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When challenges need an evaluation: for operational excellence and sustainability orientation in humanitarian supply and logistics management

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Abstract: Humanitarian Supply and Logistics Management (HSLM) is an important area of study for governments and relief aid operational managers in developing more successful practice in disaster management. During the humanitarian mission, the perspective requires to make a real focus on the triple bottom sustainability. Thus, it is vital for humanitarian operations in an emerging economy like India to deal with the probable challenges to HSLM for operational excellence by focusing on these key areas - ecological, social and economic sustainability. Therefore, the prime contribution of this article is to identify key challenges to HSLM and to analyse causal relationships between these challenges for developing sustainability in relief operations in a developing economy - the Indian perspective. The listed key challenges were analysed using Explanatory Factor Analysis and Decision Making Trial and Evaluation Laboratory Analysis. A total of 136 responses were received from Indian humanitarian sector respondents. From findings 'Governance and regulatory'; 'Technology and Facilities' and 'Strategic' challenges are the cause group challenges while 'Financial'; 'Ecological' and 'Social' challenges are identified as effect group challenges. This research is invaluable for practitioners, policy makers, NGOs and communities in bringing synergies between humanitarian operations and operational excellence to accomplish sustainability orientation in systems.

Keywords: Humanitarian Supply and Logistics Management, Operational Excellence, Challenges, Sustainability, DEMATEL - Explanatory Factor Analysis, India

1. Introduction

Humanitarian Supply and Logistics Management (HSLM) is an important area of study for governments and aid agencies in developing more successful policies and practice in disaster management (Jabbour et al., 2017). Humanitarian organizations (HOs) need to react immediately when a disaster occurs and must provide food, medical facilities and other essential commodities to victims. Successful practice in disaster relief largely depends on operational excellence of supply and logistics. If improvements in these areas can be achieved, there will be a significant impact on performance measures of humanitarian operations such as

responsiveness, effectiveness and efficiency (Charles et al., 2016). Managing humanitarian relief operations is not straightforward, due to involvement of different stakeholders (internal as well as external). A humanitarian relief operation often includes international relief organizations, host governments, the armed forces, local and regional relief agencies which may have varied expertise and supply and logistics capabilities to cope with an operation. No single agency has the variety of resources needed to respond effectively to a major disaster. This requires good communications, proposer role clarity and effective coordination among different stakeholders and supply members for accomplishing effective sustainable humanitarian assistance (Balcik et al., 2010). To develop a sustainable HSLM is a main hurdle for humanitarian practitioners because of the variety of agencies in the field, their different levels of expertise and their methods of working.

Disasters may happen anywhere in the world. On April 2015, an earthquake hit Nepal and caused severe damage to the community (Noham and Tzur, 2018). Further, Japan, Iceland, and New Zealand are all susceptible to earthquakes. According to the Emergency Event Database, more than 21,000 disasters have happened in the world from 1900 to the present day.

Natural disasters are becoming increasingly frequent in India, the seventh largest country in the world. In India, around 60% of the land mass is susceptible to earthquakes; over 40 million hectares are prone to severe flooding; about 68% of the country may suffer from drought. Extreme weather - floods, earthquakes, cyclones, hailstorms – is the cause of the most common disasters in India. India is now one of the “high risk” nations in the world along with Mexico, Italy, Indonesia, Turkey, Philippines and Canada. These disasters may cause huge losses to the environment and society and may even have a significant impact on a nation’s economy (Kabra et al., 2015).

People all over the globe are affected by many disasters each year, with much evidence now available to prove that the number of disasters is on the increase. Yet there is still little understood on finding synergy between humanitarian operations and operational excellence in disasters. Furthermore, literature also lacks in evaluating the potential barriers of successful HSLM and finding suitable solutions to tackle them (Sahebi et al., 2017). Humanitarian organisations are faced with many challenges to make suitable relief materials available as and when needed. As part the on-going work on how to effectively address these challenges, there is an increasing focus on pre-positioning logistics (Venkatesh et al., 2018). The Indian

economy is growing very rapidly but man-made and natural disasters are a deterrent; the increasing number of disasters in recent years has had a negative impact on the overall development of the country (Kabra et al., 2015). During the humanitarian mission, the perspective requires to widen to make a real focus on triple bottom sustainability (Kunz and Gold, 2017). Thus, it is vital for humanitarian and relief operations in a developing economy like India to address the probable challenges to HSLM for maintaining operational excellence by focusing on these key areas - ecological, social and economic sustainability. A dedicated knowledge management based decision approach can assist humanitarian experts to design their HSLM to make a real difference to their operations (Charles et al., 2016).

This research therefore aims to respond to following research concerns – (i) what are the main challenges to sustainability in HSLM? (ii) How are the identified challenges analysed to establish their interactions and performance in effective execution of HSLM? In line with this, the objectives of this work are:

(i) To identify challenges to sustainability in HSLM in developing economies from an Indian perspective
(ii) To evaluate the listed challenges after establishing their causal relationships to achieve effective sustainability concepts in HSLM
(iii) To propose valuable implications from the present work.

In this work, a critical review of literature and questionnaire are both carried out to uncover the most common challenges to sustainability in HSLM. The present research applies Explanatory Factor Analysis (EFA) and Decision Making-Trial and Evaluation Laboratory Analysis (DEMATEL) based research techniques to assess these challenges. EFA underpins the theory development and clusters the challenges into categories to give a comprehensive understanding of developing operational excellence cum sustainability in HSLM operations. DEMATEL helps in determining the causal relationships between and among the identified variables (Seleem et al., 2016; Mangla et al., 2018).

This research is positioned in six sections. Section 1 develops the background and objectives of this research. Section 2 speaks for relevant literature for this work. Section 3 portrays the designed research methodology. Section 4 presents the data analysis and results. In Section 5, the findings along with contributions and implications for practitioners are discussed. To end, conclusions are summarized in Section 6.

2. Theoretical Background

This section gives an overview of HSLM itself, HSLM and sustainability, together with proposed challenges to achieving success in this field. Gaps in the research are also provided in the last section.

2.1 HSLM with sustainability orientation for operational excellence in relief operations

Disaster management is an area of study by researchers and academics all over the world. Much of this work has highlighted that the supply chain has a significant role in offering assistance to disaster victims (Dubey and Gunasekaran, 2016). Millions of persons can be exaggerated by the chaos caused by these disasters; people's welfare or even survival may depend on disaster relief assistance provided by various humanitarian agencies and governments. This aid must be delivered as soon as possible to increase the survival rate of the population within the affected public (Kunz et al., 2014). Disaster can be either a man-made or natural event, causing serious losses to the environment, society, economy etc.(Kabra and Ramesh, 2015a, b; Dwivedi et al., 2017).Climate change must now be taken into account.

Climate change is a global problem being studied by both academics and practitioners. We can only guess at the effects on our planet in future years. The fear is that the global situation can only deteriorate in future as perceived by the effects of climate change (Kovács and Spens, 2007; Kovács and Spens, 2009). All governments are aware of the effects and are implementing policies accordingly. A changing climate may causes floods, droughts and heat waves, volcanic activities, earthquakes, tsunamis etc. These natural disasters are becoming more frequent and more extreme in terms of its impact to community. The social and economic tolls on a community can cause devastation that lasts for many years. Unfortunately, current disaster policies merely react to events and have a short-run focus. There are no prevention planning or long term policies for redevelopment. Humanitarian organisations and governments need to frame strategic disaster resilience plans to assist communities to prepare and recover from disasters; vision and forward planning would provide a vital step towards sustainability (Purvis et al., 2016; Papadopoulos et al., 2017).

In case of disasters, an efficient humanitarian supply chain should respond quickly (Van Wassenhove 2006), to various mediations; this is despite the uncertainty that invariably arises. Most of the developing countries lack in this kind of resilience and an effective Humanitarian Supply Chain (HSC) (Singh et al., 2018). Humanitarian logistics is the main and utmost

multifaceted component of disaster relief operations. There must be a clear awareness of the difficulties and issues involved in effective disaster management (Pettit and Beresford, 2009). After the Asian tsunami in 2004, it was announced that humanitarian logistics were seen to play a vital role in disaster relief operations. Humanitarian logistics guarantee that the right relief supplies are delivered to affected people and to disaster zones when they are required most through the HSC (Duran et al., 2013). In supply chain and logistics design, scholars study the material, information and financial flows, among different partners in a network. Humanitarian relief is complicated by the presence of multiple objectives such as location, allocation, capacity, inventory, routing decisions and effectiveness while looking at minimization of costs (Jahre et al., 2009; Javid and Azad, 2010; Gutjahr and Nolz, 2016). HSLM is now acknowledged to be extremely important as it directly indicates the effectiveness of operations in humanitarian missions (Kunz and Gold, 2017).

