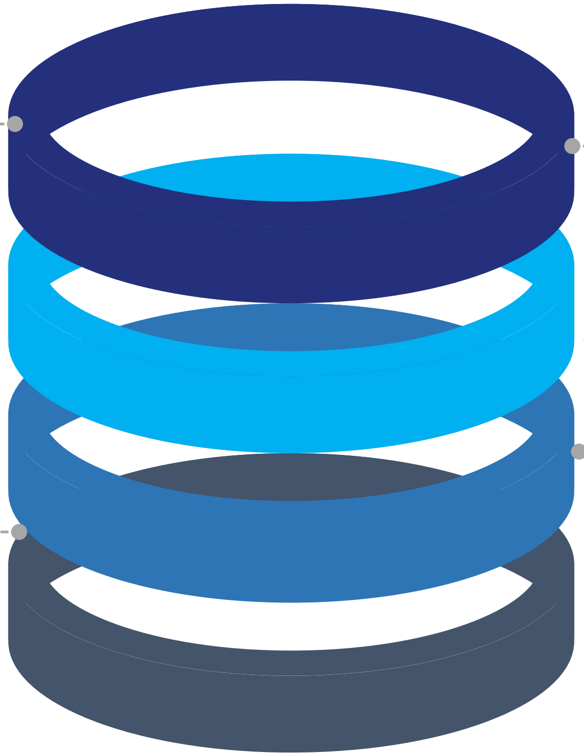

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AN INTEGRATED FUZZY MULTIPLE CRITERIA DECISION-MAKING MODEL FOR THE SELECTION OF TUGBOATS IN PORTS IN WEST AFRICA

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Agenda

- Introduction
- Problem Statement
- Critical Review
- Tugboat Accidents
- Framework
- Methodology
- Findings

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Introduction

Tugboats are small boats that are used to maneuver larger vessels by pushing or pulling them with a towline or by direct contact

Tugboats allow for faster and safer port maneuvering, resulting in a speedier flow of commodities through the port

Problem Statement

Tugboat selection for suitable operation in ports is a difficult problem that necessitates the simultaneous evaluation of several criteria

Critical Review

Fuzzy-AHP for the Selection of a Suitable Tugboat Based on Propulsion System Type

Fuzzy VIKOR Method for the Evaluation and Selection of a Suitable Tugboat

Critical Review

Fuzzy-AHP for the Selection of a Suitable Tugboat Based on Propulsion System Type

- Architecture, operational and financial parameters
- The propulsion or maneuvering systems used in tugboats were examined
- A fuzzy analytical hierarchy process was used to generate an algorithm for the selection

Fuzzy VIKOR Method for the Evaluation and Selection of a Suitable Tugboat

- Specifications for tugboats were accessed by subject experts
- Fuzzy Shannon Entropy was used to measure the weights of each criterion and Fuzzy VIKOR was used to rank the alternatives
- Best tugboat was selected for effective decision making

Tugboat Accidents

Analysis of accident for the development of an appropriate tug selection framework

