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Assessing Barriers in Humanitarian Supply Chains for Cyclone in Coastal Areas of Bangladesh: An Interpretive Structural Modeling (ISM) Approach

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Abstract: Bangladesh has frequently been affected by natural hazards, notably, cyclones in coastal areas. Humanitarian organizations are always active in helping affected communities through effective humanitarian supply-chain management by providing humanitarian goods and services, which is crucial to aiding vulnerable people after a natural catastrophe. However, some factors cause significant difficulties in achieving feasible humanitarian supply-chain (HSC) management that eventually ends up as a disfunctional and ineffective system to support to the community in need. Therefore, a lack of standard logistics support complicates horizontal cooperation between humanitarian organizations at various stages, along with relief aid. The motive of the paper is to identify and understand the barriers of HSC during the disaster preparedness and immediate response phase, particularly for cyclones in the coastal areas of Bangladesh. Through an extensive literature review and consultation with experts from different humanitarian organizations, 10 barriers were identified. To illustrate the structural relationships among the selected barriers, an interpretive structural modeling (ISM) approach with additional MICMAC (Matriced' Impacts Croisés Multiplication Appliquée á unClassement) analysis is used for data analysis. This aids in evaluating relative dependencies and driving power among the selected barriers. Findings show that a lack of an integrated approach and coordination among government and other humanitarian stakeholders, the inefficacy of multilateral information sharing among them, and a shortage of experienced logisticians are the barriers with the highest driving powers in HSC. The findings of this study will help humanitarian experts, aid agencies who distribute humanitarian aid, and organizations, to set up a good supply chain for helping people in the coastal area of Bangladesh following cyclones.

Keywords: cyclone; humanitarian supply chain; barriers; interpretive structural modeling; MICMAC analysis; coastal area; Bangladesh

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1. Introduction

The humanitarian supply chain (HSC) is an emerging field and has gained importance in the recent past. It is fundamental to provide adequate humanitarian aid to affected communities after a natural catastrophe occurs. In a humanitarian-supply-chain system, the core value and fundamental motive is to assist and provide for the community who needs help in the form of goods and services. Affected communities are very delicate after the occurrence of a natural-hazards-induced disaster because they suffer from a lack of drinking water, medicine, food, shelter, and mental support as well. An effective humanitarian supply chain helps to deliver essentials to a vulnerable community in need of aid assistance. In the context of Bangladesh, it is a disaster-prone country and has constantly suffered from natural-hazard-induced disasters for decades. Tropical cyclones pose a particular danger to a developing nation such as Bangladesh, given that the coastal regions are annually ravaged by these deadly storms [1–3]. Coastal communities have always been a victim of natural hazards. After a disaster, the most important action is a proper response to the affected community with humanitarian relief and aid assistance, which is possible with an effective humanitarian supply chain (HSC). A successful HSC helps in alleviating the suffering of affected people, who are extremely vulnerable and exposed to disasters [4–6]. However, there are some barriers in humanitarian-supply-chain management that damage the system's effectiveness; therefore, this issue needs systematic attention and a feasible planned approach. Disasters disturb the concerned population of developing countries, which leads to human, financial and material losses that make it difficult for a population's capacity to control the situation [7]. On account of reducing the adverse impacts of cyclones and improving the function of HSCs, many practitioners, academicians, and aid practices are prioritizing and emphasizing several diverse factors of the HSC by dividing them into different clusters. Standardization in humanitarian logistics is considered as a way to improve performance [8]. The supply chain needs a massive amount of preparedness and resources, such as money, relief items, and human resources, because relief efforts are thought to be very complicated and require proper handling to achieve quicker and better responses [9]. It is widely considered that proper maintenance of the supply network influences the success of emergency-relief distribution procedures. Some of the challenges in the entire HSC are a lack of adequate maintenance, transparency, monitoring, and expert logisticians [10]. Therefore, it is essential to acknowledge the whole system of HSC and the factors that affect its efficiency. It is more crucial to identify the interrelationship among the factors to establish a successful humanitarian aid service for affected communities. This paper intends to find out the relevant barriers and establish the contextual relationships among them through interpretive structural modeling (ISM). It will help in assessing the complexity of the chain to make better decisions and will answer some research questions, such as;

(a) What are the major barriers to an HSC system for cyclone in coastal areas of Bangladesh?
(b) How do those barriers interact with each other and affect the HSC system?
(c) How does the ISM approach formulate a hierarchical model considering the barriers and their contextual relationship?

