Enhancing Sustainable Maritime Business through Lean, Agile, Resilience and Green (LARG) Performance Model in Indian Seaport Supply Chain Operations

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Abstract

Seaport inefficiencies have caused barriers to maritime operations especially operational disruption which ultimately adds to high-cost expenses, redundant waste, environmental pollution, and financial losses. As a result, operations, economical and environmental sustainability cannot be attained which will impact the complete maritime supply chain-related aspects. Therefore, a lean, agile, resilience, and green (LARG) performance model is proposed as a method to control these issues and improve the competitiveness and efficiency of seaports in the Indian marine context. LARG criteria in the seaport supply chain have been identified and analyzed using extensive literature reviews and expert assessments based on the Indian seaport supply chain perspective. This paper aims to identify and select the relative importance of each LARG performance model on basis of operational. economical. and environmental related performance of seaport supply chain using the Analytical Hierarchy Process (AHP) technique by forty-three experts from various maritime domain experts in India. The research results indicate that operational performance has the highest contribution to seaport supply chain performance in Indian seaports followed by economical performance and environmental performance. This research study can also assist on related dimensions in seaport performance to enhance trade capabilities, operational efficiencies, and competitive advantages of the seaports in the maritime supply chain area. Furthermore, this LARG management tool can be applied in the global maritime context considering adaptability aspects.

Keywords
Sustainable, Seaports, India, LARG performance model, Analytical Hierarchy Process.

1. Introduction
An efficient maritime supply chain management requires synchronized development in customer service level satisfaction and maritime internal and external operation system efficiency. Maritime organizations also need to gain and possess values and advantages to be eminent from their competitors in the domain on delivery services, financial services or in aspects of industrial support (Christopher et al. 2016). The advancement of LARG (lean,

agile, resilient, green) management instrument in the seaport supply chain and maritime operations is rather new were a novel performance model of lean, agile, resilience and green (LARG) as management concept was proposed for enhancing the maritime business and environmental related sustainability in seaport related supply chain operations (Rasidi et al.2019).

1.1 Objectives

This research study engaged a compatibility analysis for the innovative LARG concept for enhancing maritime and seaport supply chain related practices. This research study identifies and explores existing research study by prioritizing four dimensions and seventeen LARG concepts that are compatible seaport supply chain related practices in Indian major seaports context. From this research study, weight assignment can be used to ascertain the dependency of four main principal dimensions on these seventeen concepts identified.

2. Literature Review

This section has been divided into three subsections consisting of the assessment on LARG ((lean, agile, resilient, green) concepts in maritime operations seaport supply chain domain perspective and its evaluation on research methodology which is focused on AHP technique.

2.1. LARG Concepts

Lean concepts related to maritime and seaport supply chain is identified for any maritime related activities or process through maximizing the profit by reducing the cost at same time for related activities or process; whereas, agile concept in maritime and seaport supply chain proposes to maximize the profit by responding very rapidly to maritime and seaport customer's request. Resilience concept in maritime and seaport supply chain is primarily used to improve the ability of coping with uncertain and unpredictable maritime or seaport business environment or disruption in seaport supply chain and on how the business can be back to its normal operation or to form a better maritime business environment. Green concept in maritime and seaport supply chain involves managing of environmental sustainability of the complete maritime and seaport supply chain (Carvalho et al. 2011). Lean, agile, resilient and green concepts have been implemented either independently or jointly as a management tool in enhancing aspects of supply chain (Marlow et al. 2003; Venkat et al. 2006; Lirn et al. 2013; Olesen et al. 2015). Azevedo et al. (2011) through research study recommended that the concurrent combination between lean, agile, resilience and green related concepts will enhance a supply chain management system to be more effective, resourceful, and efficient with more sustainability.

Numerous research studies have been carried out using the LARG application in business domains which includes manufacturing and engineering fields (Azevedo et al. 2013; Carvalho et al. 2011; Cabral et al. 2012; Maleki et al. 2016; Rasidi et al. 2019; Salleh et al. 2020). Most of the research literature pertaining to LARG concepts can be found broadly in various industrial sectors and it is found that there is lack of research papers related to maritime operations and seaport related supply chain especially in Indian maritime and seaport context. Hence, this research paper will significantly enhance the literature on the application of LARG in the maritime operations and seaport related supply chain aspects.

2.2. Review on maritime operations & seaport supply chain related concepts

Seaports are managing to create its own maritime supplychain even though being a node in international trade. The seaport and maritime supply chain integration can be defined as extend to which a seaport authorities plans, organizes and co-ordinates maritime related activities, processes and procedures associated to physical. information and economic flow outside its own gates along the maritime supply chain and also monitors the performance in such activities. In the international business, seaports perform as a node for value addition in logistics and vital associations which connects all the maritime stakeholders in the cargo supply chain (Yan et al., 2008). Seaports are consequently adding values to the maritime supply chain by execute seaport related demand level. This is due to the structural capability to decrease in the inventory levels, decrease in high related costs and strongly fulfil the customer's request by providing enhanced service within shorter lead times (Yan et al. 2008). Han (2018) through the research study indicated that with the rising demand in enhancing the maritime logistics service and competition between the seaports, seaports must cooperate with its association to provide value-addition services for maritime related customers.

An integrated seaport also is identified by seamless communication, removal of wastages, and decrease in cost for maritime operations, inter-connectivity and inter-operability of modal infrastructure, and related operations and condition of value-addition services and maritime customer and stakeholder satisfaction. Seaports also play a vital role from change in concept from being a node in the maritime supply chain towards creating its own supply by creating value, functioning as logistics hub in facilitating the flows of cargo and passengers and administering the business-related traffic as its link to the external relationship creates an sufficient flow of the transportation within the seaport (Botti et al. 2017). The numerous functions of seaports including innovativeness, core for connectivity, safety and security, hinterland related ease of access, marketing and others requisite this entity to be flexible. Therefore, the incorporation of this LARG is extremely required in seaport and maritime related operations to improve the efficiency of seaports based on the multiple roles.

