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A Stratified Methodology for the Marine Electronic Highway for Policy Makers along the West Coast of India and South Coast of Srilanka

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ABSTRACT
The Main objective is to present evaluation and judgment model for computing of Marine Electronic Highway (MEH) system & technologies. By achieving MEH system, the environmental impact has reduced along with the improvement of quality and reliability in the freedom of navigation at sea. The dissertation is a study, to examine the need for the Policy Makers along the west coast of India and south coast of Sri Lanka, to identify the critical areas of the coastline, which require urgent attention because of traffic density as well as environmental sensitivity and to propose suitable solutions to manage the shipping traffic in this region safely and effectively
For this target, a multi-attribute decision making (MADM) method is applied in the selection of options with respect to various attributes as it becomes difficult in part of authorities to arrive a suitable decision on choosing the type of parameters and factors depending for a particular area or region. TOPSIS method and AHP are used to find the parallel importance of the chosen attributes at various regions and based on this, suitable options are determined. Key deliverables of the system have been identified considering the needs of India and Sri Lanka.
Keywords - About five key words in alphabetical order, separated by comma

I. INTRODUCTION

The Western Indian Ocean Marine Highway Development was modeled individually for better assistance to shipping, to assist with the prevention of emergency and destruction of the environment. Many states have been established Ship's routing measures, Ship Reporting Systems (SRS) and Vessel Traffic Services (VTS) in areas of high traffic density in order to enhance the safety of navigation and protection of the environment which was adopted several regulations by IMO on vessel traffic management under SOLAS. Various Studies conducted by many agencies have confirmed with certainty that this vessel traffic regulations contributed significantly towards reduction of shipping accidents in areas of high risk (Cockcroft, 1978) (EfficienSea, 2012a).Realizing the fact that shipping traffic is increasing steadily, due to increasing transport demand, also recognizing the consequences of accidents involving oil, chemicals and other hazardous substances which are being carried in large quantities in recent years because of 'economies of scale' (Stopford, 2009), some of the countries have adopted additional measures with the help of latest technologies [1]. Utilizing the basic concept of MEH, USA and Canada had jointly established the Great Lakes-St. Lawrence Seaway System, which transmits the information on available water depth, tide and traffic information to ships on a real time basis (Research and Traffic Group, 2014).

The Main objective is to present evaluation and judgment model for computing the development of Western Indian Ocean Marine Highway various attributes has to be considered for completion of successful marine between India and Srilanka. By achieving Marine Highway Electronic system, the environmental impact has reduced along with the improvement of quality and reliability in the Coastal area [2, 3]. MEH is improving its technology frequently that holds into account various considerations such as technical, economic, environmental and social attributes. Therefore, it is very important to choose MEH at various locations in the west coast of India and south coast of Srilanka [4,5]. For this objective, a multi-attribute decision making (MADM) method is applied in the selection of options with respect to various attributes as it becomes difficult in part of authorities like Oil Spill Co-ordination Centre, International Maritime Organization (IMO), the International Chamber of Shipping (ICS), the International Association of Independent Tanker Owners (INTERTANKO), and the International Association of Dry Cargo Ship owners (INTERCARGO),etc to arrive a suitable decision on choosing the type of MEH technology for a particular area or region. TOPSIS (technique for order preference by similarity to ideal solution) method and Analytic Hierarchy Process (AHP) are used to find the parallel importance of the chosen attributes in various regions and based on this, suitable MEH options are determined. This systematic plan is implemented in four places in West Coast of India and Srilanka, which are having different assets and climatic conditions.

II. MARINE ELECTRONIC HIGHWAY (MEH)

The Marine Electronic Highway (MEH) is an IT system which integrates marine environmental management and protection system (EMPS) with vessel traffic management and navigational information for supporting the decision-making on-board and ashore shown in figure.1.

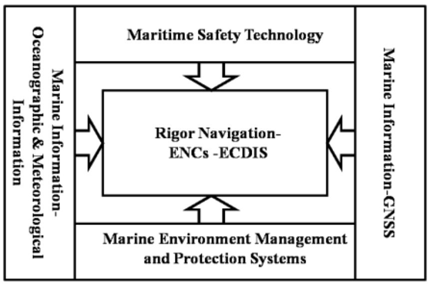


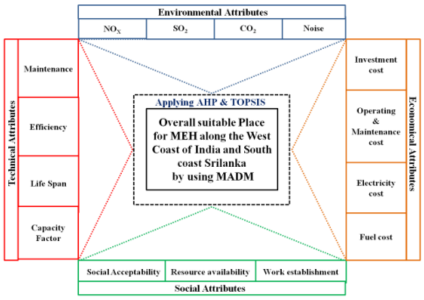
Figure 1: The Marine Electronic Highway IT System. The Concept is from IMO. Source