Researchers, practitioners and planners all hold the same view in that it would be beneficial to include local communities in actions in humanitarian operations; however this has rarely if ever been put into practice (Samaddar et al., 2015). Disaster response agencies implement plans to provide high speed relief to victims, with partial focus of the socio-economic perspective. During the disaster rehabilitation phase, a more holistic needs assessment is needed to rebuild the community (Kunz and Gold, 2017). In recent years, achieving sustainability (considering economic, ecological and social issues) along with operational excellence in HSLM has been a focus of study for both academia and practitioners after a number of disasters worldwide (Dubey and Gunasekaran, 2016). Notwithstanding the substantial contributions of these research studies, there is very little or no reported research on maximizing the sustainability of HSLM (El-Anwar et al., 2009).

2.2 Proposed Challenges to Sustainability in HSLM

The identification of key challenges is significant in operational excellence that further contribute to sustainability in humanitarian missions and a literature review was done using critical search words e.g. Challenges and Barriers; Disaster Management; Humanitarian Supply Chain and Logistics Management; Sustainability; Humanitarian Operations and Operational Excellence; Sustainability and Humanitarian Supply Chain and Operational Excellence and Logistics Management, and such like. The Google and Google Scholar search tool bars were used to link databases like Science direct; ISI WoS; Emerald; Scopus; Taylor & Francis; DOAJ; EBSCO, Wiley and Inderscience, etc. The corresponding papers were then

downloaded, reviewed and analysed (Luthra and Mangla, 2018). In this way, 33 challenges to sustainability in HSLM were identified through literature and experts' inputs (Section 4).The challenges include.

Table 1: The various challenges to sustainability in HSLM

S. No.	Challenges	Description	Reference
1	Delays in delivery	Delays in process of delivering the relief items due to inappropriate transportation availability or capacity, geographical conditions, traffic etc.	Kovács and Spens (2009); Baharmand et al. (2017)
2	Higher consumption of energy	Relief missions to victims and disaster rehabilitation may consume higher resources (energy, fuel and water), if not planned in a sustainable way.	Kovács and Spens (2011);Seifert et al., 2018
3	Higher population and urbanization	Higher population and urbanization, eg in India and China, increases the exposure of people to disasters whilst reducing their mitigation and coping strategies in humanitarian supply chain.	Kovács and Spens(2011); Kumar and Havey (2013);Dubey and Gunasekaran(2016)
4	Ignorance of social media	Social media can communicate essential information in case of disasters. Thus, ignorance of social media could lower the operational effectiveness of HSLM.	Experts' input
5	Inefficient governmental policies and regulatory directions	Inefficient governmental policies and regulatory directions in supplying relief aids to victims may create some legal and governance issues.	Natarajarathinam et al. (2009); Venkatesh et al. (2018)
6	Inequality and cultural issues	A humanitarian relief operation often includes different actors like international relief organizations, host governments, the armed forces, local and regional relief agencies, which may have varied expertise and supply and logistics capabilities to cope with an operation. Teams are from different nationalities and cultures may bring some inequality and cultural issues.	Rodon et al. (2012); Dubey et al. (2016); Bealtand Mansouri (2018)
7	Investment in training and development for stakeholders	Lack of investments in training and development of skills among stakeholders may decrease cost expenses but also decrease sustainability of humanitarian relief operations.	Majewskiet al. (2010); Anjomshoae et al. (2017)
8	Investment on capacity building and inventory management	Investment in capacity building and adequate inventory stock is crucial in providing essential assistance to victims and bring further synergy between humanitarian operations and operational excellence to sustainability.	Kovács and Spens(2011); Kunz et al. (2014); Kunz et al. (2017)
9	Lack of awareness and knowledge within a community	The mere awareness and knowledge within a community poses a challenge to HSLM.	Kovács and Spens (2011);Kabra and Ramesh (2015a)
10	Lack of competitive environment	Government needs to encourage organizations (NGOs, private sector agencies) to involve and improve operational efficiency of humanitarian missions in a competitive environment.	Van Wassenhove (2006); Kabra and Ramesh (2015a)

11	Lack of coordination andcooperation between members	The coordination of humanitarian organizations is normally hampered by their lack of communication and cooperation with each other.	Kunz and Gold (2017); Venkatesh et al. (2018)
12	Lack of early warning systems	Earl ywarning and predictive measures could bring appropriate proactive plans for managing the HSLM	Starr and Van Wassenhove (2014); Kabra et al. (2015)
13	Lack of flexibility	Stakeholders should be flexible enough to coordinate with other partners of supply chain in managing humanitarian operations.	John and Ramesh (2012); Jahre(2017); Scholten et al. (2018)
14	Lack of funds	Money constraints may hamper supplies of resources such as material, food, medicines, people, and transportation capacity to people in humanitarian operational and sustainability context.	Tatham and Kovács (2010);Oloruntoba and Kovács(2015); Kabra et al. (2015)
15	Lack of infrastructure and superior ICT network	Lack of infrastructure and superior ICT network in terms of poor roads, transport systems and ICT network may hamper the humanitarian operations in a country like India.	Kabra and Ramesh (2015a, b); Yadav and Barve (2015); Dufour et al. (2018)
16	Lack of innovation	Humanitarian organizations should exhibit a degree of innovation to devise new measures, methods, materials etc to improve sustainability in HSLM.	Abidi et al. (2014); Dubey and Gunasekaran(2016); Jabbour et al. (2017)
17	Lack of planning and preparedness	Lack of planning and preparedness often cause mismatch between demand and supply in humanitarian missions.	Kabra et al. (2015); Jabbour et al. (2017); Venkatesh et al. (2018)
18	Lack of security	Security-related challenges have seen recent troubles to humanitarian missions.	Kovács and Spens (2009); Biswal et al. (2018)
19	Lack of skills and expertise among workers	Skills and expertise is paramount for bringing operational excellence and sustainability in HSLM. However, humanitarian organizations lack research in developing skills of humanitarian supply and operations management.	Tatham and Kovács (2010); Bealt et al. (2016); Kunz et al. (2017)
20	Lack of standards and feedback mechanisms	Humanitarian organizations need to follow international standards for improved performance in relief operations. Further, the communication network should also be designed for feedback mechanism, as lack of communication may lead to inefficient resource allocation.	Kumar and Havey (2013); Jahre and Fabbe-Costes(2015); Maghsoudi and Pazirandeh(2016)
21	Lack of supplies and equipment	Adequate provision of supplies and equipment is an important component of humanitarian missions .A humanitarian supply and logistics network must cope with a surge in demand for essential supplies/equipment.	Hale and Moberg (2005); Chakravarty (2014); Pazirandeh and Maghsoudi(2018)
22	Lack of sustainability considerations	During the disaster relief operations, the perspective requires to widen to make a real focus on the triple bottom sustainability.	El-Anwar et al. (2009); Haavisto and Kovács (2014); Kunz and Gold (2017)
23	Lack of technological knowledge among the planners	Enabling technologies are quite dispersed in their functionality and accessibility. Lack of technological knowledge among the planners is reported as a key challenge to HSLM.	Özdamar and Ertem (2015); Esen and Bayrak (2017)

24	Lack of transparency and accountability	Humanitarian operations are generally complex n nature. Humanitarian organizations lack transparency and accountability among the various actors of HSLM.	Blecken(2010); Kabra et al. (2015); Zobel et al. (2016)
25	Lack of vision and values	There is a lack of clarity over vision and values among humanitarian organizations to respond quickly to crises.	Day et al. (2012);Tabaklar et al. (2015); Dubey and Gunasekaran(2016)
26	Lack of proper logistics information	Relief efforts, organized in real-time ,rely heavily on the logistics infrastructure. Lack of proper logistics information make it more difficult to manage HSLM	Pettit and Beresford (2009); Van Wassenhove and Martinez(2012); Chakravarty (2014); Gupta et al. (2017)
27	Low public and other stakeholders participation	Humanitarian operations may require involving multiple stakeholders in terms of the equipment and expertise that is needed. To adopt any methodology within the organization, it is necessary to involve their stakeholders throughout the projects.	Samaddar et al. (2015);Oloruntoba et al. (2018)
28	Low value for money (higher operational cost – cost/benefit ratio)	Lack of preparedness and long term planning may lead to higher operational cost of humanitarian operations and results in lower value for money in relief aids.	Experts' input
29	Lower speed to response	Timely response is essential to decrease mortalities and to preserve perishable food and medical supplies. Low speed and late response are constraints to disaster relief operations and needs to be taken into account.	Ertem et al. (2010); Tatham and Kovács (2010); Yadav and Barve(2015); Jabbour et al. (2017)
30	Political issues	Political crises are common and play a crucial role in an emerging economy like India. In order to improve sustainability of HLSM, political issues need to be taken into account.	Kovács and Spens (2009);Leiras et al. (2014); Jabbour et al. (2017); Seifert et al. (2018)
31	Problem of diversified geography	The geographic separation of supply and demand reduces the effectiveness of humanitarian supply and logistics operations.	Diaz and Tachizawa(2015); Behl and Dutta (2018);Oloruntoba(2018)
32	Transportation network issues	Inadequate infrastructures and a lack of transport connectivity problems are more frequent in less developed regions like India. A transportation network issue may obstruct disaster relief operations.	Kovács and Spens (2007); Duran et al. (2013); Behl and Dutta (2018)
33	Waste generation and carbon emissions	Waste generation and carbon emissions issues should also be addressed in disaster response and humanitarian operations.	Halldórssonand Kovács(2010); Gonzalez et al. (2015); Trivedi et al. (2015)

