Ranking Barriers of Supply Chain Management by MCDM Method During Disaster Management: A Case Study of India

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ABSTRACT

Disasters are often described as a result of the combination of the exposure to a hazard, the conditions of vulnerability that are present, and insufficient capacity or measures to reduce or cope with the potential negative consequences. The inability to accurately predict these types of events underscores the need for countries to have disaster response plans to mobilize appropriate resources rapidly and efficiently. A well-defined organizational structure also must be created to coordinate both national and international assistance. Human race is always a fighter of natural calamities and disasters like earthquakes, floods, droughts, cyclones, pandemics, and blizzards. After disaster, they try to establish everything buildings, establishment, infrastructure, life of human, etc. like old or better. In this paper, an effort is taken to find barriers in SCM (supply chain management) during disaster and prioritize them by multicriterion decision-making electre method.

KEYWORDS

Disaster Management, Electre Method, Supply Chain Management

1. INTRODUCTION

In today's business world competition is very high. Due to the globalization, advancement of technology, and increase in demand and supply organisations need to raise their bar of performance continuously. Increase in customer demand leads to the increase in supply chain. And supply chain management is a better way to compete in market as it is constantly evolving. It is the management of activities from availability and procurement of raw material, their processing into finished goods and then distribution of these goods. Today disasters seem to be striking all corners of world. So the importance of disaster risk management is indisputable. In any emergency the supply chain management deals with procuring food, medicines, clothes, and other resources from various government and non-government agencies. When a disaster occurs, it interrupts essential service such as health care, electricity, water, sewage removal, transportation and communications. Thus, it

DOI: 10.4018/IJSDA.2021040101

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becomes very necessary to research about all the factors affecting the supply chain, its drivers and barriers and critical success factors.

This forms the basis of our study. Reduction of risk, readiness, response, and recovery are the main four steps during any disaster management:

- Risk reduction is a kinetic process in which risks are monitored, modified and analyzed. The most probable hazards and the severity of its effects if the hazard ever comes into play is first identified. After that, any immediate risks related to people are analyzed with a predetermined set of criteria. The necessary safety measures are taken to eliminate and control the severity of those risks.
- Readiness covers all measures and emergency planning. It must include primary human needs of communication, resources, control measures, media plan of action and processing of casualties.
- The main part of response is provided by the emergency services, followed by other voluntary and utility organizations. The prime concern is to save lives and relieve suffering.
- Recovery is the last stage of disaster risk management. It includes activities for returning to normalcy. It includes restoration of emergency services, relocation, financial amends, insurance and aftercare. It mainly starts from the stage of readiness and carried out from the response stage.

Each stage faces various individual challenges regarding gathering of information, interpretation, and dissemination for quick relief operations. It is impossible to eliminate the disaster risks. However, each disaster can be analyzed and managed for its future prevention. The research attempts to provide a systematic and technology driven risk lessening method in disaster risk management.

A hazard is mainly defined as a damaging occurrence which may cause heavy loss of life and property. These include natural hazards like biological or geological and also man-made hazards like technological hazards. Vulnerability is defined as an array of conditions resulting from various factors like, social, economic, political etc. which increases the ability to be maintained against hazards. It can also be referred to as a degree of loss due to hazards.

So, disaster risk can be formulated as:

$$DisasterRisk(R) = \frac{Vulnerability \times Hazard}{CopingCapacity}$$

In case of a disaster, it is very important to make sure that the supply is prompt and effective, ensuring the suitable goods and services reach the victims of the disaster taking logistical statistics into consideration. But, to ensure proper optimization of all resources involved it is required that all the contributing agencies are managed in an integrated approach to efficiently and effectively coordinate the performance of the respective organizations, get rid of superfluity, and increase efficiency along the entire disaster supply chain. There are mainly five critical differences that differentiates between emergency supply chain management from commercial supply chain:

- The demand is unpredictable;
- Demand is shorter leading to short lead times;
- The need for timely delivery to lessen human suffering;
- Damage to the logistics infrastructure caused by the disaster; and
- A lack of resources such as technology, transportation, warehouses to implement such a system.

