Examining Critical Success Factors to Humanitarian Supply Chain of Bangladesh: An Interpretive Structural Modeling (ISM) Approach

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Abstract

There is an increasing rate of occurrence of natural or human-made calamities in the present time. So,the issue of humanitarian supply chain needs more attention with strategic and planned approaches. To control the occurrence of calamities and to strengthen the post calamities relief system, professionals and academics are giving importance to several driving factors of the humanitarian supply chain. Public and private sectors of Bangladesh lack in expertise and planned infrastructure to tackle the adverse effect of disasters. This paper aims to find out the ranking and contextual relationships of the critical success factors (CSFs) of the humanitarian supply chain in the context of Bangladesh. An interpretive structural modeling (ISM) approach along with MICMAC (Matriced' Impacts Croisés Multiplication Appliquée á unClassement) analysis has been undertaken in this study to depict the relative dependence and driving power among the identified critical success factors. 'Government rules toward risk management and organizational structure' is the most influencing CSFs that may impose pressure on the disaster management organizations to implement humanitarian supply chain practices to tackle the adverse effect of disasters. This research will be useful to practitioners to carry out effective operations of the humanitarian supply chain.
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Keywords: Humanitarian supply chain (HSC), Critical success factors (CSFs), ISM , Natural disasters, Man-made disasters.

1. Introduction

Humanitarian supply chain (HSC) focuses on the activities of alleviating the sufferings of vulnerable people while pursuing the regular activities of supply chain i.e. planning, implementing, controlling efficient, cost-effective flow of goods with relevant information from the source to the end of consumption [1]. Briefly, humanitarian supply chain mobilizes people, resources, skills,knowledge and expertise to help vulnerable people who are badly affected by natural calamities or man-made disasters [2]. Interpretive Structural Modeling (ISM) approach can be successfully employed to find out the ranking of success factors along with their contextual relationships among them.

The related literature reveals that, the research work so far conducted on humanitarian supply chain practices in Bangladeshi context is little or insignificant.This study attempts to fill this research gap in the HSC literature with the help of ISM approach. This work will focus the following objective:

- To identify and prioritize critical success factors (CSFs) of the HSC in Bangladeshi context.
- To examine the interactions among the CSFs and to develop a hierarchical structure of CSFs of the HSC by ISM approach.

This research work will help decision maker find the critical success factors as well as the contextual relationship among them. The main expectation of this work is to guide the organizations or government to tackle the critical humanitarian situation in case of natural or man-made disaster.

The paper is structured as follows: Section 2 shows the methodology. An exemplary application of ISM method is illustrated in Section 3. Results discussions are given in section 4. Finally, Section 5 concludes the present work.

2. Methodology

To evaluate the multifaceted socio-economic systems, Warfield was first introduced ISM approach [3]. ISM is a dynamic tool which can examine interrelationship among multiple factors or variables. It can formulate a framework with the help of calculated dependence power and driving power of examined critical success factors. The main advantages of using ISM approach are to examine CSFs to the humanitarian supply chain by utilizing logical thinking of assigned experts input [4]. Compared to Delphi method and Structural Equation Model (SEM), ISM can give better results with less number of experts. In the existing literature, it is clear that ISM is a well-established methodology and it can be used without any trouble. ISM can be successfully applied in supply chain sustainability management [5], reverse supply chain [6] and so on. In this present study, ISM approach has been employed to examine their contextual relationships to the HSC of Bangladesh. The important steps of ISM methodology are depicted as follows [6-7]:

Step 1: A list of CSFs to the HSC of Bangladesh is collected.
Step 2: A matrix of the contextual relationship among identified CSFs is constructed.
Step 3: A pair-wise relationship structural self-interaction matrix (SSIM) among selected CSFs is built. For constructing SSIM, given notations are employed to show the direction of the relationship between selected CSF *(i,j)*. *V* means CSF *i* will facilitate to achieve CSF *j*; *A* means CSF *i* will be achieved by CSF *j*; *X* indicates that CSF *i* and CSF *j* both help each other to achieve an exact result; and *O* means CSF *i* and *j* are unconnected from the system.
Step 4: From the SSIM, a reachability matrix is constructed to check the transitive relationship (i.e., if a CSF *L* is linked to CSF *M* and CSF *M* is linked to CSF *N*, then CSF *L* is linked to CSF *N*). To make reachability matrix following binary digit is used (i.e., For *V*, x_{ij} will be 1 whereas x_{ji} will be 0,for *X*, x_{ij} will be 1 and x_{ji} will be 1, for *O* x_{ij} is 0 and x_{ji} is 1, for *A*, x_{ij} is 0 and x_{ji} is also 0)
*Step 5:* The final reachability matrix which is obtained from the step 4 is partitioned into four levels.
Step 6: With the help of final reachability matrix a graph is constructed, and then the transitive relations are emitted.
Step 7: An ISM model is developed with the help of resulting digraph.
Step 8: Finally, the ISM model developed in step 7 is checked for theoretical inconsistencies and if so, then corrections are made.
The important steps of ISM methodology are summarized in Fig. 1.
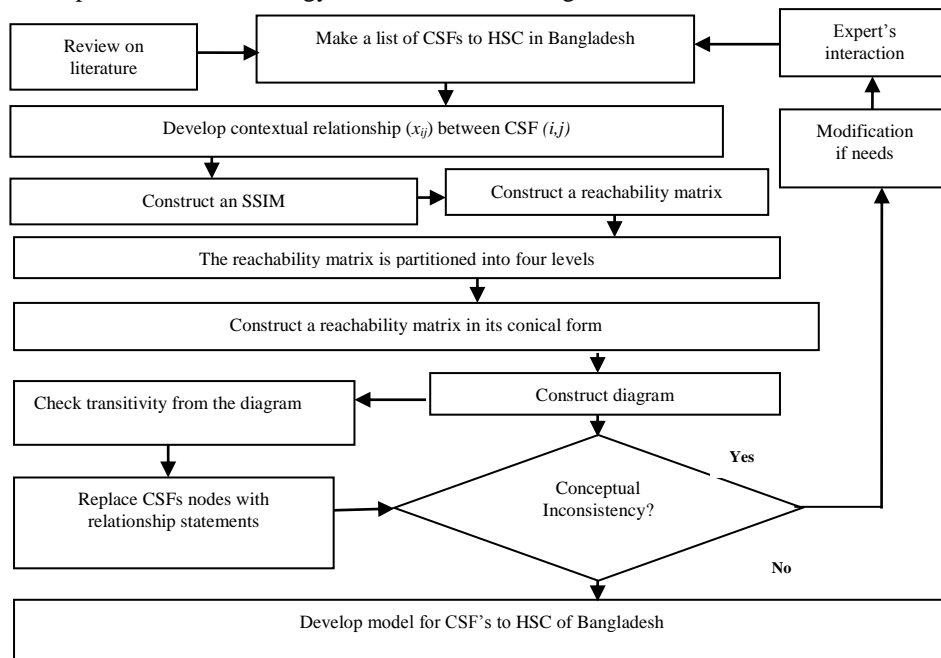
Fig. 1. Flow diagram of ISM Methodology

3. An Exemplary Applications of Proposed Model

Bangladesh is a developing country in the world. Therefore, it is not free from natural and man-made disasters. It suffers from many natural and man-made disasters like cyclone, flood, river-bank erosion, tornado, occasional earthquake, fire, accident, pollution etc. The worst one is flood which is responsible for destroying crops and hampering the lifestyle which causes huge economic loss of the country. During any kind of disasters, the supply chain needs to be agile to respond to the needs of human life. At this sense, HSC concept can be helpful

to minimize risk as well as response to the needs of human life. In this study, in the context of Bangladesh, the most CSFs for HSC management are identified. In this research, the recent disastrous flood is considered which is responsible for the death of people and destroying crops of this country. The CSFs are evaluated for minimizing risk and helping people during their needs. For this reason, the ten CSFs are found out from literature with the help of 20 experts. Experts are taken from different organizations which are relevant to disaster management, risk management and relief and rehabilitation management. Their feedback is utilized to the formation of a contextual relationship between CSFs by using ISM approach. The detail of data evaluation is described below:

Stage 1: Identify the most critical CSFs to the HSC of Bangladesh. Table 1 shows the CSFs to the HSC.