This work focuses on the following objectives:

(a) To identify the list of barriers to a proper HSC in cyclone-affected areas of Bangladesh.
(b) To determine the interaction between the barriers and develop a hierarchical model considering HSC through the ISM approach.

The related literature reveals a lack of research in the context of the HSC regarding disasters in Bangladesh. Furthermore, barriers in HSC have not been found, which creates a research gap. As a result, there is no literature written about the gap between the government and NGOs, despite many people claiming this problem exists in HSCs [4]. Several studies have already addressed HSC management from different perspectives, such as the supply-chain agility of an Indonesian humanitarian organization, a systematic literature review which assessed the performance and management of HSCs, and another study suggesting the collaborative research methodologies to apply to HSCs [11–13]. However, a lack of research works were discovered that could demonstrate the barriers, and the contextual relationships between them, in an HSC regarding the cyclone context of Bangladesh, particularly by using an ISM approach. After the execution of key informant interviews, the research gap was understood more clearly. As research work on this matter of the humanitarian supply chain, especially for the barriers within the system, were not available in the scientific community, some raw concepts were extracted from the interviews of experts from different humanitarian and relief organizations, which were unavailable in the relevant literature. This study attempts to compensate for this research gap and demonstrate the contextual relationship among the barriers in HSCs by using the ISM approach. The study will help people in charge of making decisions find out the problems with HSC and how they relate to each other. It will help organizations or the government deal with critical situations in HSC management in the case of disasters, especially cyclones.

2. Materials and Methods

2.1. Study Area

The coastal area of Bangladesh covers more than 20% of the country's total land area and more than 30% of its cultivable land, and it is home to a broad range of habitats, including the world's largest single mangrove swath, seashores, dunes, coral reefs, and marshes (Figure 1). Bangladesh's people benefit from its rich natural settings, which provide a variety of goods and services [14]. Jessore, Narail, Khulna, Bagerhat, Pirozpur, Jhalaka, Patuakhali, Bhola, Lakshmipur, Gopalgan, Shariatpur, Chandpur, Satkhira, Feni, Noakhali, Chittagong, and Cox's Bazar are Bangladesh's 19 coastline districts. People living in coastal regions, where the majority of people live in poverty, are subjected to several natural hazards every year, such as cyclones. Bagerhat, Bhola, Noakhali, and Satkhira districts have higher poverty levels than the national average. Furthermore, these areas face food, income, water, fitness, and poverty challenges [15]. Overpopulation, rapid environmental change, and coastal pollution are only a few of the key concerns that make the coastal area more vulnerable to disaster.

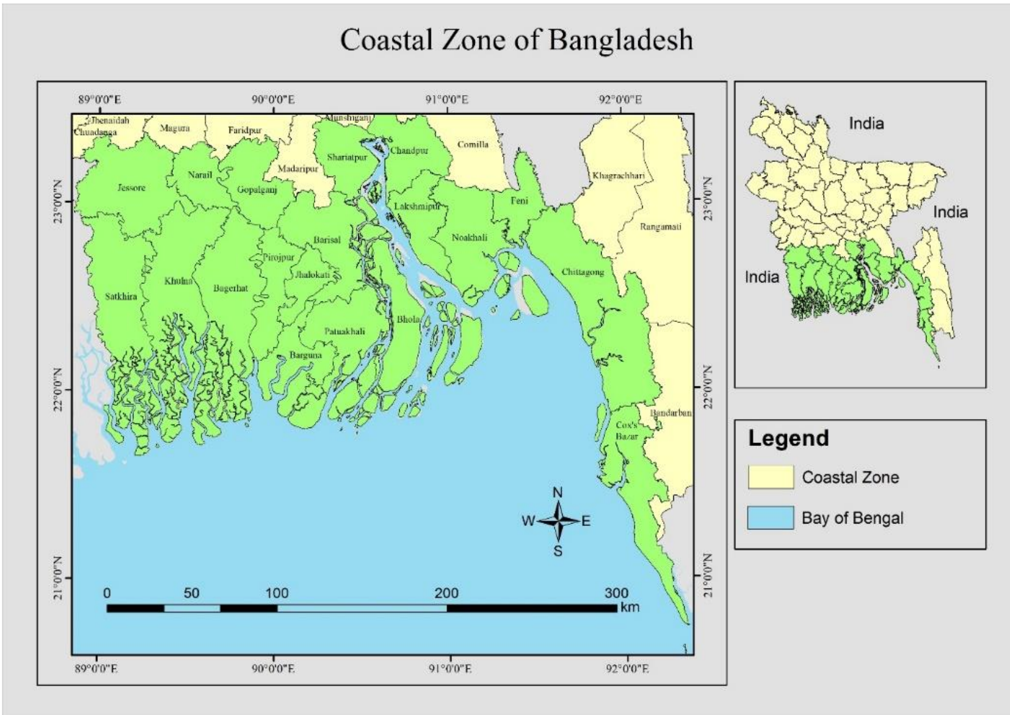

Figure 1. The coastal belt of Bangladesh (Source: prepared by the authors).

