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Analysis on Maritime Engineering Research in Shaping Policies in West Africa

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Abstract- This study employs fuzzy rule base analysis to examine the factors that influence the role of marine engineering research in shaping maritime policy making and implementation in West Africa. There is a need for a combination of scientific knowledge, and value-led knowledge, to inform decisions in maritime engineering related policy making. This approach, will help directors in maritime institutions in West Africa make well-informed decisions about engineering policies and programs, locked within anachronistic institutional framework by putting the best available evidence from research. Results from this work shows that, poor policy comprehension and the domain interest of the researcher, are ranked as the most influencing factors that impacts the role of maritime engineering research in driving policies in West Africa. In this light, member countries in West Africa are to provide resources and capacity, and are take vigorous steps in ensuring continuous regional maritime education, through the creation of research institutes. Again, there is a need for political will in government leadership to enforce networking between maritime researchers and senior governmental maritime executives.

Keywords *- Fuzzy Rule Base, Maritime Policy, Maritime Researcher and Expert Judgments*

I. INTRODUCTION

There is a need to always update maritime policies in West Africa due to rapid changes in maritime technology, environmental impacts, and increase in international trade. Researchers in the maritime domain require access to unlimited data and advance research tools such as - expert elicitation methods - when data becomes limited or inaccessible. In general, evidence transforms lives, whilst lack of evidence-based responses, has cause widespread failure in managerial procedures, misery and death in Africa [2, 3]. Also, policy making in the maritime sector and how issues of flexibility, movement, and change can be accommodated in a new maritime governance research framework is of great significance in West Africa [4]. Evidence-based interventions associated with evidence based policy approach have been most carefully pursued in areas such as education [5], social welfare [6, 7], criminology [8] and healthcare [9, 10] but interventions associated with the maritime industry in West Africa are limited. A combination of scientific and value led knowledge is a paramount input into rulemaking on maritime related affairs [2, 3]. In the past decades, there has been a need to link evidence based research for maritime policy in the West Africa region. This approach will help directors in maritime institution about programs with the use of scientific research output [4]. This is of great importance in developing nations in reducing poverty and improving economic performance. Maritime engineering research based policy implementation, tends to be less established in developing nations than in developed ones, and these polices are often not based on evidence. Failure in governance of the public or corporate maritime sector is evidenced by the inadequacies of shipping or ports policy to address the problems of environmental, security, safety and economic concerns [4]. The general proposition is that, reliable engineering knowledge is a powerful instrument for advising decision makers and for efficient governance [11]. The aim of this paper, is to apply fuzzy rule base algorithm to analyze the factors that influence maritime engineering research in West Africa. In this paper section 2 is the literature review, section 3 presents the methodology and framework, section 4 is an illustrative example and the conclusion is presented in section 5.