The literature review revealed that to date, no specific study has been conducted to find out the maritime traffic data around the Indian Sub-continent considering technical, economic, environmental and Social attributes. In order to obtain a realistic estimate of MEH, data is collected from different places will help for indication of the traffic density, traffic information by VTS, it is necessary to install tidal and current monitoring equipment's along the coast and offshore meteorological observation stations. Furthermore, all the MEH information can be displayed in a user-friendly design that can be accessed by all the relevant agencies such as MARAD, Navy, Coast Guard and State Environmental agency through the dedicated web portal (MEHSOMS, 2014).This system has been designed to provide the vessel traffic management information, real-time ship to shore communication, large scale resolution, environmental forecasts using Environmental Marine Information Overlays (E-MIO) and large scale electronic charting information for ships using the marine electronic highway and the shore authorities (MEHSOMS, 2014). The functionality of the system depends upon the availability of precise position information using DGPS broadcast stations, set up of AIS shore stations along the coast, creation of EMPS, VTS in key areas with radar coverage, establishment of ship's routine measures and Ship Reporting Systems (SRS), fitment of AIS and ECDIS on-board ships (GEF, 2003) [6,7].

Therefore, it was necessary to adopt a methodology for counting the actual number of ships transiting the region in any day, so that data can be extrapolated for longer periods. Initially, using the live feed of the National AIS chain along the West coast of India. Similar to the world-wide trend, the Indian coast has also witnessed many navigational accidents during the past five year period of 2009-2013 because of several reasons which includes increased maritime traffic in the past decade. The coastal areas of the South West coast of India and Sri Lanka are environmentally sensitive due to its unique and fragile ecosystems. Moreover, the Indian coast is highly vulnerable due to its low lying coastal area, high population density in the coastal belt, frequent occurrence of cyclones and high rate of environmental degradation on account of pollution. Also, most of the people living in coastal area are highly dependent on the natural resources of coastal ecosystems (CPEES, 2010). In addition to the services to ships, MEH in its endeavor to enhance safety of navigation and protection of the environment in the region should be able to assist, monitor the vessel traffic and to present the traffic situation to shore based enforcement authorities, for detecting any violations of national and international rules and regulations.

III. PROPOSED METHODOLOGY

In the decision making process, it is relatively difficult to provide exact numerical values for Technical, Economical, Environmental and Social attributes. Hence, in this task, the AHP method considering both quantitative and qualitative criteria and TOPSIS method are used for decision making process. The stratified decision making structure consists of four attributes as shown in Fig. 2.



. Figure.2 Flow diagram for Attribute Selection for a Place in having MEH along West Coast of India and South Coast of Srilanka by using MADM

Evaluation Attributes

A.Technical attributes: The Technical characteristics are important attributes which influence both customers and the network. Four sub-attributes are included in this category among them maintenance and efficiency are most given more preferences compared to remaining attributes and the third sub-attribute is life span, which is treated as a crucial factor for demonstrating the future of the technology for the user friendly MEH system.

B.Economical attributes: The Economical aspects play a very important role behind any investment choice and it depends on many factors like initial Investment cost, operating and maintenance costs, Investment cost covers the leading price of the MEH and installation costs for integrating it for the existing system.

C.Environmental attributes: Environmental attributes were considered sub-attributes: SO2, NOX, CO2 and Noise pollution. Coastal areas are one among the rapid population growth on the environment primarily through the use of natural resources and production of wastes which results in increase consumption of fossil fuel lead to an increase in the mixture of harmful gases significantly increased day by day in the atmosphere.

D.Social attributes: Social attributes were considered sub-attributes as Social acceptability,Resource availability,Work establishment will also make a big impact in Coastal areas as the population growth is more and job creation is to be done for them.

Analytic Hierarchy Process(AHP)

The Multi-attribute decision making (MADM) way is one among the well enough technical aids for critical planning and it selects the best resource approach with regard to the chosen attributes [8, 9]. Identifying the principle and the alternatives and they must be arranged It is necessary to estimate the weights of the judgment criteria and a similarity of target/option i and j handle a rate bij, explained in Table 1. Further, if bij = k, then bji = 1/k [10, 11].

