© 2015 IJSRST | Volume 1 | Issue 3 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X
Themed Section: Engineering and Technology

Sustainable Supply Chain in Crises Management

Marjan Mohammadjafari, Ali Reza Hatamniya
Department of Industrial Engineering, Kerman branch, Islamic Azad University, Kerman, Iran

ABSTRACT

During disaster, various organizations such as Red Cross or Red Crescent are often engaged with significant problems regarding to supply chain management. Sustainable supply chain management is defined as a collaboration between partners along supply chain to manage materials, information and capital flow for an achievement of sustainability along with environmental, economic and social dimensions. The aim of this paper is to develop a new framework for identifying the effect of sustainability concept on supply chain during emergency condition. Having a meticulous and thorough approach in this stage during the system averts technical and financial issues during the engagement with emergency condition and operational stages. In this paper, a VIKOR approach is utilized to find the best compromise solution. The most appropriate path way to improve the supply chain management towards sustainability regarding to ICS in emergency management was identified.
Keywords: Sustainable Supply Chain, disaster, Crisis Management, Emergency Management, ICS.

I. INTRODUCTION

Sustainable supply chain management (SSCM) is the integration of two independent concepts: sustainability and supply chain management. Seuring and Muller (2008) have defined sustainable supply chain management as the collaboration between partners along supply chain to manage materials, information and capital flow for an achievement of sustainability along with environmental, economic and social dimensions. From the perspective of sustainability, the pressures tend to effect throughout the entire product lifecycle along the supply chains; from product design, sourcing, manufacturing, distribution, product use, to product end of life and recovery process (Linton et al. 2007, Halldórsson et al. 2009). On the other hand, one of the main reinforced arm during disasters is an agile supply chain during emergency management process.

The term "emergency", means unexpected and potentially dangerous situation, requiring immediate action", can describe a broad range of situations. These may vary from the most minor, which are dealt by persons without emergency services involvement, through "normal" emergencies, which involve response by one or more of the principal emergency services, to major emergencies (Lindell et al. 2006). During disaster, various organizations such as Red Cross or Red Crescent are often engaged with significant problems of transporting large amounts of many different necessary material including food, clothing, medicine, medical supplies, machinery, and personnel from different locations to different destinations in the effected cordons. Sustainability in supply chain helps speed up the transportation of supplies and relief personnel to maximize the survival rate of the affected population and minimize the cost of such operations (Minner 2003). However, the main question is that "How it can become sustainable?"

It is clear that there are 3 major sustainability factors as environmental factors, economic factors and social factors (Mohamad et al. 2014). On the other hand, the main controlling center for managing the flow of resources and services is the incident command system (ICS). Incident Command System (ICS) has become a primary tool used to reduce the impact of disaster onset after making destruction to the infrastructures of the community (Rahman et al. 2015). It was developed to create a standardized approach for relief forces to use in order to conduct an efficient response effort (Zhang and She 2014). However, the traditional incident

management approach is a step-by-step approach, which is independently and largely performed with limited coordination among involved stockholders. It is essential that every engaged forces involved in the response operation work effectively and efficiently to minimize the incident response time (McGrath and Hall 2014). Different studies tries to transpose the concept of sustainability to the framework of ICS. Table 1 tries to define this path and help to identify the evaluating factors of sustainable ICS for implementation on supply chain management procedures.