2.3 Analytical Hierarchy Process (AHP) Technique

AHP technique was first initiated by Saaty in 1970 to support several decision-making problems with multiple criteria's (Longaray et al. 2015). AHP method allows reducing the complexity in decision-making process and presenting the relationship between criteria and possible alternative (Mu et al. 2017). The key characteristic of this model is hierarchical breakdown of the problem which creates a criteria hierarchy and altering the subjective evaluations of relative importance into a universal score or weight. AHP method uses pair-wise comparisons which allocates verbal judgments that improves the accuracy of findings and permit accurate ratio and scale (Oqla et al.,2012). AHP technique also deals with the qualitative and quantitative aspects of the decision-making since the judgment values from equal comparison between experience, intuition and physical data (Longaray et al., 2015).AHP methodology consists of three main stages which are done by structuring the problem and obtaining the decision-making model, relative judgment by obtaining the performance of each alternatives and precedence analysis that weighing the alternative performance.

Several research studies in maritime domain activities and seaport supply chain have employed the use of an AHP technique. Arof (2015) through maritime research study combined the AHP application and Delphi technique in the maritime transport research and Christopher et al. (2004) used AHP application in building resilience in the maritime supply chain. Han et al. (2015) conducted a maritime research using AHP technique to select the optimal transport mode of logistics, Salleh et al. (2017) used a hybrid AHP technique and Symmetric model in Fuzzy Rule-Based Bayesian Network to calculate the containership's arrival punctuality in maritime liner operations. Salleh et al. (2019) through research study employed a hybrid AHP technique and Symmetric model in Fuzzy Rule-Based Bayesian Network to appraise the maritime organizational reliability and capacity of a liner shipping operators involving a fuzzy context.AHP technique uses multi-criteria decision-making implementation in dealing with more than one parameter in the study. AHP technique is simple form of multi-criteria decision-making and is highly applicable in problem solving for management practices. Since, the purpose of this research paper is to deliberately assign the weight for each factor prior to assessment, without focusing on the interdependencies linking factors the use of AHP technique is relevant in this research study.

3. Methods

This section highlights on the methodological design to discover the weight of LARG criteria in maritime process and seaport supply chain in the Indian seaport context handling all types of cargo (container, liquid, dry bulk, break bulk and Ro-Ro). The methodology structure of AHP technique consisting of four key steps which includes:

Step 1: LARG concept criteria that possibly compatible with maritime activities and seaport supply chain will be identified and listed by using an extensive literature review of maritime studies across the globe and maritime expert consultations in the study area which involves maritime academic consultants and seaport supply chain and maritime domain industry experts.

Step 2: LARG concept criteria that possibly compatible with maritime processes and seaport supply chain in Indian seaport context will be finalized.

Step 3: The weight of each LARG concept criteria in Indian maritime processes and seaport supply chain context will be determined by investigating the influence of each criteria using AHP methodology approach.

Step 4: Finalize the weighing result for each LARG concept criteria in Indian maritime processes and seaport supply chain context.

The flowchart of the proposed research methodology has been created to conduct the research study as shown in Figure 1.

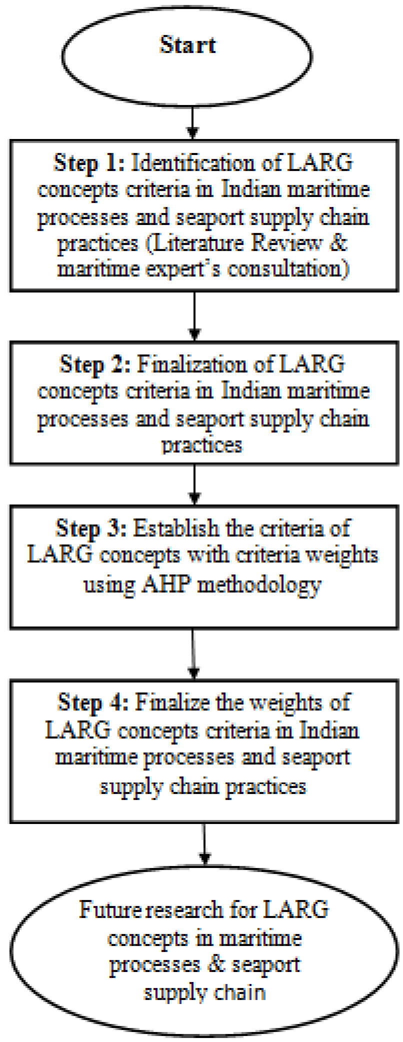

Figure 1. LARG Concept methodology framework.
Source: Authors own illustration

As per latest introductory research work by Rasidi et al. (2019) on compatibility between the LARG concept criteria's on basis of operational. economical. and environmental related performance of seaport supply chain involving maritime operations and seaport supply chain processes has been conducted. In the present research paper, the process of selecting the LARG concept criteria for maritime operations and seaport supply chain processes is conducted in two steps: (a) Listing the compatible criteria from the literature review studies across global seaports and maritime related domain for various maritime operations and seaport supply chain processes, and (b) finalizing the compatible LARG concept criteria's in consultation with maritime domain experts' and seaport employees of Indian maritime context . In the first step, the applicable LARG criteria were listed from previous maritime research studies across global seaports and maritime domain research through literature review of lean, agile, resilient and green indicators (as per Table 1).