Tugboat Accidents - I

Tug capsizes in Frazer Rivers

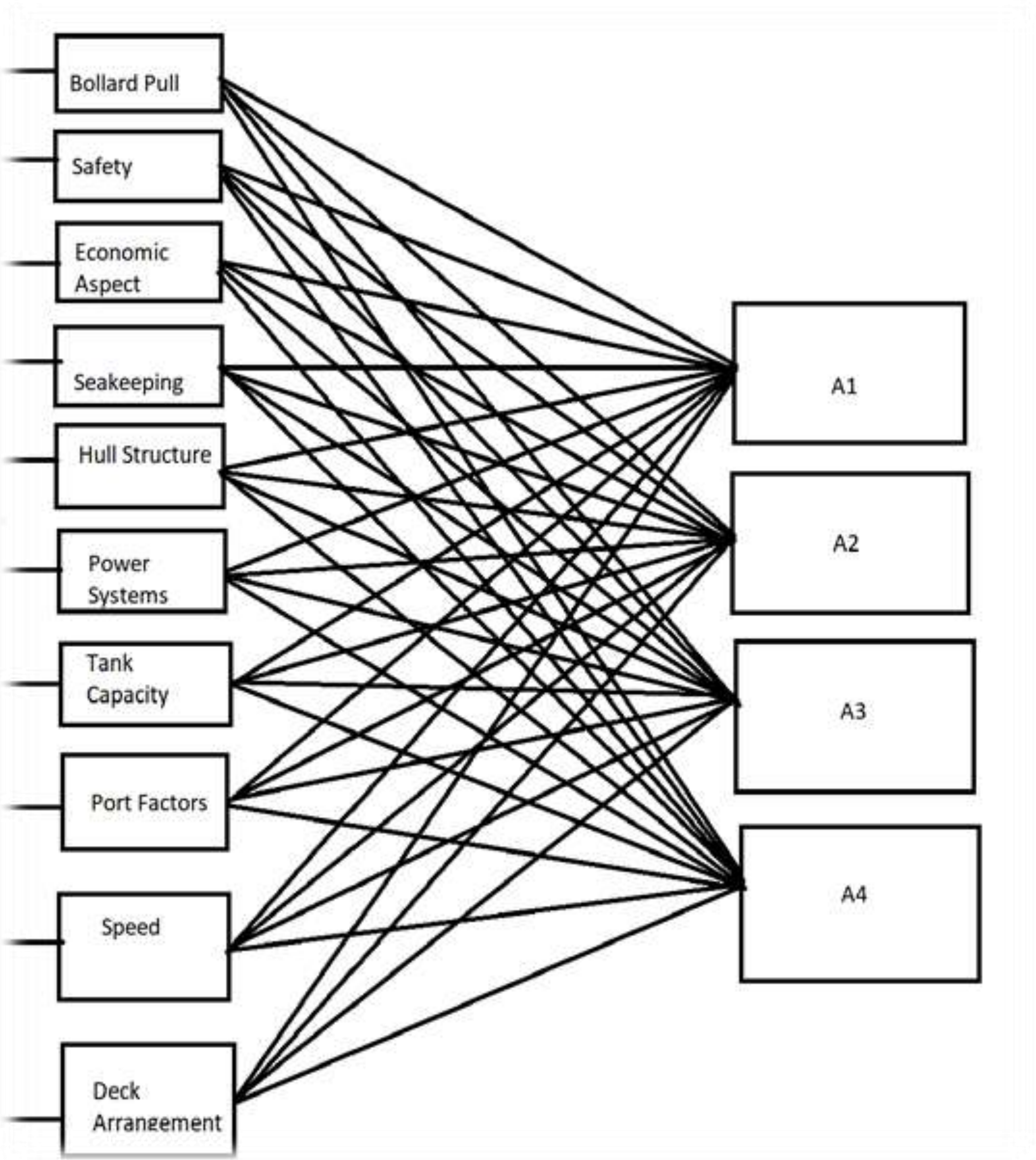
North Arm Ventures Capsizes

Tugboat Accidents - II

Stewards Tug Grounding

Fairplay 22 Tug Collapse

Tugboat Selection



Framework

	Criteria	Definitions
C1	Bollard pull	It is the measure of the pulling power of a tug
C2	Safety	Refers to the stability of the tug during towing operations
C3	Economic Aspect	Involves the initial investment cost and the overall operating costs of the tug
C4	Seakeeping	The ability of the tug to withstand adverse sea conditions
C5	Hull Structure	The characteristic design of the hull form including the size and the length
C6	Power Systems	Power systems are dependent on the propulsion systems whether mechanical, electrical or hybrid
C7	Tank Capacity	The volume or capacity of all the tanks on the tug
C8	Port factors	It includes the draft requirement, the geographical location and the technological equipment at ports
C9	Speed	The maximum and/ or service speed of the tug
C10	Deck arrangement	The size of the deck area and the arrangement or positions of the towing equipment

Methodology - I

Step 1	Step 2	Step 3	Step 4	Step 5
Determine the weights of the evaluation criteria	Develop the fuzzy decision matrix	Calculate the normalized fuzzy decision matrix	Then, compute the weighted normalized fuzzy decision matrix	Identify FPIS and FNIS

Methodology - II

Step 6: The distance of each alternative from FPIS and FNIS

Step 7: Obtain closeness coefficient and improve alternatives

Step 8: Rank the alternatives

Equations Step 4 - 7

$$\tilde{D} = \begin{matrix} & C_1 \cdots C_n \\ \begin{matrix} A_1 \\ \dots \\ A_m \end{matrix} & \begin{bmatrix} \bar{x}_{11} & \cdots & \bar{x}_{1n} \\ \vdots & \ddots & \vdots \\ \bar{x}_{m1} & \cdots & \bar{x}_{mn} \end{bmatrix} \end{matrix}, i = 1,2,\dots,m; j = 1,2,\dots,n$$