Stage 2: In this stage, structural self-interaction matrix (SSIM) is formulated by using expert's input. The procedure is given in step 2. Table 2 gives the structural self-interaction matrix (SSIM) of identified CSFs.

Stage 3: In this stage, with the help of step 4, final reachability matrix is developed which is described in details in Section 2. The final reachability matrix is in Table 3. From this Table 3; we calculate driving and dependence power for each CSF. This calculated driving and dependence power has been used in MICMAC analysis which is described in MICMAC analysis.

Table 1: Identification of CSFs to HSC

Code	Name Critical Success Factors (CSFs)	Relevant literature
F1	Strategic planning for HSC	[8]
F2	Coordination and collaboration with relief agencies	[9]
F3	Local procurement and donation management	[10]
F4	Government rules toward risk management and organizational structure	[8]
F5	Highly equipped infrastructure and transportation system	[11]
F6	Inventory management	[10]
F7	Dynamic communication system and information technology	[12]
F8	Enough qualified manpower	[13]
F9	Continuous improvement in the alertness, preparedness, and high responsiveness	[9]
F10	Proper risk assessment and planning	[9]

Table 2: Structural self-interaction matrix (SSIM)

CSFs	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
F1	X	V	V	A	A	V	V	V	V	V
F2		X	V	O	V	V	A	A	V	A
F3			X	A	A	V	A	V	A	A
F4				X	V	V	V	V	V	V
F5					X	V	O	V	V	A
F6						X	O	A	V	O
F7							X	V	A	O
F8								X	V	O
F9									X	O
F10										X

Table 3: Reachability matrix

CSFs	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	Dr. P.
F1	1	1	1	0	1	1	1	1	1	1	9
F2	0	1	1	0	1	1	0	1	1	0	6
F3	0	0	1	0	0	1	0	1	1	0	4
F4	1	1	1	1	1	1	1	1	1	1	10
F5	0	0	1	0	1	1	0	1	1	0	5
F6	0	0	0	0	0	1	0	0	1	0	2
F7	0	1	1	0	1	1	1	1	1	0	7
F8	0	0	1	0	0	1	0	1	1	0	4
F9	0	0	0	0	0	0	0	0	1	0	1
F10	0	1	1	0	1	1	0	1	1	1	7
De. P.	2	5	8	1	6	9	3	8	10	3	55

Note: Dr. P.-Driving Power; De. P.-Dependence Power

Stage 4: In this stage, level positioning is performed by searching reachability set, antecedent set, and interaction set. The reachability set, a CSF for itself may be achieved by its help. The antecedent set is
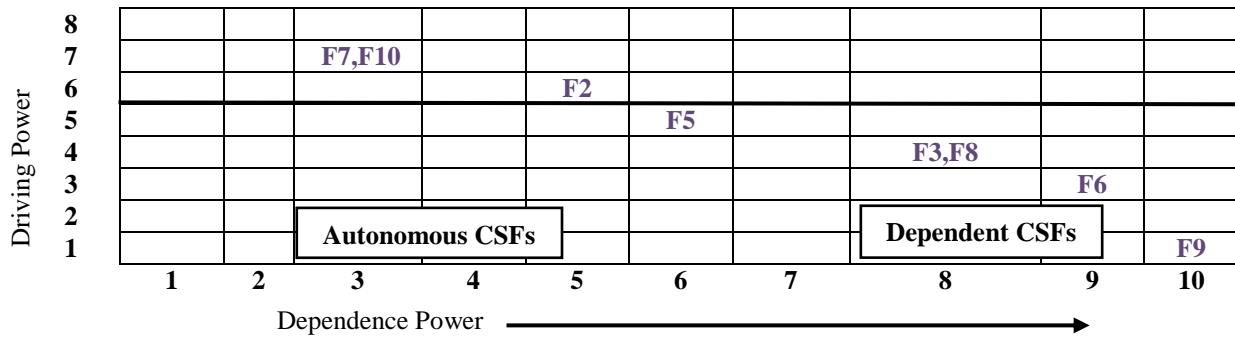
constructed of the CSFs themselves and the other CSFs which will assist in reaching it. The intersection set is derived from reachability and antecedent set of identified CSFs. If the reachability set and antecedent set of CSFs are same then this assign as a 1st level and it takes in utmost position in hierarchy structure of ISM. After getting 1st level then try to find the next level by omitting 1st level. Similarly other level is taken from level partitioning in Table 4. Fig. 2 indicates that the interactions between each CSF and their position in the hierarchical structure. The details about our results have been discussed in the discussion section. In this study, factor F9 has been assigned to the 1st level because of it has high driving power.