II. LITERAURE REVIEW

In the USA, the policy science championed by Laswell and his colleagues, were clearly linked to the values on democracy and social wellbeing [12]. Social scientists became deeply involved in grant programs of social welfare, educational reforms and urban renewal in North America, Europe and Australia [13, 14, 15, 16, & 17]. However, the results were often disappointing, and for some, the blame fell on the inadequacies of social research, as well as poor implementation and coordination capacities of government agencies [14]. The need for good information is one of the foundations for good policy but these foundations are usually shaken due to institutional, professional and cultural factors [18]. Evidence-based interventions associated with evidence based policy approach, remains a continuous cycle in the field of education [5]. Scientific research in the maritime industry spanned between four (4) to five (5) decades, and researches from West Africa maritime institutions have played an insignificant role during these past decades. Maritime research remains a dynamic process and if research funds are not enhanced, researchers would be unable to meet with the evolving pace of technological reforms. As such, there is potential to upgrade the role of research in the maritime players in West Africa in terms of informing maritime policy and management whilst at the same time, building up the paradigmatic stance of the maritime discipline [21]. Elsewhere, maritime researchers from other regions in the world have attempted to apply technical analysis adopted in finance for maritime policy decision making [22 & 23], where standard econometric model and standard cost benefit analysis [24], were used for economics/managerial accounting in an attempt to investigate the feasibility of policies in maritime industry [25]. It is clear that research in the maritime area is quite divergent. This is because, in the effort to investigate real life situations and provide answers to research problems, new questions are being formulated at the same time and new research streams emerge [26]. In addition, maritime research entails the adoption of economic, financial, management/marketing, operations, etc., and within each area, researchers may adopt different approaches towards investigating a problem or situation. In maritime related studies in developed world, decision on privatization in UK ports has been studied [27 & 28], with other researchers focusing on port policy making and governance [29, 30, & 31]. In recent years, government funded researches has been significantly reduced, and those available, are usually influenced by the funder's priorities [32]. Researchers from maritime universities in West Africa have limited access to influential policies, as few are engaged as experts, consultants and advisers in maritime related affairs [33, 34, & 35]. In an ideal world, researchers should be well funded by public agencies to conduct independent research, subject to rigorous peer review [36]. If maritime engineering policy-making is problematic, then perhaps something needs to be done [4]. In West Africa, most maritime policy formation processes are carried out by sets of authoritative and unidentifiable decision makers in the public service. Policies that reflect continuous change rather than provide a snapshot in time are necessary to make progress against a failure endemic in maritime policy [4]. To achieve this, new forms of maritime governance with research engagement is needed, that reflects the movement that characterizes the industry [4]. Rapid advancement in maritime technology, lack of technical and research personnel, are some of the challenges faced by maritime institutions in West Africa. There is an increased call for new maritime policy measures and research driven policy reforms to strengthen the position of this region in the global shipping environment. The quality (accuracy of evidence), credibility, relevance and practicalities of research carried out within the sub-region are also important factors required by policy makers [3]. Again, understanding the stage of the policy process is important for researchers - agenda setting, formulation, implementation, and evaluation – to meet national maritime engineering agenda [3]. The factors influencing maritime engineering policy making in West Africa are; experience, judgment, resources, evidence, values & tradition, lobbyist & pressure groups, pragmatics & contingencies, information, interests, ideologies, institution, time constraint, and secrecy [3 & 37]. There are limited political freedoms, as many developing countries remain undemocratic which in turn has a great impact on the use of research to inform decision making [36]. Furthermore, many developing countries suffer from civil war conflicts, which limits research and if any, is often more limited to a centralized government especially in terms of policies formulations and lack of civil society involvement [37, 38]. In developing countries, there is also lack of both in house research capacity and administrative personnel with skills to utilize research findings. The capacity of bureaucracies in maritime domain to absorb, interpret and synthesize research, and so to mount-effective mission-oriented research programs or diffuse improved technology to users is however crucially dependent on these internal factors [38]. Again, many developing countries cannot afford the luxury of pure maritime engineering research [39]. Research spending must yield an economic or social return in order for national maritime developmental objectives to be accomplished. Consequently, it is often easier and cheaper for developing countries to produce maritime science imported technology, sparing themselves the cost, effort and risk of dealing with local techno - scientific talent [39]. Research in maritime related science, is therefore unlikely to receive funding in developing countries unless it can either demonstrate practical utility, or arrange for political protectionism [39]. Researcher can provide important information, initiate resources, undertake research, and develop network infrastructure required by maritime administrators. Maritime researchers can also create common ideas that educate network participants into the values or consensus of the network. Networks with decision makers as active participants have the potential to influence policy in both the local and global domains [38]. Some maritime policies require complex results with long term and high resource implications, these can be handled by maritime researchers [40]. The main sources of evidence used by certain administrators in maritime governance for policy making are networks, academic circle of friends, and experts [40]. Fuzzy rule-based systems (FRBSs) have the capability to model and interpret vague information from experts, in a linguistic environment. FRBS has been utilized in a wide variety of applications in solving various operational problems. For instance, an application in assessing water quality in shrimp ponds has been investigated [41]. In this application, the defuzzified output of FRBS is interpreted as a quality index. In another application, a two-stage FRBS is employed in traffic signal controller [42]. Also, this methodology have been used in graphite detection [43], inventory control [44], water quality, pipeline leak detection [45] and water quality assessment [46] and reliability engineering [47]. This research proposes a hierarchical belief rule based inference methodology which provides a modeling and inference framework that enables updating of the belief rule base, using judgmental knowledge to rank the challenges faced by maritime engineering researchers in West Africa to drive policy decision making.

III. METHODOLOGICAL FRAMEWORK

Typical factors affecting maritime engineering research for maritime decision making is presented in Table 1. Communications and dissemination is hampered in developing counties by many problems such as lack of libraries, funding and infrastructures, hence making web based research difficult for maritime engineering researchers in policy decision making framework [37].