2.2. Interpretive Structural Modeling

The determinants impacting the HSC were identified using ISM and expert sampling methodologies in this study. The KII (key informant interview) method was used to conduct discussions with ten experts from various government and non-government organizations involved in the cyclone-preparation and response phases, and ISM was deployed as a tool. John N. Warfield originally developed ISM in 1976 [16].

ISM is a computer-assisted technique for creating graphical representations of system composition and structure. It is a collaborative learning strategy that combines a number of directly and indirectly connected aspects into a holistic model [17]. This interpretive structural modeling is a way to obtain a structured understanding of a problem by using different data and information that consultants gave [18]. This methodology is interpretive because it relies on group consensus to determine whether and how the various components are related. A general structure is derived from the intricate collection of components on the basis of their reciprocal relationships. The interactions between the many components of a system's complexity can be made more orderly and directed through this model. There are some other methods in terms of determining the primary influencing elements and building multi-level hierarchical structured models of them, such as TISM, IRP, DEMATEL, etc. [17]. However, the ISM approach was selected as the method for this research because it is more structural and systematic than the other methods. Decisions concerning interdependencies among variables in ISM techniques are interpretive in nature since they are based on the expert committee's experience [19]. The aims of using ISM are to investigate challenging barriers by using systematic and logical thinking supported by expert knowledge [20]. It can achieve significant outcomes with fewer experts. According to the existing literature, ISM is a well-established approach that may be employed without difficulty [21]. It has a wide range of applications. ISM was used to identify the barriers to humanitarian logistics and the supply chain in this article [22]. ISM can be utilized in a group setting as well as in an individual setting. The following are the steps to completing the ISM:

Step 1: Determine the factors and create a list of HSC barriers through a rigorous literature review and expert consultation (Table 1).

Table 1. List of barriers in the humanitarian supply chain for cyclones in the coastal area of Bangladesh.

Factor No	Barriers	Description of Barriers	Sources
F1	Lack of integrated approach and coordination among different stakeholders (GOs, NGOs and INGOs).	Coordination lack among relevant stakeholders is one of the most influential barriers.	[8–10]
F2	Lack of multilateral information sharing among GOs and other stakeholders (NGOs and INGOs).	Information gap and proper information sharing among relevant stakeholders is crucial because it determines transparency and leads to important decision making.	
F3	Improper need and loss assessment including (both for disaster preparedness and response phase).	Before any response is ensured in the form of goods and services, a calculative analysis of total need and loss is essential to ensure adequate aid to the vulnerable community.	[9,10]
F4	Lack of experienced logisticians.	Experts provide the best solution to the worst situation. Therefore, lack of experienced logisticians is a strong barrier.	
F5	Awareness among community (That leads to force evacuation and exceeding of logistic cost and time).	Unaware people bring trouble to the logistic team because it needs extra attention, money, and time to manage them.	[9]
F6	Improper distribution (equity issue).	Improper distribution due to biasness or error in the logistical calculation bring mismanagement.	
F7	Duplication effort among NGOs/Conflict among humanitarian organizational structure and culture.	Providing similar humanitarian aids by the stakeholders decrease the efficacy and motive of humanitarian supply chain. Different aid agencies should provide different goods and services to avoid repetition.	[10]
F8	Chaos and violence among community.	Impatient behavior can bring disorder and disfunction to the HSC system.	
F9	Inefficacy in cluster approach.	Lack of coordination and operational error can bring failure to the cluster approach.	[8]
F10	Lack of transparency.	Lack of accountability and difficulties in information flowing create lack of transparency.	

Step 2: Create a matrix of the contextual links between the selected barriers through expert consultation.

Step 3: Utilize the factors to generate a structural self-interaction matrix (SSIM), which illustrates the pair-wise interactions between system components. This structure uses symbols to indicate the direction of a relationship between two variables (i,j), as indicated by the notations,

- P for the connection from element i to element j and not both ways.
- Q for the connection from element j to element i, but not both ways.
- R for all relationships from i to j and j to i.
- S, if the connection between the elements does not appear valid.

Step 4: Use the SSIM to create a reachability matrix, which is then checked for transitivity. The notations are translated into 1 and 0 with some special indications to produce the reachability matrix.