TABLE 1: Pair-wise observations matrix of objectives

1	Objectives i and j are of equal importance
3	Objective i is weakly more important than j
5	Objective i is strongly more important than j
7	Objective i is very strongly more important than j
9	Objective i is extremely more important than j
2,4,6,8	Intermediate

TABLE 2: Pairwise observations matrix of objectives

	obj1	obj2	…	objn	Priority
obj1	b11	b12	…	b1n	p1
obj2	b21	b22	…	b2n	p2
.	.	.	.	.	.
.	.	.	.	.	.
objn	bn1	bn2	…	bnn	pn

Considering a problem to compute m option with n attributes, the pairwise observation of various targets has shown in Table 2.The relative weights of attributes can be computed as normalized mathematical means of the rows .The geometric means are computed as equcation(1) and the priority of the ith attributes is obtained as equcation (2)

$$\boldsymbol{h_i = \sqrt[n]{\prod_{j=1}^{n} b_{ij}}} \qquad \text{- - - (1)}$$

$$\boldsymbol{p_i = \frac{h_i}{\sum_{i=1}^{n} h_i}} \qquad \text{- - - (2)}$$

Similarly, the pairwise objective matrix is made for attributes with respect to each objective and with m attributes for the kth objective, the preference of the ith attributes and overall priority of the mth attributes is obtained as equcation (3) , (4) & (5)

$$\boldsymbol{h_{ki} = \sqrt[m]{\prod_{j=1}^{m} b_{kij}}} \quad \text{- - - (3)} \qquad \boldsymbol{p_{ki} = \frac{h_{ki}}{\sum_{i=1}^{m} h_{ki}}} \quad \text{- - - (4)}$$

$$\boldsymbol{p_m = \sum_{i=1}^{n}\sum_{k=1}^{n} p_i\, p_{km}} \qquad \text{- - - (5)}$$

In the last step of the process, priorities are calculated for each attribute and the numbers represent the alternatives ability to attain the goal.

Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)

The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is a multi-criteria decision analysis method. It is based on the approach that chosen alternative should have the shortened measurable distance from the positive solution and the longest measurable distance from the negative ideal solution. Normalization is needed as the specifications are usually of incompatible measurable in multi-criteria problems [12,13]. TOPSIS is the best method to find out the ideal solution of the problem. For the calculation of TOPSIS values, we have to go through the following steps

Step 1: In the first step, we have to determine the objective and to identify the attribute values for each alternative.

Step 2: This step involves the development of matrix formats. The row of this matrix is allocated to one alternative and each column to one attribute. The decision making matrix can be expressed as:

$$D = \begin{bmatrix} x_{11} & x_{12} & x_{13} & \cdots & x_{1n} \\ x_{21} & x_{22} & x_{23} & \cdots & x_{2n} \\ x_{31} & x_{32} & x_{33} & \cdots & x_{3n} \\ : & : & : & : & : \\ . & . & . & . & . \\ x_{m1} & x_{m2} & x_{m3} & \cdots & x_{mn} \end{bmatrix} \qquad \text{- - (6)}$$

Step 3: Then using the above matrix to develop the normalized decision matrix with the help of the formula given below:

$$X_{ij}^* = X_{ij} / \sum_{i=1}^{n} X_{ij} \quad \text{- - - (7)}$$

Step 4: Depending upon the relative importance of different attributes obtain weight for each attributes using the formula given below and the sum of the weights should be 1. Where Vj is the variance of each attribute which can be calculated by the formula given as

$$W_j = V_j / \sum_{j=1}^{m} V_j \ \& \ \sum_{j=1}^{m} w_j = 1 \quad \text{- - - (8)}$$

$$V_j = (1/n) \sum_{i=1}^{n} \left(X_{ij}^* - (X_{ij}^*)_{mean} \right)^2 \quad \text{- - - (9)}$$

Step 5: Then obtain the weighted, normalized matrix Vij by multiplying Wj with all the values Xij. * such as equcation **(10a) &(10b)**

a) The Ideal solution

$$A^+ = \{v_1^+, \dots\dots\dots, v_m^+\} = \{(maxv_{ij} \backslash j\epsilon I', minvij \backslash j\epsilon I'' \quad \text{- - - (10a)}$$

b) The negative ideal solution

$$A^- = \{v_1^-, \dots\dots\dots, v_m^-\} = \{(minv_{ij} \backslash j\epsilon I', maxvij \backslash j\epsilon I'' \quad \text{- - - (10b)}$$