TABLE I. FACTORS AFFECTING RESEARCH

Main factors	Intermediate factors	Symbol
Ineffective communication by researcher	Cost of assessing online journals	B1
	Lack of funding	B2
Governmental capacity	To recognize good research	B3
	Absorb resourceful research	B4
Domain research relevance	Social impact	B5
	Economic influence Cultural influence	B6
Ignorance of policies	Lack of cultivated relationship between researcher and bureaucrats	B7
	Lack of informal interactions	B8
Poor policy comprehension of researcher	Policy process	B9
	Methodology & relevance of research	B10
Societal disconnection	Encouraging public participation	B11
	Street level understanding	B12

This research proposes a hierarchical belief rule based inference methodology which provides a modeling and inference framework enabling the ranking of critical factors that affects maritime researchers in West Africa. For researchers to appropriately carry out research, several factors ought to be analyzed. The method is easy to understand and implement, and it requires little computational effort [48]. Each step on the methodological framework is presented in Figure 1.

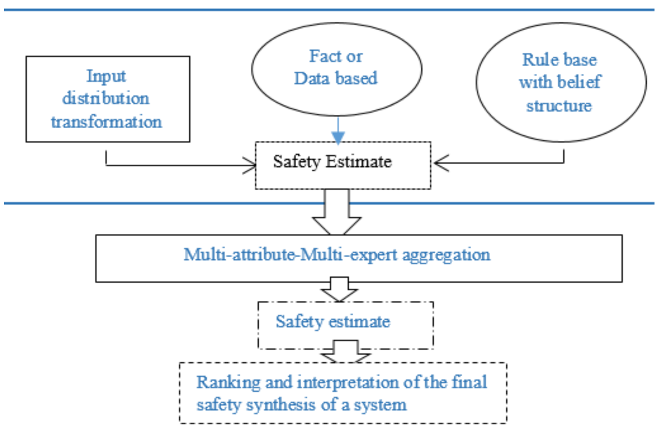

Figure 1. Fuzzy rule base framework [50]

A. Preparatory Study

The preparatory study includes, identification of experts, selection of model, and choice of approach, questionnaires and conference meeting. For critical estimation purposes, three parameters are used to define the base events. These parameters are failure likelihood (FL), consequence severity (CS) and failure consequence probability (FCP) [49]. The linguistic variables for describing each base event attribute are decided according to the situation of the case of interest. To estimate FL, for example, one may often use such variables as (FL, j = 1,..., 5), very low, low, average, frequent and highly frequent. To estimate CS, one may choose to use linguistic terms (CS, j = 1,...,5) such as negligible, marginal, moderate, critical, and catastrophic [50]. To estimate FCP, one may use such variables (FCP, k = 1,…, 5) as highly unlikely, unlikely, likely, highly likely, and definite [50]. Similarly, output S, of the particular base event can be described using such linguistic variables (Sh, h = 1, …, 4) such as good, average, fair and poor. All the criteria of base events in the hierarchical structure are given assessment grades from three (3) experts [50].

B. Belief Rule Base Interference (BRBI)

BRBI is a hybrid modelling and inference scheme in which subjective knowledge or system behavior can be described using belief rule base natural language [48, 49].

C. Development of Fuzzy Rule Base

Three (3) different multi-national experts from Cameroon, Ghana, and Liberia are consulted in this study with similar working experience as technical directors in maritime administration. The weights of the three (3) attributes (indicators) were elicited from expert and remains unchanged in the designed BRB engine where the failure consequence probability (FCP) is 5, consequence severity (CS) is given a weight of 2 and failure likelihood (FL) a weight of one (1) [50].

D. Input Transformation

Before an inference process can start, the relationship between an input (fact) and each referential value in the antecedents of a rule needs to be determined so that an activation weight for each rule can be generated [49]. The steps highlighted in this framework are as referenced, for detailed reading [49, 50].