2.3 Research Gaps

Disasters have increased vulnerability for the entire global population. To cope with this increased vulnerability, there is a greater need for quick and effective responses from humanitarian organizations and other stakeholders such as military, local government, charities and logistics and supply chain practitioners. These organizations must be able to co-ordinate supplies of food, shelter and medical facilities, ensuring they are available where and when needed (Altay and Pal, 2014; Kumar and Havey, 2013). In order to improve the sustainability of operations, humanitarian organizations needs coordinated management of multiple relief operations and for that it must be set up quickly, effectively to involve a number of partners. A

supply and logistics network that runs smoothly and efficiently is therefore crucial to humanitarian missions (Charles et al., 2016).

The increasing frequency and intensity of disasters mean that larger numbers of people are now being affected. Therefore a more systematic approach and better planning are needed to improve relief management and consequently reduce the impact on a community. In order to manage the humanitarian relief practices, scholars and practitioners are now looking at specific areas that need to be improved. Recent studies have been extended to include the roles of long-term planning, capacity and logistics network planning, early warning measures, cooperation and coordination among supply chain partners. Improving practices in specific areas will mean improvement for the operation as a whole (Yadav and Barve, 2015). Researchers and practitioners agree that there is a need to increase sustainability of humanitarian operations. Yet theory on operational excellence and sustainability to HSLM is scarce; there is still a gap in current literature (Kunz and Gold, 2017).

HSLM can involve working in chaotic conditions with a number of actors making inputs at various levels. Operations can be complex to manage. Conditions in the field mean that it is vital to have flexibility in design and operation to work effectively (Venkatesh et al., 2018). In HSLM, there can be many actors involved from different organisations and backgrounds, with differing skills and experience and with different conceptualisations of humanitarian practices. Varied backgrounds, in term of culture, experience, expectations and expertise add to the list of challenges that already exist in humanitarian work (Pateman et al., 2013). Coordination in HSLM can be fairly poor due to various problematic issues such as "the concept of demand unpredictability, the suddenness of demand, high stakes associated with on time delivery and lack of resources that extend to issues such as supply, people, technology, transportation and financing" (Kabra et al., 2015). Hence, there is a dire need to address these challenges if sustainability in HSLM is to be achieved (Papadopoulos et al., 2017).

Notably, the specific consideration of challenges to effectively achieving sustainability that addresses operational excellence in HSLM is not covered in current literature. Thus, this research aims to identify challenges to achieve sustainability in HSLM to provide a theoretical grounding. This work seeks to identify and analyse key challenges to achieve sustainability that addresses operational excellence in HSLM from a developing economy context.

3. Research Methodology

In this work, 33 challenges to sustainability in HSLM were identified and validated through experts' inputs (Section 4). These challenges provide a theoretical underpinning using EFA. A questionnaire based technique was conducted with concerned Indian humanitarian supply chain and logistics personnel such as Government officials, Police and Army, Indian Red Cross Society members, NGOs and senior academics. This work uses qualitative and qualitative research instruments, which includes instrument development, EFA application and the DEMATEL method. EFA underpins the theory development and clusters the challenges into categories to give a comprehensive understanding of developing operational excellence sustainability in HSLM operations. DEMATEL evaluates the causal relations of the challenges, and further divides them into cause and effect challenges (Mangla et al., 2018). These are discussed in the next section. The methodology for this research is illustrated in Figure 1.

[Figure 1 about here]

4. Data Analysis and Results

Concerned personnel engaged in humanitarian supply chain and logistics activities in India were considered for data collection. In this sense, 136 responses from the humanitarian supply chain and logistics sector were collected; this is considered to be sufficient sample size (Luthra and Mangla, 2018) for theoretical underpinning.

4.1 Questionnaire Design and Data Collection

Initially, 31 challenges were identified through literature support. The experts were contacted to validate the list accordingly to incorporate sustainability that addresses operational excellence in HSLM from an Indian context. Based upon experts' input, two challenges namely 'Ignorance of social media' and 'Low value for money' were added into the initial list of challenges. We collected responses from those personnel engaged in humanitarian supply chain and logistics activities who were qualified, knowledgeable and skilled based professionals. The challenges with comparatively lower mean values were deleted from the list. In this way, a total of 33 challenges to sustainability in HSLM were analysed by survey questionnaire. The survey questionnaire is shown in Annexure-A.

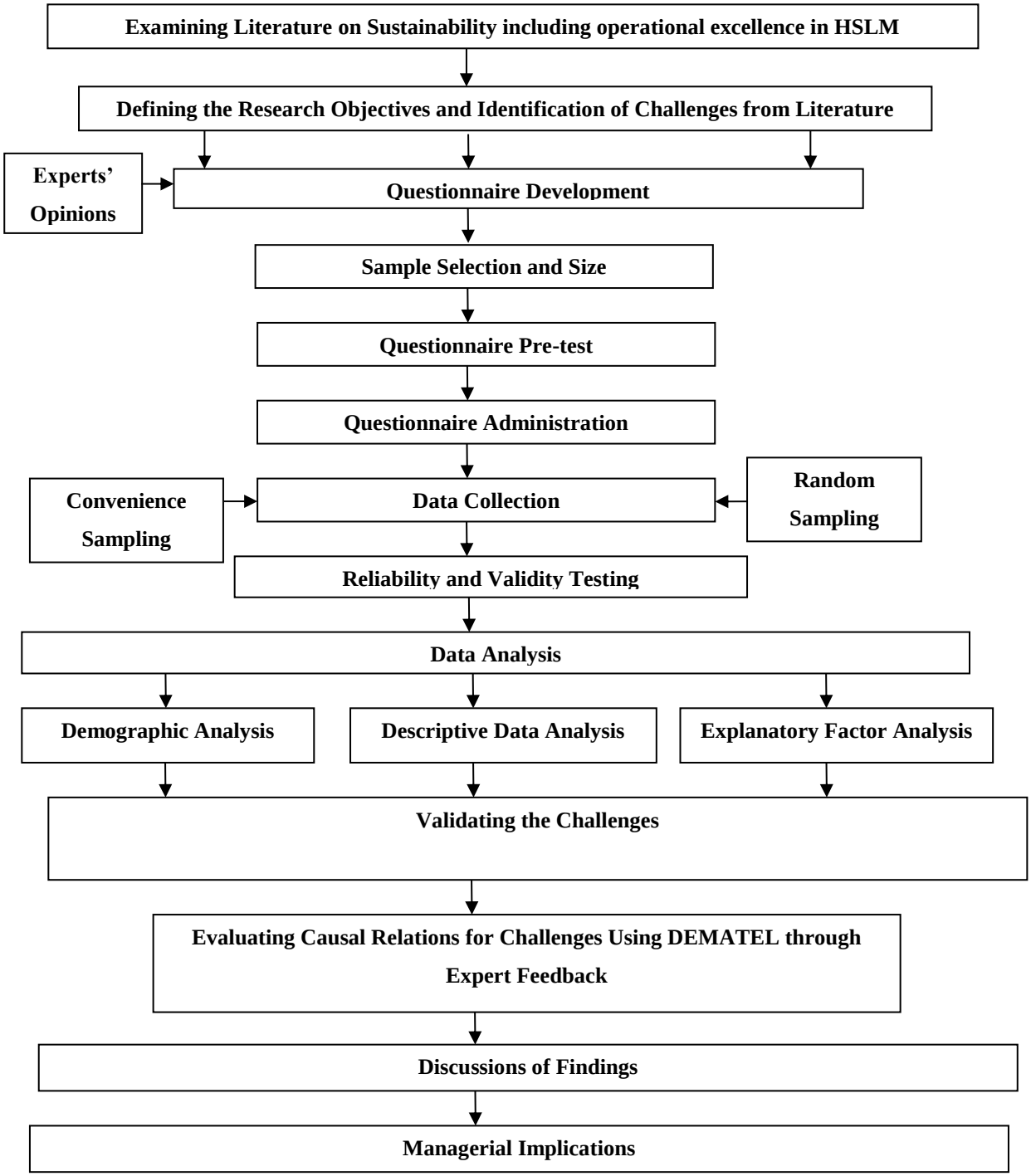

Figure 1: Research methodology

For data collection, convenience and random sampling methods Luthra and Mangla (2018), have been used. In convenience sampling, initially the survey questionnaire was pre-tested. In the pre-tested stage, academic professors engaged in research and development activities in the humanitarian sector with more than five years' work experience in operations management and related fields were contacted personally for their opinions on the challenges to sustainability on HSLM in the Indian context. After this, we visited the professionals involved in

humanitarian operations for data collection through convenience sampling method. This provided 57 usable responses. Additionally, we created a database of 300 experts involved in various domains of disaster management activities. We contacted these experts through email, Facebook, LinkedIn Twitter etc. In this process, we collected 79 viable responses including both the early and late respondents, with a valid response rate of 26.33% (Malhotra and Grover, 1998). The details of participants' profiles are shown in Table 2.