TABLE 1

MATRIX OF ICS VERSUS SUSTAINABILITY FACTORS

ICS	Environmental		Social			Economic		
	Environmental Concern	Waste Management	Collaboration	Respects	Capacity estimation	Mapping the talents	Economic consideration	Optimizations
Operations	Engaged	Engaged	Engaged	Engaged	x	x	x	x
	(Kapucu 2006, Kapucu *et al.* 2010)		(Parrillo *et al.* 2013, Singhry *et al.* 2014, Rahman *et al.* 2015)			(Kremers *et al.* 2010, Schreiber *et al.* 2012, Boersma *et al.* 2014)		
Planning	Engaged	x	Engaged	Engaged	Engaged	Engaged	Engaged	Engaged
	(McGrath and Hall 2014)		(Kapucu 2006, Kapucu *et al.* 2010)			(Kremers *et al.* 2010, Schreiber *et al.* 2012, Boersma *et al.* 2014)		
Logistic	Engaged	Engaged	Engaged	x	Engaged	x	Engaged	Engaged
	(McGrath and Hall 2014)		(Parrillo *et al.* 2013, Singhry *et al.* 2014, Rahman *et al.* 2015)			(Kremers *et al.* 2010, Schreiber *et al.* 2012, Boersma *et al.* 2014)		
Finance	x	x	Engaged	x	x	Engaged	Engaged	Engaged
	(Kapucu 2006, Kapucu *et al.* 2010, Rahman *et al.* 2015)		(Smith *et al.* 2012, Parrillo *et al.* 2013, Singhry *et al.* 2014, Rahman *et al.* 2015)			(Kapucu 2006, Kapucu *et al.* 2010)		

Thus it is very important to use this factors to integrate different parts of supply chain management system. Based on the previous studies there are different pathway to improve supply chain procedures. One of these path is accordingly energy beside saving resources (Adetunji 2008). Moreover waste management, service quality, health and safety and innovation management are other paths to improve the supply chain management (Vrijhoef and Koskela 2000, Tah and Carr 2001, McCullen and Towill 2002, Halldórsson et al. 2009, Ho 2009, Sanayei et al. 2010). However, it is very important to identify the connectivity info-graph of these pathway with sustainability during emergency condition. Figure 1 illustrate this infographic concept.

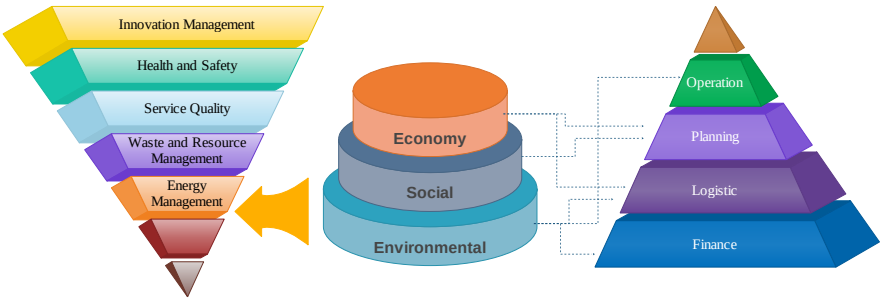

Figure 1: info graphic concept

The aim of this paper is to develop a new framework for identifying the effect of sustainability concept on supply chain during emergency condition. It is clear that, the leading of flow in emergency management supply chain is in the hand of ICS. Thus, it is very important to improve the reliability of ICS sectors regarding to sustainability concept to develop a new sustainable supply chain framework.

II. METHODS AND MATERIAL

In this research, the structured interview was employed to identify the weight of each sustainability criteria for improving supply chain management model. Furthermore, the VIKOR model was applied to evaluate the rate of effectiveness of each of the ICS sectors according to sustainability concept.

Rating and identifying the priority of pathway in sustainable supply chain is a MADM problem. For this problem, the decision is made from the courses of action (sorting and ranking) in presence of multiple, usually conflicting, attributes. There are several methods for solving the MCDM problems specified in literature (Jahan et al. 2010). However, previous methods were more focusing on simple comparative procedures between different criteria. This method was not reliable while the focus point of study was more on quantitative values and criteria such as hydrodynamic forces and structural stabilities. On the other hand, some criteria such as protection, flexibility and financial concerns were not considered in continues scales. The VIKOR method can solve this short come of previous methods.

VIKOR (VIseKriterijumska Optimizacija i Kompromisno Resenje) is a multi-attribute decision making technique with a simple computation procedure which considers the closeness to ideal alternative. In the literature, there are many studies, which have benefited from VIKOR method. Moreover, some studies conducted a comparative analysis of VIKOR and TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) methods with a numerical example (Opricovic and Tzeng 2004, Kaya and Kahraman 2010).