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right) and\ c_j^* = max_i\{C_{ij}\}\ (benefit\ criteria)$$

$$v_{ij} = \tilde{r}_{ij} \times \omega_J$$

$$A^+ = (\tilde{v}_1^*, \tilde{v}_2^*, \dots, \tilde{v}_n^*),\ where\ \tilde{v}_j^* = max_i\ \{v_{ij3}\}$$

$$A^- = (\tilde{v}_1^-, \tilde{v}_2^-, \dots, \tilde{v}_n^-)where\ \tilde{v}_j^- = min_i\ \{v_{ij1}\}$$

$$\tilde{d}_i^+ = \sum_{j=1}^{n} d\left(\tilde{v}_{ij}, \tilde{v}_j^*\right), i = 1,2,\dots,m;\ j = 1,2,\dots,n$$

$$\tilde{d}_i^- = \sum_{j=1}^{n} d\left(\tilde{v}_{ij}, \tilde{v}_j^-\right), i = 1,2,\dots,m;\ j = 1,2,\dots,n$$

$$C\tilde{C}_i = \frac{\tilde{d}_i^-}{\tilde{d}_i^+ + \tilde{d}_i^-} = 1 - \frac{\tilde{d}_i^+}{\tilde{d}_i^+ + \tilde{d}_i^-}, i = 1,2,\dots,m$$

Results - I

Combined decision matrix

	A1	A2	A3	A4
C1	5,7.667,9	3,6.333,9	3,5,7	3,5,7
C2	3,7,9	1,4.333,7	5,7,9	5,7,9
C3	3,6.333,9	1,3.667,7	5,7.667,9	5,8.333,9
C4	3,5.667,9	5,6.333,9	1,4.333,7	1,4.333,7
C5	3,6.333,9	1,4.333,7	3,5,7	3,5.667,9
C6	3,6.333,9	3,6.333,9	5,7.667,9	5,7,9
C7	3,5.667,9	3,5.667,9	5,7,9	3,5.667,9
C8	3,5,7	3,5.667,9	3,5,7	1,4.333,7
C9	3,6.333,9	3,5,7	3,6.333,9	3,7.667,9
C10	3,5,7	3,5.667,9	3,5,7	3,5.667,9

Combine weightage matrix

	ω_j
C1	5,7.667,9
C2	5,7.667,9
C3	3,6.333,9
C4	3,5.667,9
C5	3,5.667,9
C6	3,5.667,9
C7	3,5,7
C8	3,5.667,9
C9	3,5.667,9
C10	1,4.333,7