3.1 MICMAC Analysis

In this section Matriced' Impacts Croisés Multiplication Appliquée á unClassement (MICMAC) analysis is employed to show the classification of identified CSFs to the HSC of Bangladesh by driving and dependence power of identified CSFs [5]. The driving power and dependence power are calculated from the established final reachability matrix. This is used as an input data to construct a graph to categories the CSF among four identified region (i.e., Autonomous, Dependent, Linkage, and Independent CSFs). Autonomous CSFs are those that have low driving power at the same time low dependence power whereas dependent CSFs have strong driving power and weak dependence power. CSFs in linkage region indicate that the CSFs have strong dependence power and strong driving power whereas independent region has strong driving power and weak dependence power.

Table 4: Level partitioning

Level Positioning				
CSFs	Reachability Set	Antecedent Set	Intersection Set	Level
F1	F1,F2,F3,F5,F6,F7,F8,F9,F10	F1	F1	VII
F2	F2,F3,F5,F6, F8,F9	F1,F2,F4,F7,F10	F2	V
F3	F3,F6,F8,F9	F1,F2,F3,F4,F5,F7,F8,F10	F3,F8	III
F4	F1,F2,F3,F4,F5,F6,F7,F8,F9,F10	F4	F4	VIII
F5	F3,F5,F6,F8,F9	F1,F2, F4,F5, F7,F10	F5	IV
F6	F6,F9	F1,F2,F3,F4,F5,F6,F7,F8,F10	F6	II
F7	F2,F3,F5,F6,F7,F8,F9	F1,F4,F7	F7	VI
F8	F3,F6,F8,F9	F1,F2,F3,F4,F5,F7,F8,F10	F3,F8	III
F9	F9	F1,F2,F3,F4,F5,F6,F7,F8,F9,F10	F9	I
F10	F2,F3,F5,F6,F8,F9,F10	F1,F4,F10	F10	VI

Fig. 2. Proposed ISM model for CSFs to HSC of Bangladesh

Fig. 3.MICMAC analysis of CSFs to HSC of Bangladesh

4. Results Discussions

The main contribution of this present work was to identify critical success factors (CSFs) and finding their contextual relationships to build a hierarchical model of CSFs in implementing HSC management (HSCM) in Bangladeshi context. By implementing ISM model, the interactions among the selected CSFs to implementing HSCM are obtained and a structural model i.e. hierarchical model is developed. Then this model leads to calculating driving power and dependence power of each CSF. The CSF 'Government rules toward risk management and organizational structure (F4)' has got highest driving power and lowest dependence power. For this reason this CSF is placed at the last level of the structure in figure 2. On the other hand the CSF 'Continuous improvement in the alertness, preparedness, and high responsiveness (F9)' has got the lowest driving power and highest dependence power as exhibited in Table 3. For this reason this CSF has come at the top of the structural model as shown in Fig. 2. The calculation results in eight levels in the structure as displayed in Table 4. Continuous improvement in the alertness, preparedness, and high responsiveness (F9) CSF has got the 1st position of the structure whereas 'Government rules toward risk management and organizational structure (F4)' CSF has got the last position of the structure. At the bottom level the CSF has highest driving power and lowest dependence power. From bottom to top, driving power decreases and dependence power increases. CSF at the top level bears higher dependence power and lower driving power than others. Thus a comparative structural model for assessing the CSFs to the implementation of HSCM in case of natural/man-made disasters in Bangladesh has been developed. This will help disaster management organizations and managers to achieve competitive advantage through a strategic approach, economic benefit as well as goodwill.