Building an emergency supply chain system is something that is needed to be accomplished at the national level by the government. Considering various factors affecting supply chains compels

us to focus on the important issues involved in providing goods and services following a disaster and it helps us see through simple purchasing. When natural disasters strike, there is no time to waste. No matter the type of disaster, the chain members should be ready for everything. It is important for the people involved in the management to be aware of their surroundings and have swift response to any mis happenings. Among all the chaos, good statistical data and logistics can save the lives of many people and help rebuild and recovery effectively. There are many differences existing between commercial and disaster relief supply chains, but the skills and abilities required to survive in commercial supply chain are generally are the same skills and competencies that are needed to carry out disaster relief operations Overall, disaster management is a huge operation. It requires lots of analysis and preparation, along with the ability to forecast. Agencies must be flexible in terms of change and expect the unexpected.

2. LITERATURE REVIEW

There are many barriers faced by various organisations during the proper functioning of SCM. It is difficult to eliminate all barriers but if a dominant barrier, is known, it could be eliminated. The following shows extensive literature review of papers regarding barriers of supply chain management. The most important aim of all supply chain is to provide maximum satisfaction to the customer. Some secondary objectives also include gainfulness, reliability, agility, reactivity, high overturn rate, effective communication and coordination along the supply chain (Anilkumar & Sridharan, 2019). The consequences of risks are very deadly and not easy to handle. There are many severe incidents which can influence any specific member of the supply chain in an opposing manner and change their way of looking to the company or the brand (Iqbal & Shalij, 2019). The success factors of short term disaster relief mainly is dependent on the long term capability to structure something and, is very important to the public presentation of supply chain disaster operations and activities (Bhushan,2017). There has been an increasing demand for management operations in line with more and more disasters happening around us. Although the main role of supply chain is to guarantee that the transfer of resources and relief products from the origin to the destination is efficient, however the evolution of its various ideas, theories, implementations and principles are still to attain a lot of development in future (Pujawan et al.,2009).As proper disaster hindrance, preparation, response and relief is high-priced and insufficient funds, resources, technology and technicality weakens the disaster management agencies' effectiveness, the incapability of political or administrative instruments to put disaster management as a high govt. priority can have very negative impact on the effectiveness of disaster management (Meshach et al.,2018).Proper security measures are needed to be taken to prevent theft of the products and also to calm the crowd. Demand for relief supplies depends on various factors like magnitude of disaster, type of supplies needed and the proper degree of forecasting the disasters. This makes it difficult for the respective supply chain organizations to manage their budget and resources (Kovács & Spens,2007).The primary forces opposing the supply management policies and plan of action comes from the nature and type of the organization itself and the people that form the workforce of the organization.If the enthusiasm for cooperation and unity is not present,a supply chain will not be able to achieve its primary objectives of low cost and high return on investment (Fawcett et al.,2008). Further, asymmetrical cooperation between the chain agencies obstructs managers' motives to share with any important concerns, weaknesses, and best possible pathways (Fawcett et al., 2008). Due to rampage of the disasters transportation facilities gets seriously affected in many regions making those regions inaccessible. Alternative transportation and shipping methods should be considered previously taking all factors into account (Altay et al.,2009).Primarily, it is the duty of the government of the respective country to overlook the entire relief operation at the area of prime concerns at the time of disasters, but mostly, the government of the country maybe neither experienced nor might be having any proper members of experience to handle such situations which might cause a lot of chaos in the entire process of planning and course of action for the relief operation (John & Ramesh, 2016). So

it becomes necessary to rank the disasters on the basis of barriers by using MCDM methods. Many MCDM methods are based on the hypothesis of the relative importance of the criteria considering many alternatives, usually doing comparisons in pairs to ascertain their comparative importance on which they should be ranked (Milutinovic et al., 2018).