Table 2: Participants profile

S. No.	Participants profile	Criteria	Number of Respondent	Percentage
1	Nature of Job	Regulatory body	04	02.94
		Policy maker	02	01.47
		Army	16	11.77
		Police	22	16.18
		Medical service	19	13.97
		NGOs	24	17.65
		Donors	29	21.32
		Academician	12	08.82
		Other	08	05.88
2	Qualification	Under Graduate	09	06.62
		Graduate	32	23.53
		Post Graduate	78	57.35
		Doctorate	14	10.30
		Others	03	02.20
3	Work Experience (In years)	Less than or equal to 5	14	10.29
		6-10	21	15.44
		11-15	34	25.00
		16 to 20	45	33.09
		More than 20	22	16.18

This research conducts the descriptive statistics for the challenges as shown in Table 3.

Table 3: Descriptive statistics of the challenges to sustainability in HSLM

S. No.	Challenges	Mean	Standard deviation
1	Delays in delivery	4.09	0.564
2	Higher consumption of energy	3.71	0.557
3	Higher population and urbanization	3.71	0.559
4	Ignorance of social media	4.09	0.564
5	Inefficient governmental policies and regulatory directions	4.44	0.527
6	Inequality and cultural issues	4.49	0.620
7	Investment in training and development for stakeholders	3.88	0.531
8	Investment in capacity building and inventory management	3.86	0.458
9	Lack of awareness and knowledge among community	4.53	0.583
10	Lack of competitive environment	3.88	0.531
11	Lack of coordination and cooperation between members	4.42	0.495
12	Lack of early warning systems	4.40	0.491
13	Lack of flexibility	4.06	0.738
14	Lack of funds	3.82	0.569

15	Lack of infrastructure and superior ICT network	4.24	0.661
16	Lack of innovation	4.36	0.629
17	Lack of planning and preparedness	4.05	0.648
18	Lack of security	4.32	0.652
19	Lack of skills and expertise among workers	4.07	0.752
20	Lack of standards and feedback mechanisms	4.39	0.547
21	Lack of supplies/equipment	4.32	0.654
22	Lack of sustainability considerations	3.69	0.578
23	Lack of technological knowledge among the planners	4.32	0.617
24	Lack of transparency and accountability	4.49	0.571
25	Lack of vision and values	4.47	0.530
26	Lack of proper logistics information	4.04	0.704
27	Low public and other stakeholders participation	4.46	0.631
28	Low value for money	3.88	0.531
29	Lower speed to response	4.05	0.703
30	Political issues	4.48	0.516
31	Problem of diversified geography	4.49	0.620
32	Transportation network issues	4.29	0.657
33	Waste generation and carbon emissions	3.66	0.587

The mean values for all challenges come out to be well above 3. In this sense, all listed challenges are significant. The challenges obtaining a loading of more than a value of 0.5will ensure reliability and convergent validity. Further, Cronbach's alpha tests the internal consistency of survey questionnaire. The value of Chronbach's alpha is more than 0.7. Further, we submit the discriminant validity of survey instrument, which suggested that correlations between factors are less than 0.7. Next, we submit the convenience sampling bias of the responses. In so doing, we evaluated both the early and late responses for finding the non-response bias. For this, we conducted at-test and no significant difference is observed (for $P > 0.05$). Additionally, Chi-square test has also been applied to analyse any substantial difference between late and early responses.

4.2 EFA

EFA was conducted for validation of the challenges using SPSS Version 21.0. The Kaiser-Meyer-Olkin (KMO) value obtained (0.898) is significant and more than the minimum recommended value *i.e.* 0.6 (Kaiser, 1974; Hair et al. 2006). Bartlett's Test of Sphericity is also significant for the barriers ($p < 0.01$). The obtained sampling adequacy value for each barrier is above the acceptable value 0.50 (Hair et al. 2006). Thus, the collected data for challenges is suitable for applying EFA.

Further, with varimax factor rotation, EFA was carried out to determine the six dimensions of challenges to sustainability in HSLM; an Eigen value (>1) was used to obtain the final factor structure. Table 4 explains the results of factor analysis.

Table 4: EFA results

Dimension	challenges to sustainability in HSLM	Cronbach Apha	Item Loading	Eigen Values	Cumulative Percentage
Strategic (St)	Delays in delivery(St1)	0.947	0.895	5.514	16.710
	Ignorance of social media(St2)		0.895		
	Lack of proper logistics information(St3)		0.880		
	Lower speed to response(St4)		0.876		
	Lack of flexibility(St5)		0.863		
	Lack of skills and expertise among workers(St6)		0.855		
	Lack of planning and preparedness(St7)		0.821		
Technology and Facilities (TaF)	Lack of security(TaF1)	0.962	0.892	5.455	33.240
	Lack of infrastructure and superior ICT network(TaF2)		0.887		
	Lack of innovation(TaF3)		0.882		
	Lack of supplies/equipment(TaF4)		0.876		
	Transportation network issues(TaF5)		0.871		
	Lack of technological knowledge among the planners(TaF6)		0.845		
Governance and regulatory (GaR)	Lack of vision and value(GaR1)	0.935	0.935	5.233	49.097
	Inefficient governmental policies and regulatory directions (GaR2)		0.928		
	Political issues (GaR3)		0.910		
	Lack of transparency and accountability(GaR4)		0.860		
	Lack of early warning systems (GaR5)		0.845		
	Lack of standards and feedback mechanisms (GaR6)		0.810		
	Lack of coordination and cooperation between members (GaR7)		0.560		
Financial (Fi)	Investment in training and development for stakeholders(Fi1)	0.926	0.907	4.130	61.612
	Lack of competitive environment (Fi2)		0.907		
	Low value for money (Fi3)		0.907		
	Investment in capacity building and inventory management (Fi4)		0.778		
	Lack of funds (Fi5)		0.702		
Ecological (Ec)	Lack of sustainability considerations(Ec1)	0.951	0.928	3.539	72.335
	Waste generation and carbon emissions (Ec2)		0.908		
	Higher population and urbanization (Ec3)		0.873		
	Higher consumption of energy (Ec4)		0.838		
Social (So)	Inequality and cultural issues(So1)	0.968	0.855	3.477	82.871

	Problem of diversified geography (So2)		0.849		
	Low public and other stakeholders participation (So3)		0.847		
	Lack of awareness and knowledge among community (So4)		0.736		

Principal Component Analysis with Varimax with Kaiser Normalization (Rotation converged in 6 iterations).

Based on EFA results, we classified challenges into six dimensions; other details are given in Table 5.

Table 5: Finding dimension of challenges along with their variance

Dimension of Challenges	**Variance**
Dimension 1- Strategic challenges (St)	16.710% of the variance
Dimension 2-Technology and Facilities related challenges (TaF)	16.530% of the variance
Dimension 3- Governance and regulatory challenges (GaR)	15.857% of the variance
Dimension 4- Financial challenges (Fi)	12.515% of the variance
Dimension 5- Ecological challenges (Ec)	10.723% of the variance
Dimension 6- Social challenges (So)	10.536% of the variance

Next, the validated challenges have been analysed to establish their casual interactions of challenges to sustainability in HSLM through DEMATEL.

4.3 DEMATEL

DEMATEL is a sophisticated tool for analysis of a structured model (Gabus and Fontela, 1972). DEMATEL has become a popular method in recent years to appraise all intertwined causes and effect relationships in a structural model (Seleem et al., 2016; Khompatraporn and Somboonwiwat, 2017). DEMATEL helps in identifying the causal relations between variables in a system (Hsu et al., 2013; Luthra et al., 2016). Additionally, DEMATEL is capable of analysing the complex decision problems and defines the relations between the variables using graphical illustrations (Mangla et al., 2016; Gandhi et al., 2016). The steps in the DEMATEL method (Gandhi et al., 2015; Mangla et al., 2018; Jafari-Moghadam et al., 2017) are explained below.