- P = (i, j) is 1 and (j, i) is 0 if 'i' is a predictor of 'j'.
- Q = (j, i) is 1 and (i, j) is 0 if 'j' is a predictor of 'i'.
- R = (i, j) is 1 and (j, i) is 1 if 'i' and 'j' predict each other.
- S = (i, j) is 0 and (j, i) is 0 if neither one predicts the other.

Step 5: Step 4 generates the final reachability matrix, which is divided into four stages or levels based on the factor elimination process.

Step 6: Create a graph using the final reachability matrix, and then display the transitive relations.

Step 7: Create the ISM by replacing element nodes using the resulting graph and expert opinions.

Step 8: Finally, examine the theoretical inconsistencies in the ISM model established in Step 7. Make additional adjustments if necessary.

2.3. MICMAC Analysis

Michel Godet and François Bourse developed the Matrice d'impacts croisés multiplication appliquée á un classment (MICMAC) analysis [23]. MICMAC is a prospective structural analysis used to examine indirect linkages [24]. In an indirect association, three variables and their direct impacts may be observed: variable X influences variable Y, variable Y influences variable Z, X and Z have no direct effect, but their association with Y is a cross-correlation in which any change in X will influence Z. This analysis is often referred to as grey-area exploration [25]. It complements the ISM approach by investigating limitations that are often associated with the ISM method: it examines the relation "yes" or "no" and disregards the so-called gray region between 0 and 1 [6]. MICMAC analysis entails the creation of a graph that categorizes variables according to their driving power and dependency power. The study uses MICMAC analysis to identify and evaluate the ISM variables in order to obtain its results and conclusions.

2.4. Data Collection and Data Analysis

The barriers in the humanitarian supply chain were identified under a systematic procedure. Firstly, we performed rigorous literature reviews to identify the barriers in the case of HSC for the cyclone in Bangladesh (Table 1). The authors selected the ten most significant barriers after a rigorous literature review and consulting with experts from different GOs, NGOs, and academia through structured questionnaires and KII. Fifteen experts involved in humanitarian efforts for cyclones on behalf of their organizations participated in the interview. The experts represented a variety of humanitarian organizations, including Bangladesh Rural Advancement Committee (BRAC), Bangladesh Red Crescent Society (BDRCS), Cooperative for Assistance and Relief Everywhere (CARE), Action Aid, Department of Disaster Management (DDM), Disaster Management (DM) Watch, and Union Nirbahi Officer (UNO) of Shitakundo and Satkhira. The investigation was conducted by considering ten potential parameters after consulting with experts. Below is a detailed explanation of the data evaluation procedure. The results from ISM approach follow from Tables 1–5.

Table 2. Structural self-interaction matrix (SSIM).

Factor No	F10	F9	F8	F7	F6	F5	F4	F3	F2	F1
F1	R	R	P	P	P	S	Q	P	R	
F2	R	R	P	R	P	S	Q	P		
F3	Q	R	P	P	P	S	Q			
F4	R	P	P	P	P	S				
F5	S	S	P	S	P					
F6	Q	Q	R	Q						
F7	Q	Q	P							
F8	Q	Q								
F9	R									
F10										

Table 3. Initial reachability matrix based on SSIM is below.

Factors	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
F1	1	1	1	0	0	1	1	1	1	1
F2	1	1	1	0	0	1	1	1	1	1
F3	0	0	1	0	0	1	1	1	1	0
F4	1	1	1	1	0	1	1	1	1	1
F5	0	0	0	0	1	1	0	1	0	0
F6	0	0	0	0	0	1	0	1	0	0
F7	0	1	0	0	0	1	1	1	0	0
F8	0	0	0	0	0	1	0	1	0	0
F9	1	1	1	0	0	1	1	1	1	1
F10	1	1	1	1	0	1	1	1	1	1

Table 4. Final reachability matrix.

Factors	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	Driving Power
F1	1	1	1	1 [a]	0	1	1	1	1	1	9
F2	1	1	1	1 [a]	0	1	1	1	1	1	9
F3	0	0	1	0	0	1	1	1	1	0	5
F4	1	1	1	1	0	1	1	1	1	1	9
F5	0	0	0	0	1	1	0	1	0	0	3
F6	0	0	0	0	0	1	0	1	0	0	2
F7	0	1	0	0	0	1	1	1	0	0	4
F8	0	0	0	0	1 [a]	1	0	1	1 [a]	0	4
F9	1	1	1	0	0	1	1	1	1	1	8
F10	1	1	1	1	0	1	1	1	1	1	9
Dependency Power	5	6	6	4	2	10	7	10	7	5	

[a] Addition of transitivity within the initial reachability matrix based on this final reachability matrix, level partitioning was performed in the following steps.