This method focuses on ranking a set of alternatives for a problem with conflicting criteria, to determine a feasible solution which is the closest to the ideal solution, by taking into account the decision makers' mutual concessions(Opricovic and Tzeng 2002, Opricovic and Tzeng 2004, Opricovic and Tzeng 2007). The mathematical formulation of the crisp VIKOR approach is starts with equation 1.

$$L_{pj} = \left[\sum_{i=0}^{n} \left[w_i \left(f_i^* - f_{ij} \right) \Big/ \left(f_i^* - f_i^- \right) \right]^p \right]^{\frac{1}{p}}, 1 \le p \le \infty;\ j = 1,2,\cdots \quad (1)$$

Where, the rating of the ith aspect is denoted by fij for alternative aj. Furthermore, wi represents the weight of the ith indicator and f* is the maximum number (best) and f- represents the minimum number (worst) values of all criterion functions for alternative aj. IN VIKOR method, the values of Qi were determined in the seventh step by the following relation (Eq.18).

$$Q_i = \nu \times \left(S_i - S^+ \right) \Big/ \left(S^- - S^+ \right) + \left(1 - \nu \right) \times \left(R_i - R^+ \right) \Big/ \left(R^- - R^+ \right) \quad (2)$$

Where S^+ / R^+ and S^- / R^- are the maximum and minimum values achieved in each category. ν is introduced as a weight for the strategy of maximum group utility. The value of ν lies in the range of 0 to1. In Eq. 16 & 17, $\nu > 0.5$ indicates that S is emphasized more than R, while for $\nu < 0.5$, R is emphasized more. When is equal to 1, it represents a decision-making process that could use the strategy of maximizing group utility, as occurred in the traditional VIKOR approach. Whenever is equal to zero, it shows a process that could apply a minimum individual regret strategy that is found among maximum individual regrets/gaps of lower level criteria for each alternative.

III. RESULT AND DISCUSSION

After evaluation of the responses achieved from survey, the first step was weighting of criteria. The results show that of the experts are approved that the "social factors" have the highest impact on supply flow. As it is illustrated in table 2 the economy factors follow social factors with 4 value. Third shows that the experts spend more concern on environmental aspects.

Table 2
Linguistic Weighting Factors

No.	Criteria	Rated by Panel
1	Environmental	3.6
2	Economical	4
3	Social	4.5

However, 4 major pathways for improving the supply chain management was identified as Energy, Waste and Resource Management, service quality, health and safety and innovation management. Based on this selection the interviewer we asked about the impat of each of the sustainability major criteria on these factors. The mean score of the results were calculated and used in VIKOR method. Thus the normalized ratings were calculated as it is presented in table 4.

Table 3
Normalized rating values

Weights	3.6	4	4.5
	Environmental	Economical	Social
Energy, Waste and Resource Management	0.566934	0.5356	0.45091
Service quality	0.496067	0.583209	0.515325
Health and safety	0.524414	0.333262	0.515325
Innovation management	0.396854	0.511796	0.515325

In the next step the weighted values for each factors were calculated accordingly (Figure 2). In this research, according to the second step of methodology, the mentioned performance weights collected from interviews as shown in previous Tables. Moreover, The best value and worst value performance score of alternatives with respect to each criterion were identified and denoted as x_j^+ and x_j^- .Table 5 defines the amount of x_j^+ and x_j^- for each criterion. According to the sixth step the amounts of S_i and R_i were calculated.

Energy, Wast	2.040963	2.142402	2.029093
service quality	1.785842	2.332837	2.318964
health and sa	1.88789	1.33305	2.318964
innovation m	1.428674	2.047184	2.318964

Figure 2: weighted variables

Figure 3: Comparative results for VIKOR method

However, for (as for the traditional VIKOR), service quality achieved the highest rank among the other technologies. This was the same result that had been advised by panel of experts during interview. Consequently, if a strategy of maximizing group utility was targeted by decision makers, then service quality was the best choice. However, Q(service quality) – Q(Innovation) > 0.25 Thus, the service quality again should be assigned as the best solutions. The VIKOR approach reveals a more precise result and the result is also not so rigid. On the other hand, this approach prepares applicable ranking in contrast with conventional qualitative method. Therefore, based on the considered strategy for policy making process, one can decide which alternative is the best solution and which one have the most opportunity to be the best solution.