Step 1: Define a set of decision criteria -- The criteria, i.e. challenges to sustainability in HSLM, are identified.

Step 2: Compute the direct-relation matrix -- Each expert is requested to estimate the strength of relations between any two challenges using a scale with values 0, 1, 2 and 3 (no influence, low influence, high influence and very high influence respectively) in Matrix **A** (n × n), where each element of x_{ij} is denoted as the degree to which the criterion *i* affects the criterion *j* and *n* is the number of factors. For each respondent, a n×n non-negative matrix can

be established as $A^k = [x^k_{ij}]$(where k is the number of respondents with $1 \leq k \leq H$,). Thus, X^1, X^2, X^3 . . . , X^H are the matrices from H respondents. To incorporate all opinions from H respondents, the average matrix $A = [a_{ij}]$ is constructed as follows:

$$a_{ij} = \frac{1}{H}\sum_{K=1}^{H} x_{ij}^{k}. \quad (1)$$

Step 3: **Determine the normalised direct-relation matrix (D)**

The average matrix (A) is determined by using the Eq. (2):

$$D=A\times S \quad (2)$$

Where, $S = \min\left[\frac{1}{\max \sum_{j=1}^{n}|m_{ij}|}, \frac{1}{\max \sum_{i=1}^{n}|m_{ij}|}\right]$

Step 4: Determine total relation matrix (T)

The total relation matrix (T) is determined using the Eq. (3):

$$T= D(I - D)^{-1} \quad (3)$$

Where, 'I' is the identity matrix. After calculating the total relation matrix (T) the sum of row and the sum of column of total relation matrix - r_i , c_j is calculated:$r_i$shows the total effects, received by i_{th} challenge on other challenge:c_j reveals the total effects, received by j_{th} challenge from other challenges. Normally, (r_i+c_j) is called prominence, indicating the importance between each challenge: (r_i-c_j) is the relation group which is divided into cause and effect groups with respect to positive and negative values of (r_i-c_j).

After determining the key dimensions and challenges to sustainability in HSLM, key dimensions of challenges to sustainability in HSLM were analysed to determine their causal relationships. Based on the DEMATEL method, experts were asked to frame the direct relation matrix using a pre-defined scale with values 0, 1, 2 and 3. An average direct relation matrix was formed by taking the average of inputs provided by the experts. The average direct relation matrix for the key dimensions of challenges to sustainability in HSLM is illustrated in Table 6.

Table 6: Average direct-relation matrix for key dimensions of challenges to sustainability in HSLM

Dimensions	St	TaF	GaR	Fi	Ec	So
St	0.00	2.50	1.75	2.00	2.50	2.25
TaF	2.75	0.00	1.50	2.33	2.00	2.67
GaR	2.33	2.33	0.00	2.33	2.75	2.75
Fi	2.11	1.22	1.11	0.00	2.5	2.33
Ec	1.11	1.11	1.11	1.50	0.00	2.33
So	1.50	1.11	1.11	1.50	2.22	0.00

Next, the normalised direct-relation matrix is determined using Eq. (2) (see Annexure B). The normalised matrix was transformed into the total relation matrix (T) by using Eq. (3). The datasets (r+c) (known as 'prominence') and (r-c) (known as 'relation') of the considered challenges were computed (see Table 7).

Table 7: Total relation and direct–indirect influence matrix (T) of key dimensions

Dimensions	St	TaF	GaR	Fi	Ec	So	Sum = r_i	r +c	r – c	Cause/ Effect
St	0.0618	0.1509	0.1139	0.1414	0.1736	0.1669	0.8085	1.5243	0.0927	Cause
TaF	0.1704	0.0538	0.1056	0.1545	0.1573	0.1832	0.8248	1.4360	0.2135	Cause
GaR	0.1610	0.1509	0.0485	0.1607	0.1922	0.1944	0.9076	1.4079	0.4074	Cause
Fi	0.1340	0.0940	0.0824	0.0503	0.1619	0.1567	0.6792	1.3896	-0.0313	Effect
Ec	0.0863	0.0798	0.0742	0.1009	0.0500	0.1432	0.5345	1.4096	-0.3405	Effect
So	0.1023	0.0818	0.0757	0.1027	0.1401	0.0531	0.5557	1.4532	-0.3418	Effect
Sum = c_j	0.7158	0.6113	0.5002	0.7104	0.8750	0.8975				

The dimensions St, TaF and GaR come under cause group. The dimensions Fi, Ec and So comes under effect group with respect to positive and negative values of (r-c). By mapping the (r + c) and (r - c) datasets, a causal relationship diagram of the key dimensions of challenges to sustainability in HSLM is drawn as represented in Figure 2.

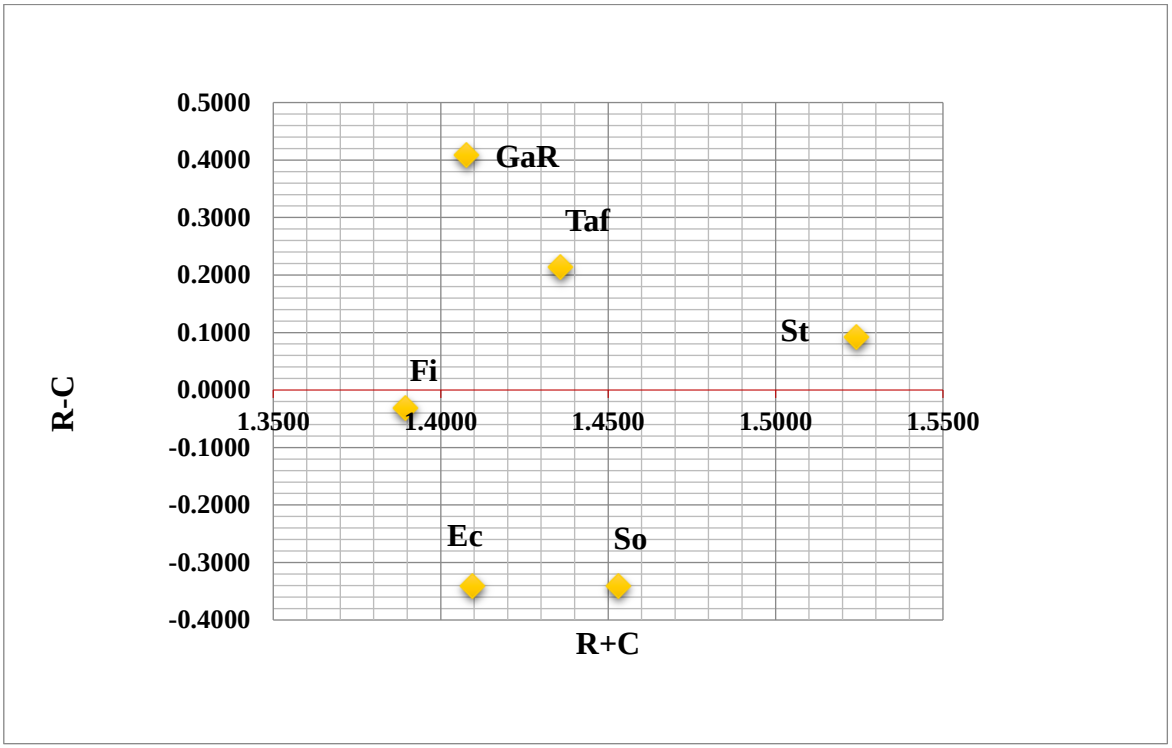

Figure 2: The Cause and Effect diagram

Similarly, the average, normalised, total relation matrix (see Annexure-B) and causal effect diagrams (see Annexure-C) for the challenges in each dimension have also been drawn.

5. Discussion of Findings

Based on findings of this work, the identified challenges have been evaluated according to their cause and effect groups. Managers need to concentrate more on causal challenges, as focusing on the cause group challenges will automatically improve the remaining effect group challenges. Based on analysis, the dimensions 'Governance and regulatory', 'Technology and Facilities' and 'Strategic' are shown to be the cause group challenges; 'Financial', 'Ecological' and 'Social' belong to the effect group. The findings are discussed considering these dimensions and their respective challenges.

From DEMATEL analysis, 'Governance and regulatory' dimension has highest influence on the system as it has the highest (r–c) score of 0.4074.However, this challenge receives less return effect from other challenges due to its comparable (r+c) score of 1.4079.There are seven challenges within this dimension. Balcik et al. (2010) reported that government is responsible for framing regulations to conduct high standard humanitarian supply and relief operations in disasters. However, the governments in a developing economy like India generally lacks in knowledge, coordination and experience needed to manage the synergy between operational excellence and humanitarian operations for sustainable development (Yadav and Barve, 2015).