Stage 1: Identify the most significant barriers to Bangladesh's HSC for the cyclone. Table 1 shows the barriers to the HSC.

Stage 2: Using expert guidance, generate the structural self-interaction matrix (SSIM) at this stage, creating a matrix of the contextual links between the chosen barriers. The structural self-interaction matrix (SSIM) of identified barriers is displayed in Table 2. Initial Reachability reachability matrix based on SSIM is showing in Table 3.

Stage 3: Using Step 4, generate the final reachability matrix at this stage. Table 4 displays the concluding reachability matrix. From Table 4, each individual's driving and dependency ability is determined. As stated in the MICMAC analysis, this calculated driving and dependence power was incorporated into the MICMAC analysis.

Table 5. Level partitioning.

Factor No	Reachability Set	Antecedent Set	Intersection Set	Level
F1	1, 2, 3, 4, 6, 7, 8, 9, 10	1, 2, 4, 9, 10	1, 2, 4, 9, 10	IV
F2	1, 2, 3, 4, 6, 7, 8, 9, 10	1, 2, 4, 7, 9, 10	1, 2, 4, 7, 9, 10	IV
F3	3, 6, 7, 8, 9	1, 2, 3, 4, 9, 10	3, 9	III
F4	1, 2, 3, 4, 6, 7, 8, 9, 10	1, 2, 4, 10	1, 2, 4, 10	IV
F5	5, 6, 8	5, 8	5, 8	II
F6	6, 8	1, 2, 3, 4, 5, 6, 7,8, 9, 10	6, 8	I
F7	2, 6, 7, 8	1, 2, 3, 4, 7, 9, 10	2, 7	II
F8	5, 6, 8, 9	1, 2, 3, 4, 5, 6, 7, 8, 9, 10	5, 6, 8, 9	I
F9	1, 2, 3, 6, 7, 8, 9, 10	1, 2, 3, 4, 8, 9, 10	1, 2, 3, 8, 9, 10	III
F10	1, 2, 3, 4, 6, 7, 8, 9, 10	1, 2, 4, 9, 10	1, 2, 4, 9, 10	IV

3. Results and Discussion

Every year, Bangladesh is ravaged by tropical cyclones, and, as a result, the coastal community requires quick humanitarian supplies and aid via a well-organized and efficient humanitarian supply network [26,27]. In addition, humanitarian logistics ensures the efficiency of the movement of goods.

The relief chain is designed to offer humanitarian aid in the form of food, water, medication, shelter, and other resources in disaster-affected areas [28]. However, studies of different literature reveal that the management and dissemination of humanitarian aid to victims faces some barriers, affecting the whole humanitarian-supply-chain management [29]. According to the research [30], the HSC for cyclones in Bangladesh is unstable, unpredictable, and challenging to adapt to the demands of the afflicted population. Table 1 presents the 10 barriers (with sources) identified in HSC for the cyclone in the coastal area of Bangladesh.

After identifying the barriers, we applied the ISM.

Table 5 explores the reachability set, antecedent set, and interaction set for level placement. The antecedent set consists of both the barriers and the supplementary barriers that will aid in locating them. The intersection set is derived from reachability, and the antecedent set of identified shared barriers between the two sets. If the reachability and antecedent barriers are identical, the first level is assigned and placed at the top of the ISM hierarchy. After finishing the initial phase, the second level is obtained by skipping the initial level. It shows that factors 6 (improper distribution) and 8 (chaos and violence among the community) were assigned to the first level due to their significant dependency power (Table 3). In contrast, factor 1 (Lack of integrated approach and coordination among different stakeholders), factor 2 (Lack of multilateral information sharing among GOs and other stakeholders), factor 4 (Lack of experienced logisticians), and factor 10 (Lack of transparency) were assigned to level 4 due to the highest driving power (Table 3).

The major contribution of the study is to identify barriers and their contextual links in order to construct a hierarchical model of the barriers to establishing an effective HSC for cyclones in Bangladesh's coastal districts. The ISM model is used to determine the relationships among the specified barriers to adopting humanitarian-supply-chain management (HSCM), and a structural model (hierarchical model) is created. Both the driving power and the dependent power of each barrier are derived using this model. The ISM approach to analysis shows that there are some separated levels, which can be seen in Figure 2 as a hierarchical tree.