Here,

I'= {j=1, 2 … n | j}: Associated with the beneficial attributes

I"= {j=1, 2… n | j}: Associated with non-beneficial adverse attributes

Step 7: Obtain separation (distance) of each alternative from the ideal solution and negative ideal solution which is given by the Euclidean distance given by the equations:

$$D_i^+ = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j^+)^2}, i = 1, 2, \dots n \quad \text{- (11a)}$$

$$D_i^- = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j^-)^2}, i = 1, 2, \dots n \quad \text{- (11b)}$$

Step 8: Calculate the relative closest to the ideal solution of each alternative which is given by the formula:

$$C_i^* = D_i^+ / (D_i^+ + D_i^-) \quad i = 1,2, \dots n \quad \text{- - - (12)}$$

Step 9: A set of value is generated for each alternative. Choose the best alternative having largest closeness to ideal solution. Arrange the alternative as an increasing order of Cj*n the first step, we have to determine the objective and to identify the attribute values for each alternative [14].

IV. RESULTS AND DISCUSSIONS

Case Study: West Coast of India

Kolachel, KanyaKumari, Kundankulam and Uvari places selected in the West coast of India with technical, economic, environmental and social attributes. Pairwise comparisons and TOPSIS method is applied (Appendix-A).

Case Study: South Coast of Srilanka

Galle, Rathgama, Dodanduwa and Godagama places selected in the South coast of Srilanka with technical, economic, environmental and social attributes. Pairwise comparisons and TOPSIS method is applied (Appendix-B).

Social Attributes for both West coast of India& South coast of Srilanka are considered same Social Acceptability, Resource availability &Work establishment

V. CONCLUSION

A multi-attribute decision making (MADM) method is applied for choosing place (area) for MEH using technical, economic, environmental and Social attributes. In the proposed methodology, data are collected for West coast of India (Kolachel, KanyaKumari, Kundankulam and Uvari) and South coast of Srilanka (Galle, Rathgama, Dodanduwa and Godagama) among all the places, Kolachel was the best among West coast of India & Galle was the best in South coast of Srilanka analysis is done for having an effective MEH. Graphical modelling and discussions indicate that places which are noticed from the proposed are favorable for starting MEH.

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APPENDIX-A

TABLE 3: Random Index (RI) for number of Objectives

1	2	3	4	5	6	7	8	9	10
0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

TABLE 4 Pairwise Comparison- Technical attributes

	Maintenance	**Efficiency**	**Life Span**	**Capacity Factor**
Maintenance	1	3	7	5
Efficiency	1/3	1	3	3
Life Span	1/7	1/3	1	1/3
Capacity Factor	1/5	1/3	3	1

TABLE 5 Pairwise Comparison -Economical attributes

	Investment cost	**Operating & maintenance cost**	**Electricity cost**	**Fuel cost**
Investment cost	1	4	5	6
Operating & maintenance cost	1/4	1	3	4
Electricity cost	1/5	1/3	1	2
Fuel cost	1/6	1/4	1/2	1

TABLE 6 Pairwise Comparison -Environmental attributes

	NOX	**SO2**	**CO2**	**Noise**
NOX	1	1/2	2	2
H2O	2	1	3	1
CO2	1/2	1/3	1	5
Noise	1/2	1	1/5	1

Case Study: West Coast of India

TABLE 7 Technical attributes

	Maintenance	**Efficiency**	**Life Span**	**Capacity Factor**
Kolachel	30	50	40	17
KanyaKumari	50	30	10	20
Kundankulam	40	50	25	10
Uvari	30	45	60	15

TABLE 8 Economical attributes

	Investment cost	**Operating & maintenance cost**	**Electricity cost**	**Fuel cost**
Kolachel	2000	0.03	0.03	0.05
KanyaKumari	1750	0.15	0.05	0.1
Kundankulam	2500	0.1	0.09	0.2
Uvari	2300	0.05	0.11	0.07

TABLE 9 Environmental attributes

	NOX	**SO2**	**CO2**	**Noise (db)**
Kolachel	0	0.05	10	20
KanyaKumari	0.01	0.026	15	45
Kundankulam	0.0053	0.1	25	27
Uvari	0.00511	0.15	10	30

Case Study: South Coast of Srilanka

TABLE 10 Technical attributes

	Maintenance	**Efficiency**	**Life Span**	**Capacity Factor**
Galle	25	45	30	15
Rathgama	40	25	15	25
Dodanduwa	32	45	25	12
Godagama	25	40	45	20

TABLE 11 Economical attributes

	Investment cost	**Operating & maintenance cost**	**Electricity cost**	**Fuel cost**
Galle	2500	0.025	0.027	0.06
Rathgama	1750	0.1	0.06	0.15
Dodanduwa	2300	0.07	0.07	0.22