Lack of strong management is identified as an important barrier (Al Zaabi et al., 2013). Lack of a proper and estimated plan of action is a major barrier as it prevents in building a long-term trust and relationship with customers and organisations (Kuo et al., 2010). The process of making and delivering supplies to customers includes various smaller establishments like raw material suppliers, component suppliers, manufacturers, wholesalers and distributors, logistics service and retailers (Huang et al., 2013). Each establishment faces a different barrier of a supply chain. Lack of information sharing is one of the cognitive barriers of SCM. A constant flow of updated and correct information about supply, demand, sourcing, and pricing is necessary for successful enforcement of risk management (Roh et al., 2014). Lack of technology and technical expertise and fear of failure is also a prime factor acting as barriers in supply chain (Govindan et al., 2020). According to (Maon et al., 2006) the various barriers affecting the process of supply chain in disaster management are:

- Learning issues:
 - Value oriented culture
 - Knowledge gap
 - Utilitarian perspective
- Strategizing issues:
 - Funding bias
 - Technological shortage
 - Faltering perspective on sourcing, purchasing and positioning
- Coordinating and measuring issues:
 - Coordination struggle
 - Individualistic actors with self-sufficient perspectives
 - Crucial objectives with no goals

3. DISCUSSION

3.1. Value Oriented Culture

Culture is viewed by people in many ways and it is complex and difficult to contemplate. In most of the cases culture is the way people live their life with the values they possess. In other words, it can be defined as a means of carrying out various things. Whenever we are defining culture or factors affecting culture, there are always many probabilities of risks to consider like standardization, discrimination, divergence and vulnerability. Today's people are very sentimental, and their beliefs mostly depend on their culture when considering the difference between right and wrong. These beliefs and sentiments play a major role in disaster management activities. The way people perceive disasters and the impact these disasters can have in the community and individuals can be influenced by many cultural behaviour such as beliefs, tradition and values, behaviour of that individual or the community that they belong to, livelihood patterns their way of living etc. (Udayangani, 2010). Therefore it is important to plan your SCM activities that coincides with the aspects of culture that reduces risk, and also decreases the exposure of individuals from disasters. It is important to make strategies for disaster management which are less or not conflicting with the cultural aspects with of the community. This will lead to strengthening of the community's for coping from a disaster.

3.2. Knowledge Gap

Although there have been a large amount of research and analysis on disaster and its prolonged effects, still there exists many shortcomings in converting these knowledge into a proper direction of action. There is always a ongoing war between knowledge and action for disaster risk management, thus implying the necessity of a more collective process consisting of hierarchical actions, knowledge involving local and national facts, and a large number stakeholders (Gaillard & Mercer, 2013). The necessity to cover the knowledge gap, as well as evaluation of the variety, version, and responsibility plays a very important role. One of the major consequences faced by disaster risk management is the lack of stages that not only helps in sharing of knowledge and information between non-government and government organisations but also ensures the application of knowledge in required cases. Although it is well established that sharing knowledge between workers in the science, policy, and public areas, is utmost needed, however more brainstorming is needed regarding the actual amount of work needed to be done (Albris et al., 2020). Second, during the disaster risk management approaches it is very important to focus on two factors i.e. vulnerability and resilience, but as of now it is not clear what kind of expertise in various fields is needed in an agency to meet the necessary goal of reducing risks. More information is also needed to understand various organizational barriers that causes impediments in the approaches to disaster risk management.

3.3. Utilitarian Perspective

During a disaster much less, attention is given to the logistics and supply chain management and is not considered as one of the necessary supportive operation. Most of the organizations focus on direct relief from the disaster rather than focusing on the supplies and reliefs and underestimates the importance Supply Chain Management brings during a disaster and its relief work. (Arminas, 2005).

3.4. Funding Bias

Donations are the main source of funding the reliefs and supplies to be provided. These donations often increase after a disaster happens. (Ratliff, 2007). A good financial supply chain is needed to transfer these funds for relief. The time taken for the request of funds to be transferred to the governmental and the nongovernmental agencies and the time taken for the discharge of the requested funds is usually a lot which impacts the stakeholder in the SCM (John & Ramesh, 2016). When most of the funds cannot be approved the necessary steps for disaster reduction cannot be further carried out. Most of the times, agencies operate only with the funding received from the donor, and without its presence they cannot operate in a particular area (John & Ramesh, 2016). The supply chain flexibility is affected by these funding problems since the organizations are generally required to raise a huge amount of funds in a very limited time. A more detailed and scrutinised survey on the donors and increasing value for money can make the reaction and recovery stages very easy to attain.