In the 'Governance and regulatory' dimension, challengesGaR1, GaR2, GaR3, GaR4, GaR5 and GaR6 belong to causal challenges; GaR7 belongs to the effect group. Among these, 'Political issues (GaR3)' is the most prominent cause factor. Being as a reference to natural disasters, in India, around 60% of the land mass is susceptible to earthquakes; over 40 million hectares is prone to severe flooding; about 68% of the country may suffer from drought. The government in India are mainly responsible for providing humanitarian aids. While significant progress has been made in post-disaster response and reconstruction by the Indian government, there are still formidable challenges to reducing the risk of future disasters. Political issues in countries such as India are of major concern to achieving sustainability in HSLM.

The dimension 'Technology and Facilities (TaF)' comes next in the cause group. This dimension obtained second highest (r-c) score of 0.2135. Technology and Facilities (TaF) include challenges such as Lack of security, Lack of infrastructure and superior ICT network, Lack of innovation, Lack of supplies/equipment and Lack of technological knowledge among the planners; these are major hurdles to achieving sustainability in HSLM in developing countries like India. Many researchers have reported that technologies play a major role in

preparing in advance and responding effectively in case of disasters. Information coordination and management is also a big problem in an emerging economy like India due to diverse geographical conditions and cultures. This is validated by the research of Baharmand et al. (2017) who noted that humanitarian organizations faced information and communication technology related issues in Nepal's 2015 earthquake disaster. This dimension contains six sub challenges. In another research, Biswal et al. (2018) suggested that RFID technology in India can play a prominent role in managing the inventory subjected to shrinkage and misplacement in a humanitarian supply chain. Among them, TaF2, TaF3, TaF4 and TaF5 belong to the cause group, while TaF1 and TaF6 are in the effect group. Among these six challenges, 'Lack of innovation (TaF3)' and 'Lack of infrastructure and superior ICT network' are the most prominent cause factors. This means that technological innovation and ICT network can plan a key role in increasing operational excellence sustainability to HSLM in disasters. Governments, policymakers and practitioners need to focus on identifying innovative solutions and on developing strong ICT networks such as GIS to include remote sensing and satellite communication etc. for disaster preparedness, response and mitigation.

The dimension Strategic (St) comes next in the cause group. This dimension had third highest (r-c) score of 0.0927. The research of Yadav and Barve (2015) and Tofighi et al. (2016) concluded that disaster relief efforts are generally complex. Thus, longer planning could be an effective choice for, managing humanitarian operations in such situations. But, humanitarian organisations fail to effectively manage disaster relief efforts due to numerous challenges such as delays in delivery, ignorance of social media, lack of proper logistics information, low speed to response, lack of flexibility, lack of skills and expertise among workers and lack of planning and preparedness. Pettit and Beresford (2009) suggested in their research that time is evidently one of the key performance parameters for the stocks to reach the right zone at the right period in order to help the victims in any emergency relief operations. This dimension contains seven sub-challenges. Among them St2, St3, St5 and St7 belong to the cause group, while St1, St4 and St6 come under the effect group. Among these seven challenges, 'Lack of planning and preparedness (St7)' has been reported as the most prominent cause factor.

The dimension 'Financial (Fi)' is placed in the effect group. This dimension of challenges obtained a (r-c) score of -0.0313. Economic resources are important for any disaster management. The Indian economy is growing very rapidly but man-made and natural disasters are a deterrent; the increasing number of disasters in recent years has had a negative impact on

the overall development of the country (Kabra et al., 2015). Further, there are five sub challenges; Investment in training and development for stakeholders (Fi1), Lack of competitive environment (Fi2), Low value for money (Fi3), investment on capacity building and inventory management (Fi4) and Lack of funds (Fi5)) in this dimension. Among them, Fi1, Fi2, Fi3 and Fi4 belong to the effect group, while Fi5 comes under the cause group. Therefore, lack of funds are mainly responsible for the poor ICT infrastructure, poor capacity building and inventory management, lack of innovation and disparity of IT facilities among actors.

The dimension 'Ecological (Ec)' comes next in the effect group. This dimension of challenges obtained a(r-c) score of -0.03405.The humanitarian disasters may cause huge losses to environment and society such as water, air and soil pollution, waste generation, and may even have a significant impact on nation's economy (Trivedi et al. 2015; IFRC and Swedish Red Cross, 2017).Further, there are four sub challenges in this dimension. Among them, Ec1 and Ec3 belong to the cause group, while Ec2 and Ec4 come under the effect group. Among these four challenges, 'Lack of sustainability considerations (Ec1)' has been reported as the most influential cause factor. However, the Indian government is now more conscious in the approach to disaster management and has taken many steps towards sustainability of humanitarian operations especially in the development process. But much more is needed to achieve real sustainability in HSLM.

Finally, the dimension, 'Social (So)' is placed last in the effect group. Challenges in this group make a substantial impact on the system. This dimension has the smallest (r-c) score of -0.3418, implying that this challenge receives the highest impact. Further, there are four sub challenges in this dimension. Among them, So3 belongs to the cause group, while So1, So2 and So4 come under the effect group. The Government of India has included humanitarian mission agenda in its five-year planning policies as a foundation to sustainable development of societies. In order to develop sustainability orientation in HSLM, the humanitarian organisations needs to manage the problems stemming from social inequities and cultural issues. 'Low public and other stakeholders' participation (So3)' is one of the key problems to achieving true sustainability in HSLM. Humanitarian supply and logistics activities depend on a variety of stakeholders; they need to manage their ideology, religious beliefs and coordinated efforts for accomplishing operational excellence in relief operations (Van Wassenhove, 2006).

6. Contributions and Implications

The present research seeks to identify and analyse the challenges to sustainability in HSLM in a developing economy i.e. Indian context.

6.1 Theoretical contributions

The present work attempts to make the following contributions to existing theory:

- This research seeks to address the research question '*What are the challenges that lower the sustainability initiatives in HSLM practices?* 'The present research work guides the sustainable development of HSLM activities from a nation's perspective. This work reveals the key challenges to HSLM, especially in the case of a developing nation like India.
- The next prime contribution of this work is to evaluate the causal relationships among these challenges. This will facilitate managers and decision makers to plan sustainability-oriented strategies to adopt HSLM. This research further helps practitioners in understanding the behaviour of challenges by identifying the relationships among each set of major group challenges as well as sub-group challenges.

6.2 Implications for practitioners

This research also offers several prominent implications for practitioners and managers as follow:

6.2.1 Role of government policies and supportive guidelines

Government plays an imperative role in setting up an efficient HSLM concept, as a government must frame emergency response plans and policies. In this sense, a suitable government regulatory structure and framework can help in dealing with issues of governmental support and incentive systems for infrastructure development (e.g. for capacity planning, transportation network, manpower requirement), better co-ordination between central and state governments and a shared commitment to increasing the effectiveness of activities (both pro-active and reactive) in disaster management. Working together effectively may also allow practitioners to negotiate joint collaboration agreements for disaster relief eg offering tax-exemption to humanitarian supplies and priority management at customs.

6.2.2 Allocation of funds and essential resources

Funding and investment are amongst the prime concerns in attaining sustainability in HSLM adoption. Provision of funds can underpin government and non-government organisations to develop their capabilities in terms of innovation, technological up-grades, purchase of specialized material and specific equipment and enhancement of skills and expertise among a workforce to enhance sustainability. In this sense, practitioners may wish to consider cost/benefit analysis.

6.2.3 Provision of technological advancements and innovations

To manage an emergency, practitioners need to concentrate on technology, products and services. Victims may need different commodities such as food, clothes, medicines or shelter to survive in such situations. To help people, organisations should adopt technological updates and innovations to provide the highest degree of relief possible to affected peoples. Raising awareness about technology advancements in emerging economies can develop an efficient HSLM concept.

6.2.4 Provision of training and development programme among supply chain and logistics partners and stakeholders

Government needs to develop a humanitarian relief centre infrastructure for higher effectiveness of on-going activities. In so doing, practitioners also need to align the essential knowledge and varying expertise of people within the humanitarian relief operation ecosystem. Additionally, decision makers should implement the 'Skillset Development Initiative' to increase the skills of a larger number of workers. For this, managers should launch new training and development programmes for workers and stakeholders with a focus on humanitarian operational excellence. Government should also launch employment options in the humanitarian and disaster sectors to attract more of the younger generation into relief operations management.