IV. CONCLUSION

Different categories of concepts are investigated as possible pathway to improve supply chain management towards sustainability by former. Focusing on ranking and selecting from a set of alternatives in the presence of conflicting criteria regarding to ICS in emergency management and sustainability criteria by a VIKOR approach achieves a more precise result rather than the conventional type applied in former research.

Selecting of a best strategy for improvement of supply chain management is often influenced by uncertainty in practice. Moreover, the fact that determining the exact values of the criteria is difficult or impossible suggests considering them in linguistic terms. By providing a maximum group utility for the ‘‘majority’’, this approach determines a compromise solution that is approved by former results. However, If the consensus of a maximum group utility for the ‘‘majority’’, and a minimum of individual regret for the ‘‘opponent’’ is required, then, also the service quality which is followed by innovation management could also be assigned as the appropriate concept for strategy of improvement. Flexibility is one of the significant characteristic of this proposed approach. This approach performs assessing and ranking alternatives to achieve a best framework for improving supply chain management towards sustainability regarding to ICS in emergency management.

V. REFERENCES

[1] Adetunji, I., Price, A. D. F. And Fleming, P., 2008. Achieving sustainability in the construction supply chain. Proceedings of the Institution of Civil Engineers Engineering Sustainability 161–172.

[2] Boersma, K., Comfort, L., Groenendaal, J. & Wolbers, J., 2014. Editorial: Incident command systems: A dynamic tension among goals, rules and practice. Journal of Contingencies and Crisis Management, 22 (1), 1-4.

[3] Halldórsson, Á., Kotzab, H. & Skjøtt-Larsen, T., 2009. Supply chain management on the crossroad to sustainability: A blessing or a curse? Logistics Research, 1 (2), 83-94.

[4] Ho, J.C., Shalishali, Maurice K., Tseng, Tzu-Liang (Bill)., Ang, David. And Auburn, S. , 2009. Opportunities in green supply chain management. The Coastal Business Journal 8(1), 202-211.

[5] Jahan, A., Ismail, M.Y., Sapuan, S.M. & Mustapha, F., 2010. Material screening and choosing methods - a review. Materials & Design, 31 (2), 696-705 Available from: http://www.sciencedirect.com/science/article/B6TX5-4X08777-2/2/7b504dbf2cbbd4a45e56c001e2d221b4.

[6] Kapucu, N., 2006. Interagency communication networks during emergencies boundary spanners in multiagency coordination. The American Review of Public Administration, 36 (2), 207-225.

[7] Kapucu, N., Arslan, T. & Demiroz, F., 2010. Collaborative emergency management and national emergency management network. Disaster Prevention and Management, 19 (4), 452-468.

[8] Kaya, T. & Kahraman, C., 2010. Multicriteria renewable energy planning using an integrated fuzzy vikor & ahp methodology: The case of istanbul. Energy, 35 (6), 2517-2527 Available from: http://www.sciencedirect.com/science/article/B6V2S-4YRPMT0-2/2/7d7a40ee6735287cc1f4352286759be4.

[9] Kremers, J., Rietjens, B., Voordijk, H. & De Boer, S.J., 2010. Construction contracting and civil–military interaction. Construction Management and Economics, 28 (8), 871-883 Available from: http://dx.doi.org/10.1080/01446191003762256 [Accessed 2011/09/19].

[10] Lindell, M.K., Perry, R.W., Prater, C. & Nicholson, W.C., 2006. Fundamentals of emergency management: FEMA.