Further, the listed in previous step will be finalized using compatibility analysis. The research analysis was conducted by selecting the criteria with average score of 3.5 and above from the outcome of maritime domain and seaport supply chain experts' consultation. Forty-three experts from maritime academic and seaport supply chain industry background have given their responses on the research questionnaire. All experts in this research study have more than 5 years of experience in the related maritime domain field and in total of 17 LARG criteria's are selected. As shown in Figure 2, three seaport performance measurements were employed to be the key criteria's in order to measure the maritime processes and seaport supply chain operations in Indian seaport context which includes operational. economic and environmental performance. LARG concepts were engaged to be the sub criteria's and 17 LARG criteria's were used as the key indicators sub criteria for the research study.

Table 1. LARG criteria's for maritime operations and seaport supplychain context for Indian seaports

LARG criteria & practices in Indian maritime and seaport supply chain context	**Criteria**	**References**
Lean	• Higher resource utilization rate • Information spreading through network • Just-in-time practice • Shorter lead time	(Azevedo et al. 2013); (Carvalho et al. 2011); (Cabral et al. 2012); (Ugochukwu et al., 2012); (Rasidi et al., 2019); (Saleh et al. 2020); (Fazendeiro, P,et al. 2013); (Lu et al.,2013)
Agile	• Excess buffer capacity • Quick response to customer needs / claim • Total marketplace visibility • Dynamic alliance	(Shahjahan et al 2000); (Azevedo et al. 2013); (Carvalho et al. 2011); (Cabral et al. 2012); (Salleh et al. 2020); (Fazendeiro, P,et al. 2013); (Lu et al.,2013)
Resilience	• Strategic inventory/ equipment resiliency • Demand visibility • Responsiveness • Risk sharing • Flexible transportation	Azevedo et al. 2013); (Carvalho et al. 2011); (Cabral et al. 2012); (Azevedo et al. 2016); (Ha et al.2016); (Rasidi, al.2019); (Salleh et al.2020); (Fazendeiro, P,et al. 2013); (Lu et al.2013)
Green	• Environmental risk sharing • Waste minimization • Renewable energy/initiative • Waste recycling	(Azevedo et al. 2013); (Carvalho et al. 2011); (Cabral et al. 2012); (Azevedo et al. 2016); (Ha et al.2016); (Rasidi, al.2019); (Salleh et al.2020); (Fazendeiro, P,et al. 2013); (Lu et al. 2013)

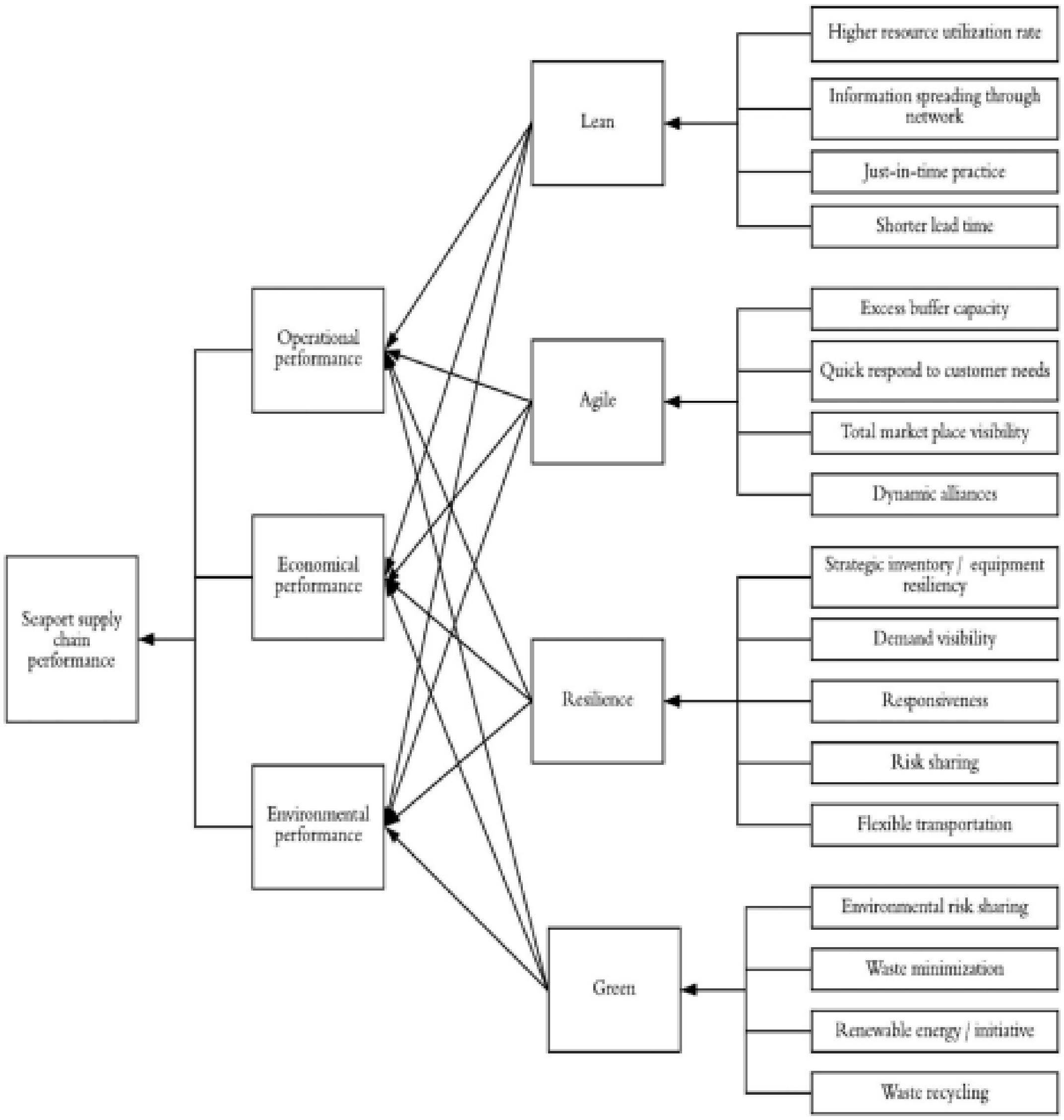

Figure 2. Mapping of the LARG criteria for Indian maritime operations and seaport supply chain context; Source: Authors own illustration.