3.5. Technological Shortage

After a disaster it is very important to have good and efficient electronic infrastructure, but most of the NGOs lack this which causes a hindrance in the supply chain (Lee & Zbinden, 2003). Visibility is mainly defined as the ability to see what is happening beyond the barriers. The visibility of the supply chain should be increased with the help of the chain members of the supply chain by sharing relevant and important information. This enables to see what is happening in the disaster area. The information and electronic technology plays a decisive role in improving visibility across the supply chain agencies. There are many technologies which require less skills and they can be learned at a faster rate, however a high level of expertise is required. Few innovative technologies have risen in the field of distributed application with unique and accessible solutions and an encouraging system but the investment needed to ensure such digital and disruptive technology for risk mitigation is very high. Different countries have different financial conditions and stability to ensure the use of these

ICTs for management situations. Even within countries, there are deviations in the level of access to these technologies hence affecting their field application. This may cause an issue for some necessary technologies to gain wide impact in future. When the relief operations are undergoing or have already been completed, logistics departments in the field should know about the availability of the items, the quantity of supply on hand, the expected days of supply, and the location where these supplies are stored. This information can be shared to help suppliers, donors and public with the help of dedicated website or media so that the inventory can be replenished with supply.

3.6. Faltering Perspective on Sourcing, Purchasing and Positioning

The ability to predict the needs allows for the coordination of supply and demand. If the synchronisation is not maintained, then it may lead to having larger facility as the organization is unsure of the inventory requirement and as a result will keep more inventory in stock. While preposition inventories it is required to keep many things in mind like the amount of the dispersion centres and their proposed areas of act; and their storage capacity and quantity. These decisions are limited by the budget which restricts building of dispersion centres and inventories in the required areas. As there are very few contributions and investments in the field of SCM, it confines disaster relief agencies' ability to make an appropriate plan of action and follow it for effective sourcing, purchasing and inventory pre-positioning. The case of management of relief supplies is always faced with many perplexity. The prepositioned inventory contains the supplies can be obtained immediately after disaster strikes, with a low price (Yao et al., 2018). Since the demand is uncertain in such cases large scale production and storage can cause various problems. So, developing various strategies and doing deep analysis of factors affecting of SCM components provides a proper strategized action for efficient disaster relief in the future.

3.7. Coordination Struggle

During a disaster, coordination among the people is very important. Without proper coordination it is impossible to provide relief from disaster. For a systematic approach in relief steps there must a good coordination between the service providers and organization to lessen the effects of the disasters, some measures need to be performed in the pre-crisis phase to help build the coordination between organizations during preparation (Bahadori et al., 2015). Understanding and acknowledging different types of shortcomings, plan of action, strategies, and investing in increasing knowledge helps in disaster coordination. It includes the standardization accepted by the government and a leadership who supports at all levels of chain members. Doubts regarding seriousness and obligations can set up a barrier to interaction and cooperation among organizations, and act as a major obstacle (Bahadori et al., 2015). There will be problems faced by the service agencies in meeting the demand from their customers from time to time, since most of the services are requested at the same prime times (Schulz & Blacken, 2010). There should be a common tongue as the absence of the same can create a confusion and may make it difficult to collaborate. Stability in obtaining funding is one of the firsthand hindrance to maintain cooperation and timing. The funding origins are often limited and exist for a short period of time, and building coordination is a long-term process (Bahadori et al., 2015). The detailed survey and models of disaster management needs to be done and analyzed in detail at different levels of country i.e. national, regional, local to set up more coordination effectively among responsible chain members.

3.8. Individualistic Actors With Self-Sufficient Perspectives

Individualism defines the moral worth of an individual. To decrease superfluity, NGOs must work together instead of competing. The lack of communication is still a big concern, despite the acute need for chain members to share information about their strengths and shortcomings before a disaster. Based on these emergency logistics preparation becomes a challenge. Also, the process of cooperation and discussion within a competitive organisation remains a critical challenge. Most of the organizations provide relief for a shorter period of time, and then later shuts down the services

and relocates without any connection to the long-term restoration and recovery of the disaster struck areas. The assistance concerned primarily with human welfare is still mainly focused on rural areas and the variety of requirements of affected people in urban areas are often not considered properly. In many cases the range and time period of the disaster response is not specified. When an organisation pulls away from the affected region, the people are left to take responsibility for themselves.