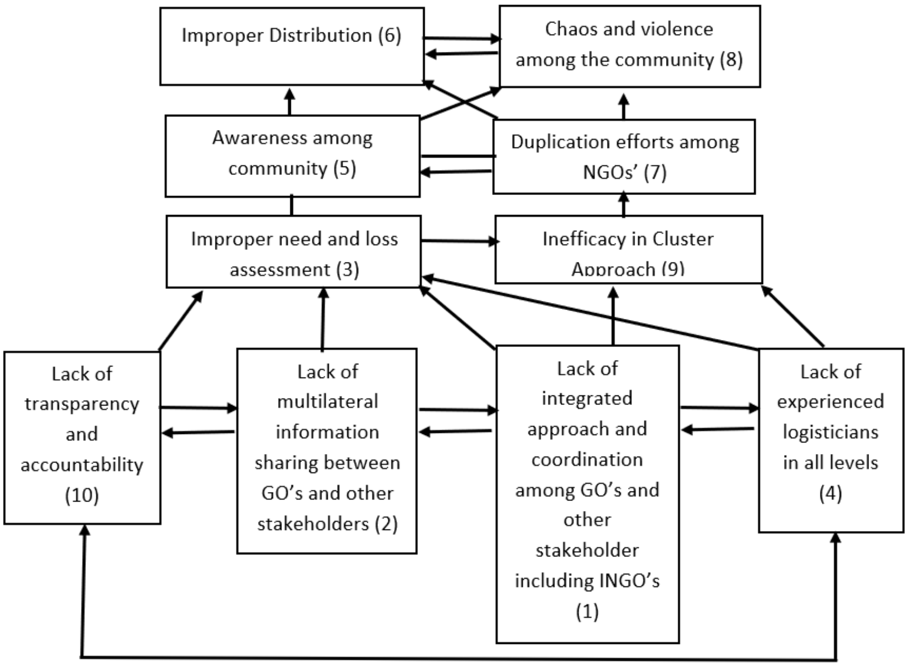

Figure 2. Hierarchical tree of different levels based on the previous steps.

Over the past decade, the number of natural-hazard- and human-induced disasters worldwide has increased considerably. This condition poses challenges for governments and necessitates coordination between governments and other stakeholders, such as humanitarian groups, in order to improve the efficiency and efficacy of disaster response operations [11]. Aid organizations must establish supply chains for the collection and distribution of relief commodities and other essentials to recipients [31]. HSC operations include preparation and planning, procurement, transportation, warehousing, and distribution (delivery) to disaster-affected communities [32]. Due to the unpredictability of natural hazards, such as cyclones, HSC may encounter various barriers. Bangladesh, a nation prone to cyclones, is impeded by a number of these barriers, as demonstrated by our research. According to our knowledge, this is the first study to examine the barriers to HSC for cyclones in Bangladesh using the ISM approach. There were several approaches utilized to evaluate HSC from various viewpoints [11–13]. However, ISM could provide the outcome in a structured manner.

Our finding shows the hierarchical model of HSCM barriers and the driving and dependent powers. It was already found, in Table 3, that barriers such as a lack of an integrated approach and coordination among different stakeholders, lack of multilateral information sharing, lack of transparency, and lack of experienced logisticians have the highest driving power. In contrast, improper distribution has the lowest driving power. For that reason, the lack of an integrated approach and coordination among different stakeholders, the lack of multilateral information sharing among different stakeholders, the lack of transparency, and the lack of experienced logisticians were placed at the bottom level of the tree structure (level 4) because they have the highest driving power. Hence, these factors influence most of the barriers at the upper levels (Figure 2). On the other hand, lack of awareness has the lowest dependency power. However, improper distribution, chaos, and violence among communities have the highest dependency power, with lower influence on the bottom level. Constantly, disaster preparedness requires efficient cooperation among stakeholders [33]. Programs for disaster management entail an intricate network of institutional connections. These include national and local government bodies, corporations and private-sector associations, non-government organizations, volunteer groups, the academic community, the media, and foreign funding agencies. Some communities impacted by or susceptible to natural hazards have also created groups for disaster preparedness [33].