Table 2: Comparison scale for research study

Numerical Assessment (Scale)	Meaning
1	Equally Important
3	Weakly Important
5	Strongly Important
7	Very Strongly Important
9	Extremely Important
2,4,6,8	Intermediate value in between the values

In the next step, the weights were estimated for the criteria are obtained from the study research survey. The three main stages for AHP are structuring the problem by obtaining the decision-making model, comparative judgement that obtained performance of each options and precedence analysis that weighing the alternative performance (as per Table 2). A weight can be obtained using a scale of relative importance based on a pair-wise comparison (Salleh et al., 2019). The pair wise-comparison matrix is constructed by setting up various criteria in the row and column of an n×n matrix. Then, the pair-wise comparison is executed using scale as stated in Table 3. To measure judgements on pairs of various attributes, Ai and Aj are presented by an n×n matrix A. The entries aij are defined by entry rules as follows:
Rule 1: If aij = α, then aij = 1/α, α ≠ 0; and Rule 2: If Ai is judged to be of equal relative importance as Aj, then aij = aji = 1

Using the above rule, the matrix A present as follows:

A = aij = [1 a12........ a1n]
[1/a12 1......a2n]
[.......................]
[1/a1n 1/a2n... 1] ....(1)

A weight value Wk can be calculated as follows:

Wk=1/n n,j=1Σ(akj / n,i=1Σ aij) (k = 1, 2, 3, ... , n)............(2)
To ensure the consistency of all the judgments, a Consistency Ratio (CR) is computed by using equations (3) to (5) (Salleh et al., 2020).
CI = λmax−n/(n – 1)........................... (3)
CI = λmax−n/(n – 1)............................ (4)
n j=1 Σ [n k=1Σ = wk ajk/wj]/ n........... (5)

4. Data Collection
Forty three experts from various maritime domain academicians, seaport supply chain industry experts in Indian maritime sector and seaports with a range of experience between five to twenty five years were selected. The maritime domain experts were selected as a sample in this research paper to give the comparative importance of every parent nodes for their linked child nodes respectively using an Analytical Hierarchy Process (AHP) process. The forty –three experts involved for this research study are listed as follows:

- Twenty- two seaport operations managers from traffic/marine/engineers at major seaports in India with fifteen years and above of experience;
- Nine senior seaport administration manager, commercial with twelve to twenty five years of experience;
- Three senior executive in maritime port supply chain operations with fifteen years of experience or more;
- Five senior maritime domain & seaport consultants and analysts with sixteen to thirty years of experience;
- Four senior academicians from maritime background with seven to twelve years of experience.

5. Results and Discussion
5.1 Numerical Results
Comparison matrix is engaged to obtain the weight. For example, for calculating the weight for seaport operational performance, a 4×4 comparison matrix is employed. Wl, Wa, Wr and Wg are matrix for lean, agile, resilience and green concepts for Indian major seaports respectively. Based on Equations (1) and (2), the weight calculation for the main criteria is demonstrated as follows:

$$
\begin{array}{r|cccc}
\text{Lean} & [1 & 0.56 & 0.88 & 1.27] \\
\text{Agile} & [1.79 & 1 & 1.16 & 1.18] \\
\text{Resilience} & [1.14 & 0.86 & 1 & 1.27] \\
\text{Green} & [0.79 & 0.85 & 0.79 & 1] \\
 & \text{Lean} & \text{Agile} & \text{Resilience} & \text{Green}
\end{array}
$$

Then, the weight computation is verified as:

Wl = ¼(1/(1+1.79+1.14+0.79)) +(0.56/(0.56+1+0.86+0.85))+(0.88/(0.88+1.16+1+0.79)) +(1.27/(1.27+1.18+1.27+1)) = 0.2204;

Wa = ¼(1.79/(1+1.79+1.14+0.79)) +(1/(0.56+1+0.86+0.85))+(1.16/(0.88+1.16+1+0.79)) +(1.18/(1.27+1.18+1.27+1)) =0.3100;

Wr = ¼(1.14/(1+1.79+1.14+0.79)) +(0.86/(0.56+1+0.86+0.85))+(1/(0.88+1.16+1+0.79)) +(1.27/(1.27+1.18+1.27+1)) = 0.2586;

Wg = ¼(0.79/(1+1.79+1.14+0.79)) +(0.85/(0.56+1+0.86+0.85))+(0.79/(0.88+1.16+1+0.79)) +(1/(1.27+1.18+1.27+1)) =0.2210.

As a result, the Wl, Wa, Wr and Wg are evaluated as 0.2204, 0.3100, 0.2586 and 0.2110. By using the similar computations, the results of AHP for all main and sub-criteria's are listed in Table 3.

Table 3: Relative importance of each LARG criteria's, Sub Criteria's, weights and CR values.