Godagama	2100	0.05	0.13	0.08

TABLE 12 Environmental attributes

	NOX	**SO2**	**CO2**	**Noise (db)**
Galle	0.01	0.06	15	25
Rathgama	0.02	0.032	18	40
Dodanduwa	0.006	0.1	20	25
Godagama	0.005	0.12	12	27

Figure 3.Technical attributes- West Coast of India

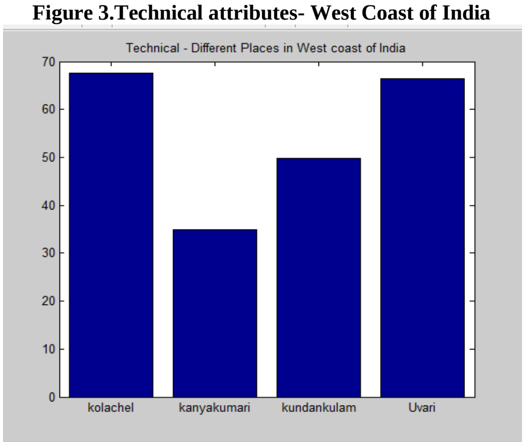

Figure 4 Economical attributes - West Coast of India

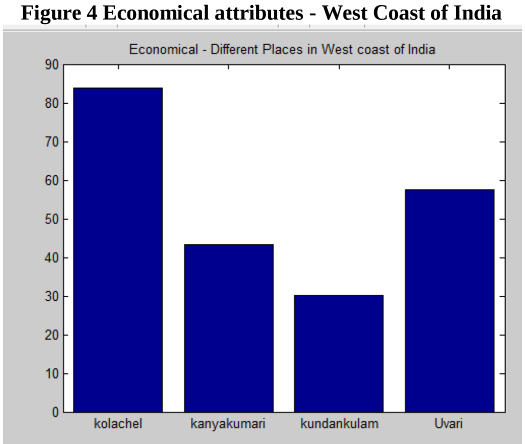

Figure 5 Environmental attributes - West Coast of India

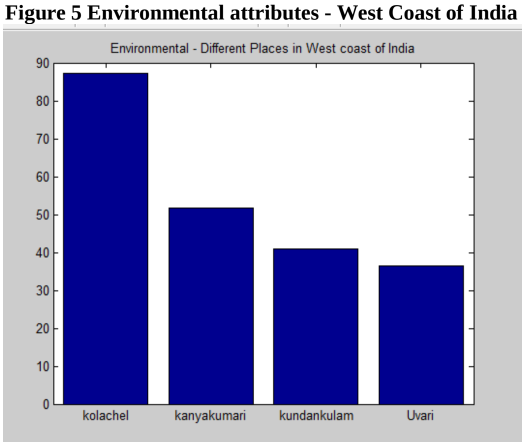

Figure 6.Technical attributes- East Coast of Srilanka

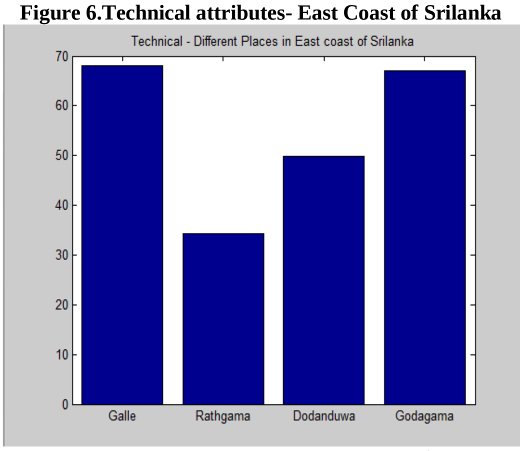

Figure 7 Economical attributes - East Coast of Srilanka

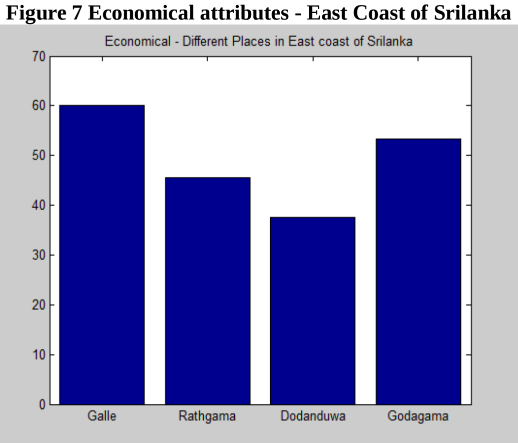

Figure 8 Environmental attributes - East Coast of Srilanka