Results - II

Normalized fuzzy decision matrix

	A1	A2	A3	A4
C1	$\frac{5}{9},\frac{7.667}{9},\frac{9}{9}$	$\frac{3}{9},\frac{6.333}{9},\frac{9}{9}$	$\frac{3}{9},\frac{5}{9},\frac{7}{9}$	$\frac{3}{9},\frac{5}{9},\frac{7}{9}$
C2	$\frac{3}{9},\frac{7}{9},\frac{9}{9}$	$\frac{1}{9},\frac{4.333}{9},\frac{7}{9}$	$\frac{5}{9},\frac{7}{9},\frac{9}{9}$	$\frac{5}{9},\frac{7}{9},\frac{9}{9}$
C3	$\frac{1}{9},\frac{1}{6.333},\frac{1}{3}$	$\frac{1}{7},\frac{1}{3.667},\frac{1}{1}$	$\frac{1}{9},\frac{1}{7.667},\frac{1}{5}$	$\frac{1}{9},\frac{1}{7},\frac{1}{3}$
C4	$\frac{3}{9},\frac{5.667}{9},\frac{9}{9}$	$\frac{5}{9},\frac{6.333}{9},\frac{9}{9}$	$\frac{1}{9},\frac{4.333}{9},\frac{7}{9}$	$\frac{1}{9},\frac{4.333}{9},\frac{7}{9}$
C5	$\frac{3}{9},\frac{6.333}{9},\frac{9}{9},$	$\frac{1}{9},\frac{4.333}{9},\frac{7}{9}$	$\frac{3}{9},\frac{5}{9},\frac{7}{9}$	$\frac{3}{9},\frac{5,667}{9},\frac{9}{9}$
C6	$\frac{3}{9},\frac{6.333}{9},\frac{9}{9}$	$\frac{3}{9},\frac{6.333}{9},\frac{9}{9}$	$\frac{5}{9},\frac{7.667}{9},\frac{9}{9}$	$\frac{5}{9},\frac{7}{9},\frac{9}{9}$
C7	$\frac{3}{9},\frac{5.667}{9},\frac{9}{9}$	$\frac{3}{9},\frac{5.667}{9},\frac{9}{9}$	$\frac{5}{9},\frac{7}{9},\frac{9}{9}$	$\frac{3}{9},\frac{5.667}{9},\frac{9}{9}$
C8	$\frac{3}{9},\frac{5}{9},\frac{7}{9}$	$\frac{3}{9},\frac{5.667}{9},\frac{9}{9}$	$\frac{3}{9},\frac{5}{9},\frac{7}{9}$	$\frac{1}{9},\frac{4.333}{9},\frac{7}{9}$
C9	$\frac{3}{9},\frac{6.333}{9},\frac{9}{9}$	$\frac{3}{9},\frac{5}{9},\frac{5}{9}$	$\frac{3}{9},\frac{6.333}{9},\frac{9}{9}$	$\frac{3}{9},\frac{7.667}{9},\frac{9}{9}$
C10	$\frac{3}{9},\frac{5}{9},\frac{7}{9}$	$\frac{3}{9},\frac{5.667}{9},\frac{9}{9}$	$\frac{3}{9},\frac{5}{9},\frac{7}{9}$	$\frac{3}{9},\frac{5.667}{9},\frac{9}{9}$

Results - III

Weighted normalized decision matrix

	A1	A2	A3	A4
C1	2.778,6.531,9	1.667,5.395,9	1.667,4.259,7	1.667,4.259,7
C2	1.667,7,9	0.556,3.691,7	2.778,7,9	2.778,7,9
C3	0.333,1,3	0.429,1.727,9	0.333,0.826,1.8	0.333,0.760,1.8
C4	1,3.568,9	1.667,3.988,9	0.333,2.728,7	0.333,2.728,7
C5	1,3.988,9	0.333,2.728,7	1,3.148,7	1,3.568,9
C6	1,3.988,9	1,3.988,9	1.667,4.827,9	1.667,4.408,9
C7	1,3.148,7	1,3.148,7	1.667,3.889,7	1,0.630,7
C8	1,3.148,7	1,3.568,9	1,3.148,7	0.333,2.728,7
C9	1,3.988,9	1,3.148,3.148	1,3.988,9	1,4.828,9
C10	0.333,2.407,5.444	0.333,2.728,7	0.333,2.407,5.444	0.333,2.728,7

FPIS and FNIS

	A^{+}	A^{-}
C1	2.778,6.531,9	1.667,4.259,7
C2	2.778,7,9	0.556,3.691,7
C3	0.429,1.727,9	0.333,0.760,1.8
C4	1.667,3.988,9	0.333,2.728,7
C5	1,3.988,9	0.333,2.728,7
C6	1.667,4.827,9	1,3.988,9
C7	1.667,3.889,7	1,0.630,7
C8	1,3.568,9	0.333,2.728,7
C9	1,4.828,9	1,3.148,3.148
C10	0.333,2.728,7	0.333,2.407,5.444

Closeness

	d_i^*	d_i^-	CC_i	Rank
A 1	8.363	13.458	0.6167	1
A 2	9.620	13.841	0.5900	2
A 3	11.452	9.503	0.4535	3
A 4	10.639	8.771	0.4535	4

The way to get started is to quit talking and begin doing

Walt Disney

Findings

Findings I

- The most important criteria considered in the selection of tugboats are *safety* and *bollard pull*

Findings II

- The *A1* of tugs was most suitable as in this illustrative example with inputs from three experts from West Africa

Summary

This presentation outlines numerous aspects in the selection of an appropriate tugboat for port operations

As a guide, this proposed decision model may be used by ports authorities and organizations working in tugboat selections ports in West Africa to enhance safety and maximize operational efficiency

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THANK YOU

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