3.9. Crucial Objectives With no Goals

Due to the lack of clear picture of the performance of the relief agencies, the quality of the relief supplies that is provided to the people is most affected. This mainly happens because the supply chain management performance is rarely measured. Reporting becomes more difficult because of the various barriers in the communication of information, as well as the limited training undergone by the field workers (Thomas, 2005). To overcome this situation, disaster relief agencies should derive functioning objectives and parameters and put those to immediate effect. This will help them to learn from each operation so that they can provide a better service in future (Davidson, 2006).

4. METHODOLOGY

An expert analysis meeting is conducted by taking 50 persons who are experts in disaster management and academicians and from expert analysis and literature review these barriers of SCM are found, and then ranked by Electre method, so that more emphasis can be given to that barrier and policies can be modified. The main advantage of the ELECTRE method is that the comparison of the alternatives on the basis of different criterion can be achieved even if there is not a clear preference for one of the alternative. Other methods of decision making is sensitive to the decision maker's beliefs and hence are unreliable. This puts this MCDM method at a more advantageous position. A standout expression is a choice model which mainly accounts for three types of situations: preference, in-difference, and singularity.

By means of outranking relationships, ELECTRE method reveals the domination of one alternative among different options of alternatives. Therefore, it is viable that, these stand out relationships can differentiate among the various available alternatives. There are two types of indices, concordance and discordance index that is used in the ELECTRE method for comparison of alternatives.

4.1. Weighted Matrix

In this step the weight of the criterion is taken into consideration. The weighted matrix's indicated values are calculated as multiplied the values with their respective weights.

4.2. Concordance and Discordance Sets

For each pair of alternatives A_p and A_q ($p, q=1,2,m$ and p does not equal q), there are two subsets for each set of attributes.

The concordance set, which consists of all attributes for which alternative A_p is more preferable than alternative A_q . It can be expressed as:

$$C(p, q) = \{j, V_{pj} \geq V_{qj}\} \quad (1)$$

where V_{pj} is weighted rating of alternative A_p with respect to the j th attribute. In other words, $C(p, q)$ is the collection of attributes where A_p is better than or equal to A_q .

The complement of $C(p, q)$, which is called the discordance set, contains all attributes for which A_p is worse than A_q . This can be written as:

$$D(p, q) = \{j, V_{pj} < V_{qj}\} \quad (2)$$

4.3. Concordance and Discordance Indexes

The relative power of each concordance set is measured by means of the concordance index. The concordance index C_{pq} represent the degree of confidence in the pair wise judgments of $C(p,q)$. The discordance index, on the other hand, measures the power of $D(p,q)$.

According to (Mary & Suganya, 2016) for every criterion, every decision maker must define the following:

1. Preference threshold (p)
2. Indifference threshold (q)
3. Veto thresholds (v) where ($v \geq q \geq p$)
4. Importance rating (w_j) for each criterion j

4.4. Computation of Concordance Matrix

The strength of the hypothesis that alternative A_i is at least as good as alternative A_j is measured by the concordance index between the pair of alternatives A_i and A_j and is calculated by using Equation (1):

$$C(a, b) = \frac{1}{W} \sum_{j=1}^n w_j c_j(a, b) \quad (1)$$

where:

$$W = \sum_{i=1}^n w_i \quad (2)$$

$$C_j(a, b) = \begin{cases} 1, & diff \geq -q_j \\ \frac{diff + P_j}{P_j - q_j}, & -q_j > diff > -P_j \\ 0, & diff \leq -P_j \end{cases} \quad (3)$$

4.5. Computation of Discordance Matrix

The discordance index measures the strength of evidence against the hypothesis and is calculated using Equation (4):

$$D_j(a, b) = \begin{cases} 1, & diff \geq v_j \\ \frac{diff - P_j}{v_j - P_j}, & P_j \leq diff \leq q_j \\ 0, & diff \geq P_j \end{cases} \quad (4)$$

5. DATA ANALYSIS

In this paper, an extensive literature review (Tables 1-3) is conducted and barriers and criterias are found. The various barriers are denoted as C1,C2,C3 and so on and various disasters are denoted with A1, A2, A3 and so on.