[11] Linton, J.D., Klassen, R. & Jayaraman, V., 2007. Sustainable supply chains: An introduction. Journal of Operations Management, 25 (6), 1075-1082.

[12] Mccullen, P. & Towill, D., 2002. Diagnosis and reduction of bullwhip in supply chains. Supply Chain Management: An International Journal, 7 (3), 164-179.

[13] Mcgrath, C.G. & Hall, C.J., Year. Standardizing incident command system training internationally in the public and private sectored.^eds. International Oil Spill Conference ProceedingsAmerican Petroleum Institute, 300322.

[14] Minner, S., 2003. Multiple-supplier inventory models in supply chain management: A review. International Journal of Production Economics, 81, 265-279.

[15] Mohamad, M., Ibrahim, R. & Nekooie, M., 2014. A new method for evaluating the current collaborative teamwork environment within the malaysian construction industry. International Journal of Management Science and Engineering Management, 9 (4), 265-275.

[16] Opricovic, S. & Tzeng, G.-H., 2002. Multicriteria planning of post-earthquake sustainable reconstruction. Computer-Aided Civil and Infrastructure Engineering, 17 (3), 211-220 Available from: http://dx.doi.org/10.1111/1467-8667.00269.

[17] Opricovic, S. & Tzeng, G.-H., 2004. Compromise solution by mcdm methods: A comparative analysis of vikor and topsis. European Journal of Operational Research, 156 (2), 445-455 Available from: http://www.sciencedirect.com/science/article/B6VCT-484SPB6-8/2/e150143717827405f1712462790115ca.

[18] Opricovic, S. & Tzeng, G.-H., 2007. Extended vikor method in comparison with outranking methods. European Journal of Operational Research, 178 (2), 514-529 Available from: http://www.sciencedirect.com/science/article/B6VCT-4JFHF3F-3/2/70006635422bac3a355ec1e6e3987da4.

[19] Parrillo, S., Bail, J., Arora, R. & Arora, P., 2013. Incident command systems. Disaster Management: Medical Preparedness, Response and Homeland Security, 153.

[20] Rahman, M., Khan, S.M., Chowdhury, M., Huynh, N., Ogle, J., Dey, K.C. & Bhavsar, P., Year. Incident command system strategies for incident management on freeways: A simulation analysised.^eds. Transportation Research Board 94th Annual Meeting.

[21] Sanayei, A., Farid Mousavi, S. & Yazdankhah, A., 2010. Group decision making process for supplier selection with vikor under fuzzy environment. Expert Systems with Applications, 37 (1), 24-30 Available from: http://www.sciencedirect.com/science/article/B6V03-4W7YXRH-6/2/52aa4892a4af379fc97d8d18d7c65422.

[22] Schreiber, M., Pfefferbaum, B. & Sayegh, L., 2012. Toward the way forward: The national children's disaster mental health concept of operations. Disaster medicine and public health preparedness, 6 (02), 174-181.

[23] Singhry, H.B., Rahman, A.A. & Imm, S.N.S., 2014. The potential moderating role of supply chain capabilities on the relationship between supply chain technology and concurrent engineering in product design. International Journal of Supply Chain Management, 3 (2).

[24] Smith, J., Levy, M.J., Hsu, E.B. & Lee Levy, J., 2012. Disaster curricula in medical education: Pilot survey. Prehospital and disaster medicine, 27 (05), 492-494.

[25] Tah, J. & Carr, V., 2001. Towards a framework for project risk knowledge management in the construction supply chain. Advances in Engineering Software, 32 (10), 835-846.

[26] Vrijhoef, R. & Koskela, L., 2000. The four roles of supply chain management in construction. European Journal of Purchasing & Supply Management, 6 (2000), 169-178 Available from: http://www.sciencedirect.com/science/article/B6VGR-412RWK0-4/2/ae426efd963dc68d307af45caa3f7b7a.

[27] Zhang, M. & She, L., 2014. Incident command system in china: Development and dilemmas evidence from comparison of two cases. Journal of Contingencies and Crisis Management, 22 (1), 52-57.