IV. ILLUSTRATIVE EXAMPLE

To illustrate how the rule based system works, the definitions of the belief rules using linguistic terms with the consequents are constructed in Table 5 [50]. One (1) scenario is use to explore on some possible combinations of the values to obtain the output using base event (B12). For this scenario, the inputs are given by three (3) experts with approximately the same number of working experience as maritime technical experts in Ministry of Transport in West Africa. Scenario 1: the input for “B12” is given by three experts (E1.., E3, with same number of years of experience) with the three indicators’ linguistic description (FCP, CS, FL) as presented in Table 2. Step 1 is on transforming the input given in linguistic terms with the belief degree based on subjective judgment. Each belief is the individual matching degree of the input to the linguistic values as presented in Table 2. Step 2 is to calculate the rule activation weights. The activation weights for all the 4 rules (K =1…..9) are generated as seen in Table 3.

TABLE II. EXPERT INPUT FOR B12

E/B	B 12
E1	F^{L}_{VH} C^{S}_{NE} F^{CP}_{U}
E2	F^{L}_{L} C^{S}_{NE} F^{CP}_{HU}
E3	F^{L}_{L} C^{S}_{NE} F^{CP}_{HU}

TABLE III. ACTIVATION RULES FOR B12

1/3 F_2	1/3NE_0	1/3 HU_0	
2/3 A_0		2/3U_0	= 2 x 1 x 2 = 4 RULES

Using Table 3 to compute the resultant weight of B12,

= [1/3 x 2 + 1/3x0 + 1/3x0] + [2/3x2+ 1/3x0 + 2/3x0] +

[2/3x0 + 1/3x0 + 1/3 x0] + [2/3x0 + 1/3x0 + 2/3x0] =

1 + 0 + 0 + 0 = **0.33**

In obtaining the data analysis for societal disconnection by most researchers in maritime engineering, the results of B12 and B11 were added. This gives a value of 0.66 as seen in Table 4. The other factors as computed is also presented in Table 1. The results as seen in Table 4, shows that societal disconnection by researchers is the least factor that affects the role of maritime engineering research in influencing maritime policies in West Africa as compared to poor policy comprehension by researcher, ranked highest with a value of 38.5. Adequate policy comprehension can only be achieved if maritime administrators co-operate more with researchers in identifying relevant policies The findings, further indicates that there is lack of collaboration between the research institutions and the maritime government agencies in research driven policies. Of the six (6) factors hypothesized to influence the degree of research participation in policy making - *poor policy comprehension by researcher* and *the domain of university researcher*, were the most critical elements obtained from expert informant interview. Maritime institutions are encouraged to be more involved in policy driven research.

TABLE IV. RESULTS FROM EXPERT ELICITATION

Ineffective Communication by researcher (9.11)		B1=0.33 B2=8.8
Government Capacity (3.66)		B3=3.66 B4=0
Domain Reasearch (10.66)		B5=10.66 B6=0
Ignorance of Policies (2.66)		B7=2 B8=0.66
Poor Policy Comprehension of Researcher (38.5)		B9=38.5 B10=0
Societal Disconnection (0.66)		B11=0.33 B12=0.33

V. CONCLUSION & RECCOMENDATION

Previous research on the role on maritime engineering research in policy making had mainly focused on benchmarking developed countries based on different set of indicators. However, no research has been made to assess the challenges faced by maritime engineering researchers in West Africa. One of the main knowledge gaps that is addressed in this paper, is the introduction of fuzzy rule base as a tool that can assist decision makers in West Africa to strategically allocate resources for evidence based maritime engineering policy implementation. Throughout this process, key insights were garnered on assisting maritime decision maker source evidence from research institutions in a variety of ways – leveraging on personal networks, accessing peer reviewed publications, developing formal linkages with national statistics agencies, academic, or independent research institutions, or by assembling expert committees - for defined task. However, there is a need to mount effective mission-oriented maritime engineering research programs and to make policy processes less centralized and more open to help facilitate information necessary by researchers in the academic space. Also, having university engineering research experts on maritime policy decision making committees would help expose these researchers and solidify the regional confidence lacking within West Africa on matters relating to maritime engineering.

TABLE V. SAMPLE FUZZY RULE BASE GENERATION

R	F^{L}	C^{S}	F^{CP}	P	F	A	G	VG
1	Very low	Negligible	Highly U					1
2	Very low	Negligible	Unlikely				0.25	0.75
3	Very low	Negligible	Likely			0.25		0.75
4	Very low	Negligible	Highly L		0.25			0.75
5	Very low	Negligible	Definite	0.25				0.75
6	Very low	Marginal	Highly U				0.4	0.6

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