5.1. Step 1: Normalizing the Decision Matrix

In Table 4, first the indicator values were squared, and the sum was found out. Then the square root value of the respective sum was noted.

Table 1. Various barriers found from literature review

Criteria	Types
C1	Value oriented culture
C2	Knowledge gap
C3	Utilitarian perspective
C4	Funding bias
C5	Technological shortage
C6	Faltering perspective on sourcing, purchasing and positioning
C7	Coordination struggle
C8	Individualistic actor with self sufficient perspectives
C9	Crucial objectives with no goals

Table 2. Various disasters found from literature review

Alternatives	Types
A1	Earthquakes
A2	Floods
A3	Droughts
A4	Cyclones
A5	Pandemics
A6	Blizzards

Table 3. Showing the dependency of different disasters on various barriers of supply chain

	C1	C2	C3	C4	C5	C6	C7	C8	C9
A1	4	2	3	2	4	4	3	4	3
A2	4	2	3	4	3	2	3	4	2
A3	4	4	4	4	4	4	4	4	4
A4	4	5	5	5	5	5	4	5	4
A5	5	5	4	2	4	4	3	4	4
A6	4	4	3	4	4	4	2	4	4

In Table 5, the respective indicator values were divided by their respective squared root values to get the normalized decision matrix.

5.2. Step 2: Weighing the Normalized Matrix

Since there are 9 criterion, considering each criterion equally important the weight of each criteria is considered as 0.111. To obtain the weighted normalized matrix the respective weights were multiplied to the values of normalized decision matrix (Table 6).

5.3. Step 3: Concordance Set

In this step alternatives are compared with alternatives. When comparing, those values of an alternative in the weighted matrix, which are greater than or equal to the values of the alternative with which it is being compared, their respective weights are added and put.

Then the sum of the respective alternatives was found out and total sum was calculated. C Bar value was obtained by dividing the total sum to the total number of non-zero values (Table 7).

If the value of concordance set is greater than the C Bar value, it is replaced by 1 otherwise it is replaced by 0. This gives the concordance dominance matrix (Table 8).

5.4. Step 4: Discordance Set

In Table 9, the values of an alternative was taken from the weighted matrix and it is subtracted from the values of remaining alternatives.

The maximum difference of the difference values from above was found out and was divided with the maximum indicator value. Then the sum of the respective alternatives was found out and

Table 4. Shows Initial decision matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9
A1	16	4	9	4	16	16	9	16	9
A2	16	4	9	16	9	4	9	16	4
A3	16	16	16	16	16	16	16	16	16
A4	16	25	25	25	25	25	16	25	16
A5	25	25	16	4	16	16	9	16	16
A6	16	16	9	16	16	16	4	16	16
SUM	105	90	84	81	98	93	63	105	77
SQRT	10.246950	9.4868329	9.165151	9	9.8994949	9.6436507	7.9372539	10.246950	8.7749643

Table 5. Shows Normalized decision matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9
A1	0.390	0.211	0.327	0.222	0.404	0.415	0.378	0.390	0.342
A2	0.390	0.211	0.327	0.444	0.303	0.207	0.378	0.390	0.228
A3	0.390	0.422	0.436	0.444	0.404	0.415	0.504	0.390	0.456
A4	0.390	0.527	0.546	0.555	0.505	0.518	0.504	0.488	0.456
A5	0.488	0.527	0.436	0.222	0.404	0.415	0.378	0.390	0.456
A6	0.390	0.422	0.327	0.444	0.404	0.415	0.252	0.390	0.456