Coordination among these groups, therefore, remains a formidable barrier for all concerned stakeholders [34]. Study also identified a lack of transparency one of the main barriers for humanitarian organizations [35]. The Grand Bargain, one of the primary initiatives of the 2016 World Humanitarian Summit, ties 22 of the greatest government humanitarian contributors and 31 of the largest humanitarian organizations to ten goals, the first of which is improved transparency [36]. Specifically, "The Grand Bargain commits [them] to ... demonstrate how funding moves from donors down the transaction chain until it reaches the final responders and, where feasible, affected people" [36]. The findings of a study indicate that the process by which transparency might improve the effectiveness of humanitarian logistics following a disaster relief operation must be investigated. Information is essential for greater inter-agency cooperation during emergency responses [37]. The coordination of the deployment of information and communication technology and the coordination of information management procedures are significant instruments for providing this information [38]. Due to the unpredictability of disasters, the difficulty in making decisions, and the absence of disaster-related training and education for logisticians, there is a widespread scarcity of skilled logisticians in the HSC sector. Previous research has demonstrated similar difficulty in HSC for disaster management [39]. Our result found that improper distribution, chaos, and violence among the community are positioned at the top of the hierarchical tree (level 1). The directions among the factors from bottom to top indicate the interactions among the factors. With goodwill, economic gain, and a strategic approach, this finding will help many nonprofits and managers gain a competitive edge.

The levels of each barrier were not only proven through this ISM model but also some literature reviews, which can also be used as evidence. For example, a lack of bonding between the stakeholders decreases the efficacy of an HSC system due to a lack of coordination, adequate information sharing, and transparency [8]. Furthermore, this initial single obstacle can trigger the other factors to become barriers of HSC, such as the occurrence of duplication among the NGOs, the incapability of the system to find the best logisticians, and making the community aware of their assistance during the response phase [9]. Again, these cause dysfunction in the cluster approach, where the government fails to maintain the uniqueness of each cluster [8]. According to the literature reviews, bottom-level barriers are also the strongest and most influential barriers among all the obstacles in an HSC system. An additional process is conducted to evaluate the validity of the ISM model's results.

Thus, MICMAC analysis (Figure 3) demonstrates that the ISM model of the identified obstacles is accurate. The driving-power-dependence power graph helps put the different obstacles to HSC into groups. A lack of skilled logisticians (Factor 4) was identified in the independent quadrant. Factors in the independent quadrant carry high driving power and low dependent power. It is very important for HSCM to work in Bangladesh's coastal districts in cases of a cyclone. On the other hand, in the dependent quadrant, there is wrong distribution, duplication of efforts, chaos, and violence among the community (Factors 6, 7, and 8). These barriers have the highest dependent power and the lowest driving power. These are the weakest barriers of all. Moreover, some of the factors are placed in the rest of the two quadrants. The lack of awareness in the community (Factor 5) is seen as an independent factor from the point of view of the case. This means that it is not part of the system. Lastly, the linkage quadrant shows that the last two barriers (Factor 3, ineffectiveness of the cluster approach, and Factor 9, improper need and loss assessment) have high dependence power and high driving power. However, a lack of an integrated approach and coordination among different stakeholders, as well as a lack of transparency, are in the middle of the list of independent and linkage factors. This shows that these are both independent and linkage barriers.

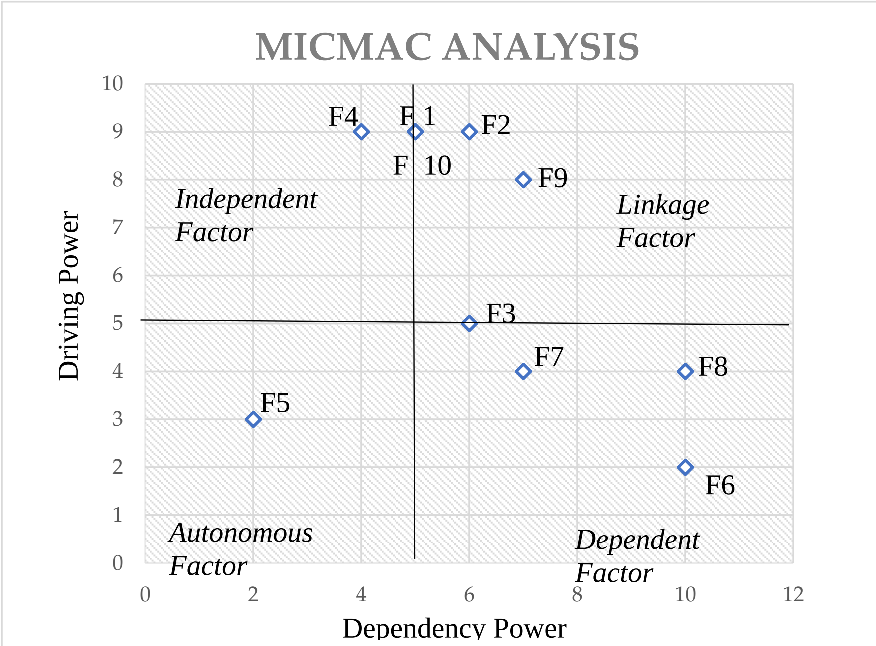

Figure 3. MICMAC analysis of the barriers.