6.2.5 Set the benchmark for proactive actions

In the case of developing nations, practitioners need to set some benchmark practices to develop sustainable HSLM operations. Speed, flexibility and collaboration are amongst the major prerequisites for higher standard relief operations. In this way, practitioners can design, plan and execute operations that may adopt benchmark models from developed countries; this may further help in the development of sustainable practices to boost resources in other nations.

7. Conclusions

This research attempts to address the challenge of disaster relief by listing and evaluating the key areas to attain sustainability in HSLM activities. The concept of humanitarian operational excellence is fairly underdeveloped in some nations, especially in India, leading to a demand for a focused knowledge based understanding to be put into practice. In so doing, this work identifies 33 important literature driven challenges to HSLM that may inhibit sustainability of activities at operational levels. We have conducted a questionnaire-based survey and applied EFA to provide a theoretical foundation to a list of challenges by taking views from different stakeholders in India. This research has also examined the causal relationships among and between listed challenges through the application of DEMATEL analysis.

Based on analysis, the 'Governance and regulatory', 'Technology and Facilities' and 'Strategic' dimensions are in the cause group of challenges; 'Financial', 'Ecological' and 'Social' belong to the effect group. Managers need to concentrate more on causal challenges, as focusing on the cause group challenges will automatically improve the remaining effect group challenges.

This research unlocks the potential hurdles in humanitarian supply and logistics that may influence the overall sustainability of operations in emerging economies such as India. This research is useful to practitioners in developing knowledge on humanitarian supply operations and managing the probable barriers to successful HSLM implementation while maintaining operational competitiveness and ecological-social-economic perspectives in supply chains.

Built on current limitations of this research, we can provide several key directions for future work. The confirmed set of challenges may be revised for inclusion or omission in other national contexts. We have designed this research in the context of India, but the outcomes may be applied to other emerging economies with slight variations. Comparisons may be made for findings among other developing nations such as Brazil, China, and Thailand. The statistical findings obtained may be explored in different geographical regions in India. The DEMATEL based model evaluates the causal relationships of challenges; however, some other qualitative and quantitative as well as decision making approaches may be applied to further test and evaluate the challenges.

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Annexure-A

SURVEY QUESTIONNAIRE

SECTION A: General Information

Please tick (✓) only one choice in each question as follows:

1. How will you classify your nature of service/work?

(a) Regulatory body
(b) Policy maker
(c) Army
(d) Police
(e) Medical service
(f) NGOs
(g) Academician
(h) Donor
(i) If any other, please specify……

2. How will you classify your qualification?

(a) Under Graduate
(b) Graduate
(c) Post Graduate
(d) Doctorate
(e) If any other, please specify……

3. How will you classify your work experience (in Years)?

(a) Less than or equal to 5
(b) 6-10
(c) 11-15
(d) 16 to 20
(e) More than 20

SECTION B: Significance of the challenges to Sustainability in Humanitarian Supply and Logistics Management (HSLM) in Indian Context

4. Rate the following challenges to sustainability in HSLM on 5 point Likert scale (1- not significant, 2-somewhat significant, 3-significant, 4-very significant and 5-extremely significant) (Please tick only ONE in each row).

S. No.	Challenges to sustainability in HSLM	Rating				
		1	2	3	4	5
1.	Delays in delivery					
2.	Higher consumption of energy					
3.	Higher population and urbanization					
4.	Ignorance of social media					
5.	Inefficient governmental policies and regulatory directions					
6.	Inequality and cultural issues					
7.	Investment in training and development for stakeholders					
8.	Investment on capacity building and inventory management					
9.	Lack of awareness and knowledge among community					
10.	Lack of competitive environment					

11.	Lack of coordination and cooperation between members					
12.	Lack of early warning systems					
13.	Lack of flexibility					
14.	Lack of funds					
15.	Lack of infrastructure and superior ICT network					
16.	Lack of innovation					
17.	Lack of planning and preparedness					
18.	Lack of security					
19.	Lack of skills and expertise among workers					
20.	Lack of standards and feedback mechanisms					
21.	Lack of supplies/equipment					
22.	Lack of sustainability considerations					
23.	Lack of technological knowledge among the planners					
24.	Lack of transparency and accountability					
25.	Lack of vision and values					
26.	Lack of proper logistics information					
27.	Low public and other stakeholders participation					
28.	Low value for money					
29.	Lower speed to response					
30.	Political issues					
31.	Problem of diversified geography					
32.	Transportation network issues					
33.	Waste generation and carbon emissions					
34.	If any other, please specify					

Name and Signature of Respondent
Designation:
Organization:
Mobile Number:
Email:
Date:
Place:

Thank you very much for completing this questionnaire

If you have any comments about this questionnaire or issues involved please write them in the box given below

Annexure-B

Table B.1: Normalised direct-relation matrix for the key dimensions of challenges

Dimensions	St	TaF	GaR	Fi	Ec	So
St	0.0000	0.1087	0.0761	0.0870	0.1087	0.0978
TaF	0.1196	0.0000	0.0652	0.1013	0.0870	0.1161
GaR	0.1013	0.1013	0.0000	0.1013	0.1196	0.1196
Fi	0.0917	0.0530	0.0483	0.0000	0.1087	0.1013
Ec	0.0483	0.0483	0.0483	0.0652	0.0000	0.1013
So	0.0652	0.0483	0.0483	0.0652	0.0965	0.0000

Total relation matrix of challenges to sustainability in HSLM

Table B2: Total relation and direct–indirect influence matrix of challenges of Strategic (St) dimension to sustainability in HSLM

Dimensions	St1	St2	St3	St4	St5	St6	St7	Sum = r_i	r +c	r – c	Cause/ Effect
St1	0.1075	0.1582	0.2018	0.1869	0.1706	0.1219	0.1239	1.0708	2.4997	-0.3581	Effect
St2	0.2392	0.0896	0.1771	0.2372	0.1861	0.1334	0.1758	1.2383	2.3045	0.1720	Cause
St3	0.2466	0.1759	0.1037	0.2445	0.1929	0.1765	0.1806	1.3207	2.4771	0.1642	Cause
St4	0.2001	0.1061	0.0770	0.0829	0.1536	0.1433	0.1050	0.8681	2.2900	-0.5539	Effect
St5	0.2196	0.1829	0.2263	0.2542	0.1206	0.2218	0.1878	1.4131	2.6619	0.1642	Cause
St6	0.1851	0.1575	0.1643	0.1845	0.1697	0.0779	0.1215	1.0604	2.1337	-0.0129	Effect
St7	0.2308	0.1962	0.2063	0.2317	0.2554	0.1986	0.2488	1.5678	2.7111	0.4244	Cause
Sum = c_j	1.4289	1.0662	1.1565	1.4220	1.2489	1.0733	1.1434				

Table B3: Total relation and direct–indirect influence matrix of challenges of Technology and Facilities (TaF) dimension to sustainability in HSLM

Dimensions	TaF1	TaF2	TaF3	TaF4	TaF5	TaF6	Sum = r_i	r +c	r – c	Cause/ Effect
TaF1	0.0891	0.1395	0.1395	0.1451	0.1463	0.1691	0.8287	1.9426	-0.2852	Effect
TaF2	0.2184	0.0685	0.1485	0.1544	0.1572	0.2184	0.9654	1.7096	0.2213	Cause
TaF3	0.2271	0.1544	0.0744	0.1974	0.1635	0.2271	1.0440	1.7882	0.2999	Cause
TaF4	0.2184	0.1485	0.1485	0.0744	0.1572	0.2184	0.9654	1.7793	0.1515	Cause
TaF5	0.2184	0.1485	0.1485	0.1544	0.0772	0.2184	0.9654	1.7941	0.1367	Cause
TaF6	0.1426	0.0847	0.0847	0.0881	0.1272	0.0626	0.5897	1.7036	-0.5242	Effect
Sum = c_j	1.1139	0.7441	0.7441	0.8139	0.8287	1.1139				

Table B4: Total relation and direct–indirect influence matrix of challenges of Governance and regulatory (GaR) dimension to sustainability in HSLM

Dimensions	GaR1	GaR2	GaR3	GaR4	GaR5	GaR6	GaR7	Sum = r_i	r +c	r – c	Cause/ Effect

GaR1	0.1186	0.2223	0.2230	0.2095	0.2195	0.2079	0.2287	**1.4296**	2.6470	0.2122	Cause
GaR2	0.2244	0.1231	0.2133	0.2028	0.2084	0.2095	0.2425	**1.4239**	2.6990	0.1488	Cause
GaR3	0.2103	0.2307	0.1159	0.2036	0.2130	0.2103	0.2563	**1.4401**	2.6321	0.2481	Cause
GaR4	0.1845	0.1927	0.1464	0.0938	0.2011	0.1927	0.2101	**1.2212**	2.3650	0.0775	Cause
GaR5	0.1974	0.1948	0.2025	0.1610	0.1078	0.1975	0.2168	**1.2776**	2.5252	0.0301	Cause
GaR6	0.1831	0.2058	0.1896	0.1584	0.1930	0.1029	0.2138	**1.2464**	2.4667	0.0262	Cause
GaR7	0.0991	0.1059	0.1014	0.1147	0.1048	0.0994	0.0675	**0.6928**	2.1285	-0.7429	Effect
Sum = c_j	**1.2174**	**1.2751**	**1.1920**	**1.1438**	**1.2475**	**1.2202**	**1.4357**				