Table 6. Shows Weighted Normalized decision matrix

	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111	0.111
Weights	C1	C2	C3	C4	C5	C6	C7	C8	C9
A1	0.043	0.023	0.036	0.025	0.045	0.046	0.042	0.043	0.038
A2	0.043	0.023	0.036	0.049	0.034	0.023	0.042	0.043	0.025
A3	0.043	0.047	0.048	0.049	0.045	0.046	0.056	0.043	0.051
A4	0.043	0.058	0.060	0.061	0.056	0.057	0.056	0.054	0.051
A5	0.054	0.058	0.048	0.025	0.045	0.046	0.042	0.043	0.051
A6	0.043	0.047	0.036	0.049	0.045	0.046	0.028	0.043	0.051

Table 7. Shows concordance set

	A1	A2	A3	A4	A5	A6
A1	0	0.888	0.444	0.111	0.555	0.666
A2	0.666	0	0.333	0.111	0.333	0.555
A3	0.999	0.999	0	0.333	0.777	0.999
A4	0.999	0.999	0.999	0	0.888	0.999
A5	0.999	0.888	0.777	0.333	0	0.888
A6	0.888	0.777	0.777	0.222	0.555	0
Sum	4.551	4.551	3.33	1.11	3.108	4.107

Total Sum=20.757
C BAR=0.6919

Table 8. Shows Concordance dominance set

	A1	A2	A3	A4	A5	A6
A1	0	1	0	0	0	0
A2	0	0	0	0	0	0
A3	1	1	0	0	1	1
A4	1	1	1	0	1	1
A5	1	1	1	0	0	1
A6	1	1	1	0	0	0

total sum was calculated. D Bar value was obtained by dividing the total sum to the total number of non-zero values (Table 10).

If the value of discordance set is greater than the D Bar value, it is replaced by 1 otherwise it is replaced by 0. This gives the discordance dominance matrix (Table 11).

Table 9. Shows Discordance set

	C1	C2	C3	C4	C5	C6	C7	C8	C9
A1-A2	0	0	0	-0.024	0.011	0.023	0	0	0.013
A1-A3	0	-0.024	-0.012	-0.024	0	0	-0.014	0	-0.013
A1-A4	0	-0.035	-0.024	-0.036	-0.011	-0.011	-0.014	-0.011	-0.013
A1-A5	-0.011	-0.035	-0.012	0	0	0	0	0	-0.013
A1-A6	0	-0.024	0	-0.024	0	0	0.014	0	-0.013
A2-A1	0	0	0	0.024	-0.011	-0.023	0	0	-0.013
A2-A3	0	-0.024	-0.012	0	-0.011	-0.023	-0.014	0	-0.026
A2-A4	0	-0.035	-0.024	-0.012	-0.022	-0.034	-0.014	-0.011	-0.026
A2-A5	-0.011	-0.035	-0.012	0.024	-0.011	-0.023	0	0	-0.026
A2-A6	0	-0.024	0	0	-0.011	-0.023	0.014	0	-0.026
A3-A1	0	0.024	0.012	0.024	0	0	0.014	0	0.013
A3-A2	0	0.024	0.012	0	0.011	0.023	0.014	0	0.026
A3-A4	0	-0.011	-0.012	-0.012	-0.011	-0.011	0	-0.011	0
A3-A5	-0.011	-0.011	0	0.024	0	0	0.014	0	0
A3-A6	0	0	0.012	0	0	0	0.028	0	0
A4-A1	0	0.035	0.024	0.036	0.011	0.011	0.014	0.011	0.013
A4-A2	0	0.035	0.024	0.012	0.022	0.034	0.014	0.011	0.026
A4-A3	0	0.011	0.012	0.012	0.011	0.011	0	0.011	0
A4-A5	-0.011	0	0.012	0.036	0.011	0.011	0.014	0.011	0
A4-A6	0	0.011	0.024	0.012	0.011	0.011	0.028	0.011	0
A5-A1	0.011	0.035	0.012	0	0	0	0	0	0.013
A5-A2	0.011	0.035	0.012	-0.024	0.011	0.023	0	0	0.026
A5-A3	0.011	0.011	0	-0.024	0	0	-0.014	0	0
A5-A4	0.011	0	-0.012	-0.036	-0.011	-0.011	-0.014	-0.011	0
A5-A6	0.011	0.011	0.012	-0.024	0	0	0.014	0	0
A6-A1	0	0.024	0	0.024	0	0	-0.014	0	0.013
A6-A2	0	0.024	0	0	0.011	0.023	-0.014	0	0.026
A6-A3	0	0	-0.012	0	0	0	-0.028	0	0
A6-A4	0	-0.011	-0.024	-0.012	-0.011	-0.011	-0.028	-0.011	0
A6-A5	-0.011	-0.011	-0.012	0.024	0	0	-0.014	0	0

5.5. Step 5: Aggregation of Concordance and Discordance Set

Aggregate Dominance Matrix was found out by putting an AND operator between Concordance & Discordance Dominance Matrix. Then the sums of respective sums of rows and columns were found out for each alternative (Table 12).