Goal	Main Criteria	Weights	CR	Sub-criteria	Weights	CR
Maritime operations and Seaport Supply Chain Performance of Indian Major Seaports	Operational performance	0.4012	0.4015	Lean Agile Resilience Green	0.2204 0.3100 0.2586 0.2110	0.0132
	Economic performance	0.3339		Lean Agile Resilience Green	0.2255 0.3395 0.2730 0.1621	0.0282
	Environmental performance	0.2649		Lean Agile Resilience Green	0.2343 0.1872 0.1736 0.4049	0.0157

Table 4: Relative importance of each LARG maritime operations and seaport supply chain practices for Indian major seaports

LARG Practices	Weights	CR
Lean Practices Higher resource utilization rate Information Communication Just-in-time practice Shorter lead time	 0.2539 0.2819 0.2483 0.2159	0.1000
Agile Practices Excess buffer capacity Quick respond to customer needs Total marketplace visibility Dynamic alliances	 0.1215 0.2955 0.3338 0.2492	0.0331

Resilience Practices Practices Strategic inventory/ equipment resiliency Demand visibility Responsiveness Risk sharing Flexible transportation	 0.1607 0.1834 0.2071 0.2317 0.2171	0.0499
Green Practices Environmental risk sharing Waste minimization Renewable energy/ initiative Waste recycling	 0.1772 0.1213 0.3384 0.3631	0.0466

5.2 Graphical Results

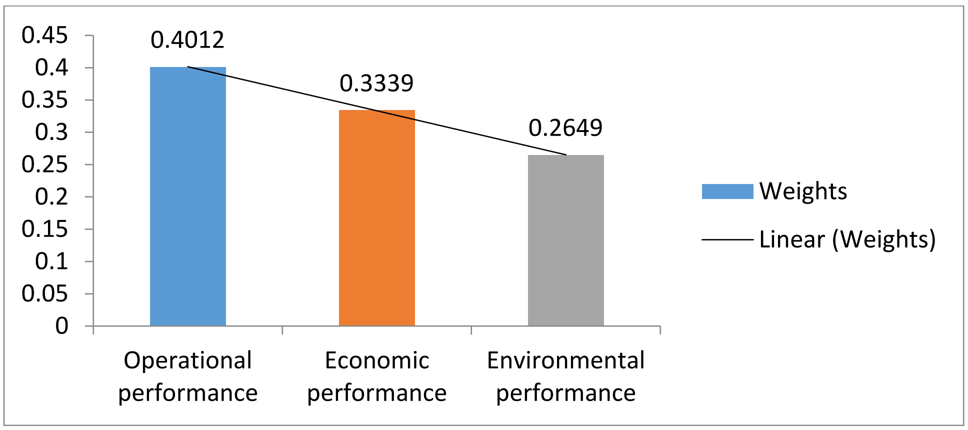

Figure 3. Relative important for LARG main criteria's.

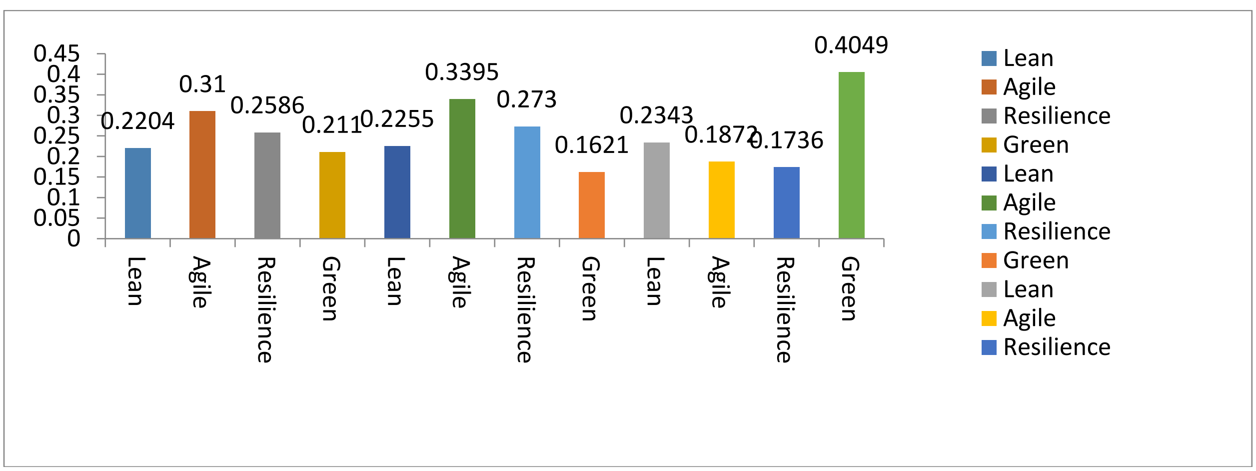

Figure 4. Relative importance for LARG main factors.

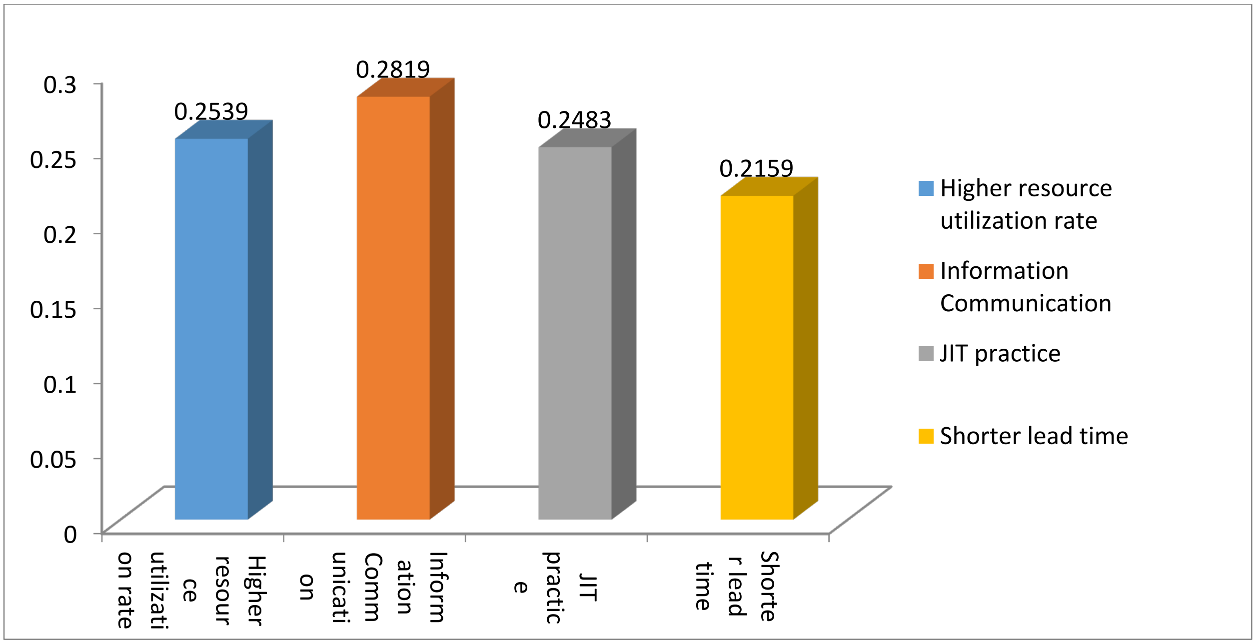

Figure 5. Relative important for Lean concepts.