MICMAC analysis is performed to validate the ISM model of the identified CSFs. The driving power-dependence power graph helps to classify various CSFs in implementing HSC. Five CSFs (F1, F2, F4, F7 and F10) have been recognized in the independent quadrant. Driver or independent CSFs carry high driving power and low dependence power. They play a significant role in implementing HSCM in the case situation. No CSF has been found as linkage CSFs from the case situation perspective. Linkage CSFs have high dependence power and also high driving power. Five CSFs (F3, F5, F6, F8 and F9) have been recognized in the dependent quadrant. Dependent CSFs indicate that it has low driving power and high dependence power. Dependent CSFs are weak but strongly dependent on other CSFs. These CSFs indicate desired objectives for the implementation of HSCM. In this category, Continuous improvement in the alertness, preparedness, and high responsiveness (F9) has got the highest dependence power but least driving power. Strong dependence means all other CSFs will contribute to encourage organizations to adopt HSCM policies in their organizations to implement HSCM to enhance competitiveness and responsiveness. No CSF was identified in the autonomous category which means there is no CSF which may be considered as disconnected from the system.

In our model, 'Government rules toward risk management and organizational structure (F4)' has been distinguished as most important CSF which has driving power in implementing HSC in the case situation. If the government makes strict rules toward risk management and organizational structure for establishing a modern HSC structure, disaster management organizations will arrange necessary steps and strategy for its smooth implementation. These initiatives will enhance and establish dynamic communication system and information technology and plan for proper risk assessment. By this way a good coordination and collaboration with the relief agencies will be established. All these activities will lead to creating a highly equipped infrastructure and transportation system with a strong local procurement and donation management, enough qualified manpower and a dynamic inventory system. This will enhance continuous improvement in the alertness, preparedness and high responsiveness during the disasters. Thus disaster management organizations will initiate to adopt HSC management system in their policies to tackle the natural/manmade disaster in Bangladeshi context.

5. Conclusions

With the expanding recurrence and force of disasters and an extensive number of people being influenced, Bangladeshi disaster management organizations are facing pressure to implement modern HSC. Environmental concerns are gaining more attention recently. In this research work we have identified major critical success factors in implementing HSCM in case of a natural/man-made disaster in Bangladesh. A total of ten CSFs are selected through critical literature review and expert opinions to implement HSCM in the case situation. In this research, the ISM model has been developed and also MICMAC analysis has been conducted to understand the interdependence among identified CSFs.

Findings reveal that 'Government rules toward risk management and organizational structure' is at the base of the structural model whereas 'Continuous improvement in the alertness, preparedness, and high responsiveness' is at the top of the structural model. It means government rules toward risk management and organizational structure will push disaster management firms to implement HSC management to achieve high responsiveness by adopting HSCM supporting policies in their organizations. Bangladeshi disaster management organizations may implement HSCM in their organizations by the identified success factors and thus can tackle the disasters smoothly. This study has some limitations. As ISM highly depends on the judgment of experts which may be biased, other multi-criteria decision making (MCDM) tools may be used i.e. Fuzzy- ISM, structural equation modeling (SEM). The proposed structural model may be utilized for other organizations of Bangladesh or other developing countries. This research work sets a framework for enhancing research in the area of HSC practices to achieve sustainable and competitive advantages.

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