Therefore, it is evident that factors 1, 2, 4, and 10 are the most important barriers, which pose the highest negative impact on the effectiveness of the humanitarian supply chain. These barriers are the lack of an integrated approach and coordination among different stakeholders; a lack of multilateral information sharing; a lack of transparency; and a lack of experienced logisticians. If the relevant parties analyze this study inside the humanitarian supply chain, many difficulties would be addressed and resolved, and a more effective humanitarian supply chain could be secured. If the government sets strong risk-management and organizational-structure norms for the development of a contemporary HSC structure, only then will the organizations that work for disaster management adopt the necessary procedures and strategies to guarantee its proper implementation. These activities will speed up and develop an effective communication system, as well as information technology and a risk-assessment strategy. This will help aid agencies to create a solid coordination and partnership framework.

All of these efforts will contribute to the development of a good infrastructure and transportation system, as well as effective local procurement and donation management, enough professional employees, and a flexible inventory system. Consequently, disaster-management organizations in Bangladesh will attempt to incorporate the HSC management system into their policies in order to fight natural-hazard-induced and human-induced disasters.

4. Implications

This study has a strong future direction to the research community. In addition, the findings from this study may assist the relevant government and non-government organizations in preparing an effective cycone-response strategy from a national and international perspective. Additionally, this study will be helpful for the concerned authorities and practitioners to understand the humanitarian-supply-chain system so that any inefficiencies in the system can be reduced. For example, affected communities will obtain relief aid on time according to their need and aid agencies will be able to provide all humanitarian goods and services such as food, medicine, water, shelter, support with their maximum level of professionalism. In addition, an effective HSC for the cyclone-prone areas in the coastal regions of Bangladesh can be ensured considering those barriers. The authors suggest performing deep exploration on the given research study to find research gaps to continue for better solutions in the HSC system, so that it can serve its motive towards the people who are in need of humanitarian assistance and aid during the response phase when a cyclone hits the country.

5. Conclusions

Bangladesh is notably susceptible to frequent natural hazards because of its geographical location, landscape features, diversity of rivers, and monsoon climate. It witnessed 219 natural hazards between 1980 and 2008 [40]. The coastal morphology of Bangladesh affects the impact of natural hazards on the area [40]. Cyclones are one of the major natural hazards in Bangladesh that may cause damage, and the people who live by the shore are generally the ones that suffer the most compared to those who live in other parts of the country because of the geographical condition. Coastal inhabitants of Lakshmipur, Bhola, Feni, Noakhali, Chandpur, Bagerhat, Satkhira, Khulna, Shariatpur, Pirozpur, Patuakhali, Barguna, Jhalakata, Barisal, Chittagong, and Cox's Bazar are more likely to be impoverished than the rest of the region. This is because natural hazards directly impact them, and, sometimes, they are forced to change their livelihood patterns. Different organizations and stakeholders are working together in the process of the HSC for the cyclone in the coastal areas of Bangladesh. Still, a large number of factors act as barriers in the HSCM system and make the situation more complex [41]. To identify these barriers and know the contextual relationships among them, it is necessary to use ISM, because it helps to find the most significant barriers in a structured way and make a hierarchy [42]. The barriers to the HSC for cyclones in Bangladesh's coastal areas were identified in this study, and the contextual interaction between those barriers was evaluated using the ISM approach. The results of the study show barrier numbers 1, 2, 4 and 10 have the highest driving power, and, thus, they secure their place at the bottom of the hierarchical structure, constituting the most influential barriers in the HSC system. Therefore, if these barriers are not taken into correct consideration, the whole HSC will certainly collapse. On the other hand, barriers numbered 6 and 8 have the lowest influence on the other barriers, but have the highest dependency power. The rest of the barriers were placed in between, according to their levels. The result from MICMAC analysis provides a visual idea that indicates the types of the barriers according to their driving and dependency power. Though this study found out some major aspects of the humanitarian supply chain system in terms of finding barriers and the contextual relationship of those barriers among the system, there are still some limitations of the study that will be considered for future research. One of the limitations is that there are many variables that are used in ISM, which creates a problematic scenerio. As many variables are used, they may create complexity in the ISM methodology. Furthermore, the ISM model has not been properly statistically validated [15]. This model needs experts opinions to finalise the driving power and dependence variables on problematic issues [14].

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