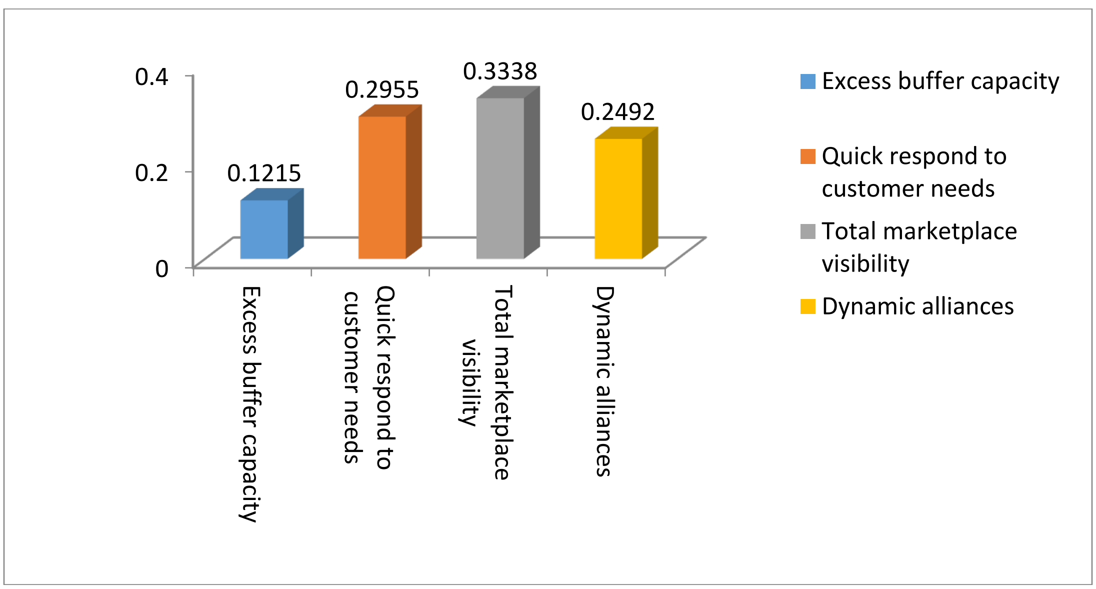

Figure 6. Relative important for Agile concepts.

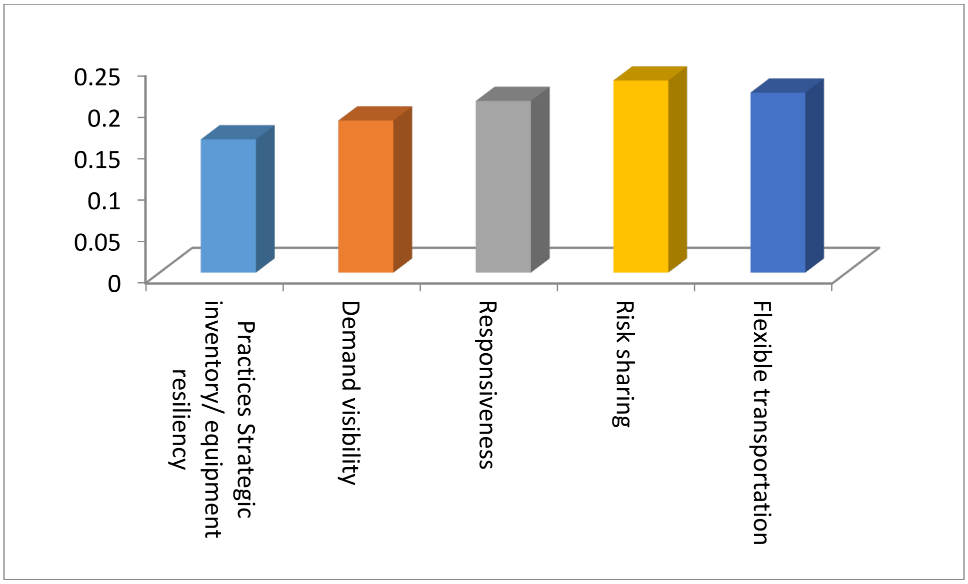

Figure 7. Relative important for Resilience concepts.