5.6. Step 6: Ranking

For each alternative, the final solution was found out by subtracting the total sum of columns from the total sum of rows. The alternative which got the highest value got the highest rank and so on (Table 13).

Table 10. Shows Total sum

	A1	A2	A3	A4	A5	A6
A1	0	1	1	1	1	1
A2	0.9583	0	1	1	1	1
A3	0	0	0	1	0.4583	0
A4	0	0	0	0	0.3055	0
A5	0	0.6857	1	1	0	1
A6	0.5833	0.5384	1	1	0.5833	0
Sum	1.5416	2.2241	4	5	3.3471	3

Total Sum=19.1128
D Bar=0.868763636

Table 11. Shows Discordance dominance matrix

	A1	A2	A3	A4	A5	A6
A1	0	1	1	1	1	1
A2	1	0	1	1	1	1
A3	0	0	0	1	0	0
A4	0	0	0	0	0	0
A5	0	0	1	1	0	1
A6	0	0	1	1	0	0

Table 12. Shows Aggregate dominance matrix

	A1	A2	A3	A4	A5	A6	Sum
A1	0	1	0	0	0	0	1
A2	0	0	0	0	0	0	0
A3	0	0	0	0	0	0	0
A4	0	0	0	0	0	0	0
A5	0	0	1	0	0	1	2
A6	0	0	1	0	0	0	1
Sum	0	1	2	0	0	1	

6. CONCLUSION AND FUTURE IMPLICATIONS

Today's operational environment needs a supply chain design that is both guaranteed and resilient. The field of disaster risk management in supply chain is young, growing and promising. Hence through this research, an important step has been taken in recognising some of the important disasters and the various barriers affecting them. The results from the ranking were found and the dependency of various disasters on different barriers was well determined. Finally, it can be found that implementing a supply chain wide risk judgement is a complex and difficult task. It is important for organizations

Table 13. Shows higher values in final solution have higher ranking

Alternatives	Sum of rows	Sum of columns	Final solution	Rank
A1	1	0	+1	2
A2	0	1	-1	4
A3	0	2	-2	5
A4	0	0	0	3
A5	2	0	+2	1
A6	1	1	0	3

to understand risk assessment along the chain members and developing more practicable concepts to channelise the process. This study provides circumstantial perspective of how the SCM practices currently carried out by disaster relief agencies can be improved. Although they are recognized as crucial role for achieving effective disaster relief operations, many agencies still disregard logistics and SCM as important plan of actions. Disaster relief supply chain management is almost the unexplored domain with application in software based system like the ELECTRE method discussed earlier. As human life is the prime concern in disaster relief supply chain, the application of ELECTRE method would bring great profit to the most recent stages of development and also acts as an instigator to researchers to explore more on this research area. Future researchers may also investigate how disaster risks can be eased within supply chains. For an instance, organisations can plan to build and plan inventory governing body, its methods and state of the art with a chain member to maintain adequate flow of materials through the supply chain during and after a disaster event. Also, future research work can mainly focus on the outcome of internal, operational or external risks on supply chain networks. The ranking of the barriers and steps taken to implement SCM which are ascertained by several experts can be biased due to the presence of characteristic acceptance of every individual expert. Another shortcoming is that this research considered only 9 barriers. Besides, in this study, all barriers and steps were examined without considering any uncertainties. Therefore, in future work, researchers can concentrate on barrier analysis to rank disasters under uncertainties. This survey can be further carried out by using other MCDM methods such as ANP, AHP, Fuzzy-ELECTRE, ISM, and DEMATEL.

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