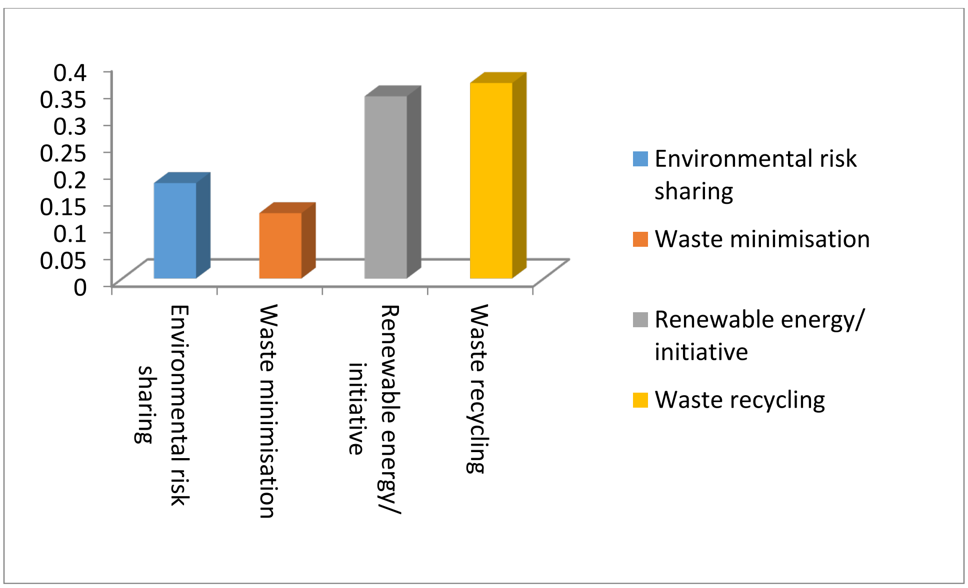

Figure 8. Relative important for Green concepts.

On the basis of the results obtained from Table 3, as for the maritime operations and seaport supply chain performance for Indian seaports, the operational performance dimension (0.4012) has the most reflective weight followed by economic dimension (0.3339) followed by environmental dimension (0.2649) related performances. For the operational performance dimension, the main principal influences by LARG paradigms are agile (0.3100), resilience (0.2586), lean (0.2204) followed by green (0.2110). For economic performance dimensions, agile (0.3395) is the most influential aspect followed by resilience (0.2730), lean (0.2255) and green (0.1621). However, green (0.4049) has the maximum value in environmental performance dimension followed by lean (0.2343), agile (0.1872) and resilience (0.1736). The relative importance for LARG main criteria's is illustrated Figure3 and comparative important of sub-criteria (LARG concept) to its linked main criterion are further illustrated in Figure 4. Using the identical AHP calculation to obtain the weight, the weight value for LARG concepts were derived. Table 4 shows the comparative important obtained for each LARG concept.

The comparative importance for lean concept is illustrated in Figure 5. Information spreading through network (0.2819) has the majority insightful weight for lean followed by higher resource utilization rate (0.2539), just-in-time practices (0.2483) and shorter lead time (0.2159). For agile concept, total marketplace visibility (0.3338) has the highest value followed by quick response to customer needs (0.2955), dynamic related alliances (0.2492) followed by excess buffer capacity (0.1215) as shown in Figure 6. Risk sharing (0.2317) has the large dominated value in resilience dimension followed by flexible transportation (0.2171), responsiveness (0.2071), demand visibility (0.1834) and strategic inventory/equipment resiliency (0.1607) and it is indicated in Figure 7.
Finally, waste recycling (0.3631) is most dominated value in green port practices followed by renewable energy/ initiative (0.3384), environmental risk sharing (0.1772), and waste minimization (0.1213) which is indicated in Figure 8.

5.3 Proposed Improvements

The result of this research paper indicates that every LARG criterion in maritime context and seaport supply chain domain has a diverse function in determining the weight of the performance measurement in the maritime processes and seaport supply chain operations in Indian maritime field. For both operational and economic performances were led by agile, different with environmental performance which has insightful influence of green dimension. This indicates that both operational and economic aspects prioritize to maximize profit and increase customer service at the similar time. Since, environmental performance is alarm about the impacts on the natural environment of maritime business and seaport supply chain goods; the highest weight value was scored by green related practices.
In the context of lean, information spreading through network has the most profound weight, due to the growth of available technology by improving the performance of spreading information between the maritime supplychain stakeholders. The usage of Information Technology allows the development of quicker, reliable and precise time information. As for the maritime process and seaport operations in India, seaport can be streamlined towards the growth of using information technology (IT), automation and electronic data interchange (EDI). In seaport, higher productivity indicates that freight moving effectively through seaport supplychain which reflects on the improvement of overall trade flow.
In order to add maximum utilization in maritime processes and seaports supply chain, it can be referred to berth occupancy ratio and port yard utilization. Just in time practice may increase the operational efficiency while decreasing waste by accepting cargo only when it is required therefore the inventory cost will decrease. Lean principle can increase optimistic customer satisfaction and reduced transport costs which eventually will be synchronized with shorter lead time by speeding the equipment operations and faster conversion of raw materials into quality products in the shortest amount of time possible (T N Prathvi et al. 2022).
Market place visibility scored the highest score since visibility means that the players able to see the problems before they occur and aware and have control over the goods from supplier until the end user .As for seaport operations, seaport can focus on its capability to forecast or predict future demand. Hence, seaports will be able to provide bigger demand or any connected issues before they occur. Meanwhile, quick response to seaport customer will reflect on the customer satisfaction and maritime supply chain business quality. It is directly associated with agile concept which is a paradigm that is directly associated with customers. In today's maritime business environment, customer satisfaction is a key factor to a successful seaport supply chain and marine business(Ha et al., 2017). Seaports must focus on responsiveness to maritime customer special request or claim which this reflect on the seaport supply chain service quality and maritime customer satisfaction. Also, relationship between various maritime alliances needs to be supported as a key prerequisite for the improvement in the maritime business quality. The seaport supply chains need an extraordinary level of co-operation between the seaport supply chain players for data and system related effectiveness.
Seaports can prominence on its ability to co-operate with maritime related alliances and their collaboration with stakeholders for system effectiveness to support their dynamic alliances. Buffer capacity in agile factor is necessary to determine flawless activities of the seaport supply chain as increasing changes in marketplace and customer requirements in order to gain competitiveness especially in the seaport sector. Seaport supply chain risk management assists maritime stakeholders to prepare and cope with disturbance to return to normal state maritime operation base on requirements by certain parties that can share the risk. Having flexible maritime transportation is significant to guarantee operational continuity and the effectiveness of transportation during cargo delivery. Responsiveness to disturbance in resilience is about the ability to return, recovering or perform to a normal or new state after a disruption which falls under user satisfaction from the perspective of service fulfillment of a seaports. Demand visibility is capabilities of seaport in continuing critical equipment functionality and business continuity of operations. In seaport operations, larger demand can lead to operation halted, delay and even deviation of operations due to the limited resources in seaports.

Consequently, it is important for seaports to forecast its potential demand to determine their capacity to accommodate volume of cargo in seaports. Strategic inventory or equipment resiliency is the organizations ability in adapt and organize the required elements as preparation in facing disruptions. Disruptions can occur routinely due either large events such natural disasters, seaport supply chain labour strikes or terrorist attacks, and even on minor machine breakdowns, supplier stock-outs, or quality related issues. These events can affect the maritime supply process and cause delays in shipping transportation and dysfunction in some of the seaport supply chain facilities and also inventory related shortages (Thumbe Narasimha Prathvi et al.,2021).

Waste recycling and its minimization aims to decrease, avoid, recycle and re-using of waste materials rather than to be disposed into the maritime ecological environment. This ensures high quality of life, hygienic environment, healthier and safer approaches in maritime related aspects. Renewable energy or its related initiatives can protect the electricity consumers from the cost adding, enhanced reliability and power quality, avoid risk and improved fuel and energy related security in maritime domain. The green initiative rise in seaports and relate maritime supply chain are trying to control shipping associated toxic waste. On the other aspect of green aspect in seaport, there is environmental risk sharing. The liquidation of risk makers in case of disasters may lead to insufficient compensation. Risk sharing also has been used in high-risk sectors in maritime sector, since it can minimize a supply chain interruption risk.

India has pledged to decrease the emissions intensity per unit GDP by 33-35% below 2005 level by 2030 and has set the target to achieve 40% national energy through renewable sources by 2030. Maritime sector in India pays a critical role in the overall trade and growth with 95% share in trade volume and 65% share in trade value. Government of India has developed the Maritime India Vision (MIV) 2030 which aims to strengthen the seaports, shipping and waterways sectors of India through concerted interventions. There have been 150 initiatives identified under the MIV 2030 (increase share of renewable energy to greater than 60% across major ports by 2030 ; reducing air emissions & air quality improvement; optimizing water usage with an aim to reduce and recycle water usage; improving water and solid waste management; port equipment electrification; LNG bunkering and safety program through zero accident safety program, and centralized monitoring system identification) to enable the ports to chalk out a roadmap in achieving the targets set out in the MIV 2030 and to take forward the vision under each segment. ‘Safe, Sustainable and Green Maritime Sector’ is one of the focus areas under the MIV.

Indian seaports have undertaken various green initiatives in line with the broad vision of the nation to be in adherence with International Marine Organization’s alignment to 9 UN Sustainable Developmental Goals (SDG) which includes obligations on safe, efficient & sustainable ports. Government of India has also proposed 100% financial assistance for developing dedicated coastal berths at ports through Sagarmala programme & offering more berths in PPP mode. Green Ports Policy (GPP) aims to expand on the initiatives under the MIV 2030 to provide guidance on potential implementation model and incentive framework for seaports with the aim to encourage stakeholders (port operators, port authorities) to implement initiatives that will reduce the impact of the sector on climate change aspects. Various novel projects have been undertaken by the seaports under support of Government of India which includes: buffer parking yard for container trailers, smart vessel traffic management system, 5G network pilot project, supervisory control and data acquisition (SCADA) system for oil pipeline operations, automated vehicle scanning, Radio Frequency Identification & Detection (RFID) scanning of personnel, drone surveillance, green warehousing system, rejuvenation of water bodies w.r.t seaports to prepare a master plan in order to become Mega Ports by 2047

6. Conclusion

In this research paper, seventeen LARG related concepts and related criteria which were compatible with seaport supply chain related practices in Indian maritime operations and seaport context were prioritized and gathered to form the LARG seaport performance model. This research model allocates the maritime and seaport decision-makers to objectify and formalize the decision on basis of pair-wise comparison of the LARG related concepts towards applying and to assessing of the level of lean, agile, resilience and green of the Indian major seaports in broader perspective. The finalized criteria in this research study will be used in assessing LARG model in maritime operations and seaport supply chain at major seaports in India by using Bayesian Belief Network (BBN) model. However, this research study has certain limitations, where the LARG practices listed in this research study can be varying from type of seaports and maritime organizations context and also on basis of geographical locations. This research study does not cover holistic maritime operations and seaport supply chain practices as the domain of activities are huge in nature, rigid, dynamic and keep changing from point in time. It is significant to point out that the identified criteria’s and related practices in this research study can be adapted to suit to the maritime practitioners and the features of the seaport supply chain or maritime business.

The finding of this research study involves incorporation about modelling LARG related concepts performance in maritime operations and seaport supply chain activities of Indian context and result of this paper can be utilized to support seaports to be competitive among their customers and seaport related stakeholders to ensure the operational sustainability aspects of the seaports and also includes support towards economic growth. This research paper guides to innovative scope towards maritime and seaport domain research to establish the dependency of LARG (lean, agile, resilience and green) key dimensions based on its concepts and to investigate the applicability of the proposed model by assessing the LARG performance in the maritime operations and seaports supply chain. To evaluate the LARG performance in the seaport supply chain and maritime operations several seaports across the geographical locations and cargo position-wise can be chosen as test cases for the research.
This research study will also support maritime domain experts and seaport practitioners, decision makers to comprehensively develop a holistic substantial management concept to boost the seaport performance in efficiency and effectiveness aspects. This research study can further also support associated maritime and related seaport entities with stakeholders towards enhancing of the trade capabilities, operational efficiencies and competitive improvements of seaports supply chain and maritime operational activities.

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