Table B5: Total relation and direct–indirect influence matrix of challenges of Financial (Fi) dimension to sustainability in HSLM

Dimensions	**Fi1**	**Fi2**	**Fi3**	**Fi4**	**Fi5**	**Sum = r_i**	**r +c**	**r – c**	**Cause/ Effect**
Fi1	0.0149	0.0606	0.0963	0.0704	0.0624	0.3045	0.6730	-0.0640	Effect
Fi2	0.0676	0.0116	0.0576	0.1008	0.0641	0.3017	0.6848	-0.0814	Effect
Fi3	0.0637	0.0609	0.0101	0.0930	0.0536	0.2812	0.6669	-0.1046	Effect
Fi4	0.1091	0.1086	0.1064	0.0163	0.0629	0.4033	0.8448	-0.0381	Effect
Fi5	0.1132	0.1414	0.1154	0.1611	0.0210	0.5520	0.8160	0.2881	Cause
Sum = c_j	0.3685	0.3831	0.3858	0.4415	0.2639				

Table B6: Total relation and direct–indirect influence matrix of challenges of Ecological (Ec) dimension to sustainability in HSLM

Dimensions	**Ec1**	**Ec2**	**Ec3**	**Ec4**	**Sum = r_i**	**r +c**	**r – c**	**Cause/ Effect**
Ec1	0.0173	0.1197	0.0957	0.1267	0.3593	0.6093	0.1094	Cause
Ec2	0.0655	0.0102	0.0516	0.1006	0.2279	0.5786	-0.1228	Effect
Ec3	0.1068	0.1118	0.0096	0.1012	0.3293	0.5868	0.0718	Cause
Ec4	0.0604	0.1090	0.1007	0.0210	0.2910	0.6404	-0.0584	Effect
Sum = c_j	0.2500	0.3507	0.2575	0.3494				

Table B7: Total relation and direct–indirect influence matrix of challenges of Social (So)dimension to sustainability in HSLM

Dimensions	**So1**	**So2**	**So3**	**So4**	**Sum = r_i**	**r +c**	**r – c**	**Cause/ Effect**
So1	0.0085	0.0563	0.0536	0.0584	0.1768	0.4088	-0.0553	Effect
So2	0.0606	0.0048	0.0510	0.0503	0.1667	0.3903	-0.0569	Effect
So3	0.1066	0.1061	0.0054	0.1011	0.3192	0.4826	0.1557	Cause
So4	0.0564	0.0563	0.0536	0.0055	0.1718	0.3871	-0.0435	Effect
Sum = c_j	0.2321	0.2236	0.1635	0.2153				

Annexure-C

The cause and effect diagram for the challenges to sustainability in HSLM

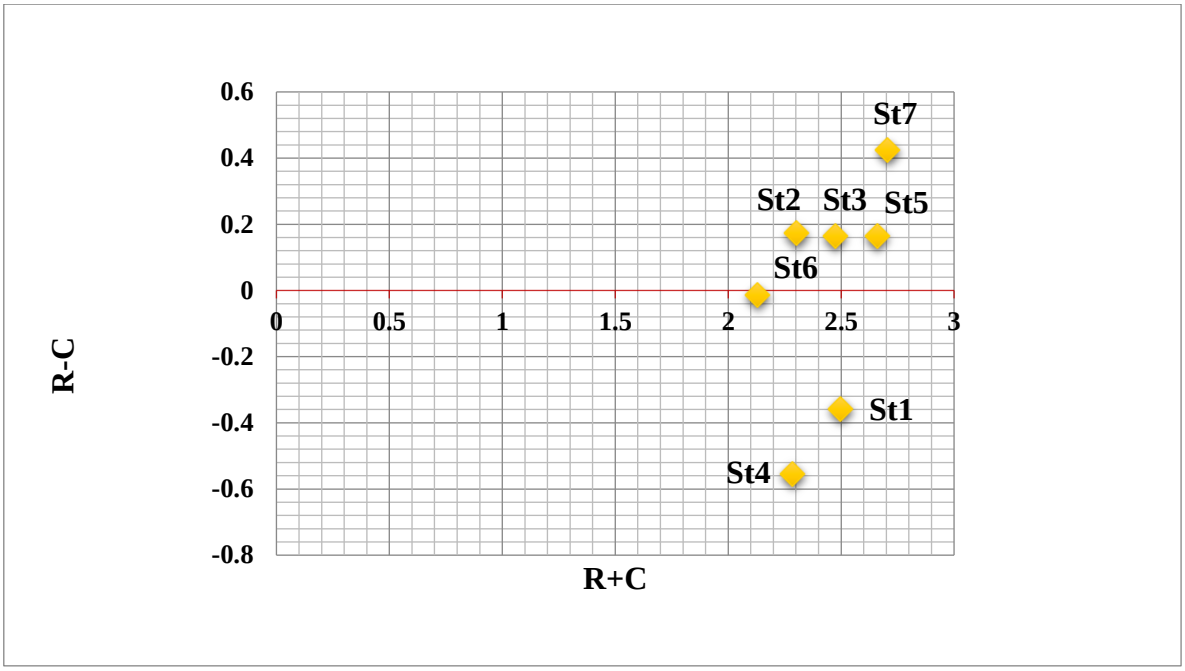

Figure C1: The cause and effect diagram for the challenges of strategic (St) dimension to sustainability in HSLM

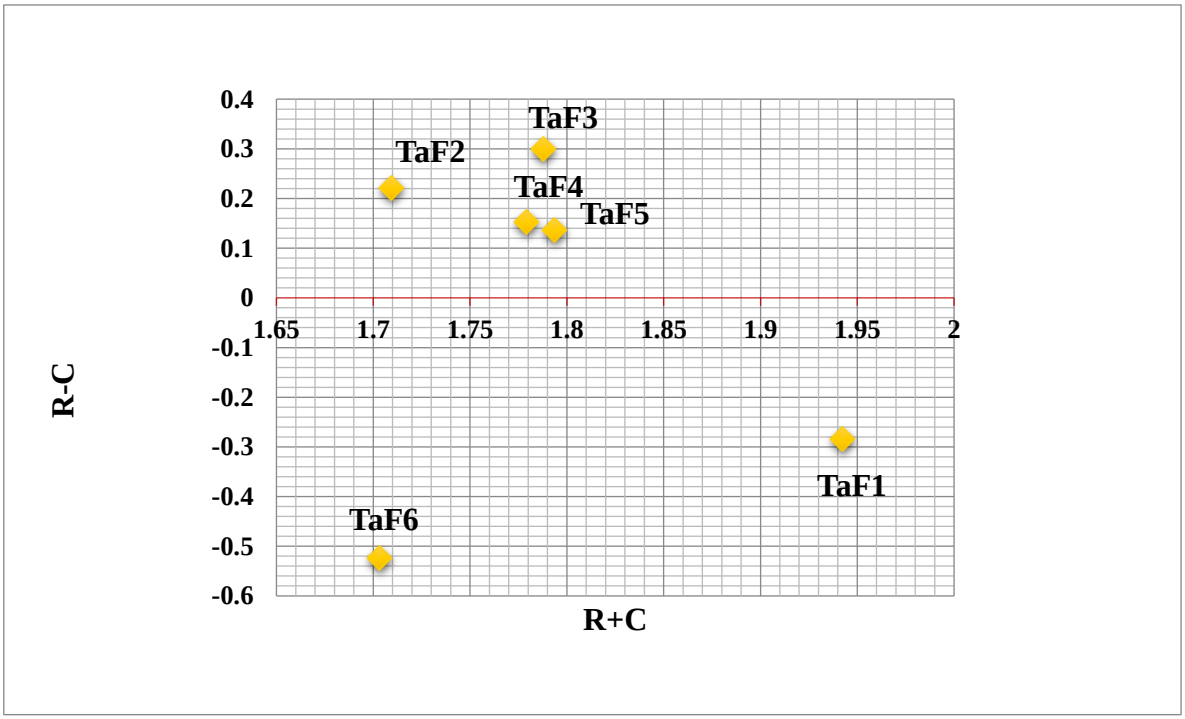

Figure C2: The cause and effect diagram for the challenges of Technology and Facilities (TaF) dimension to sustainability in HSLM

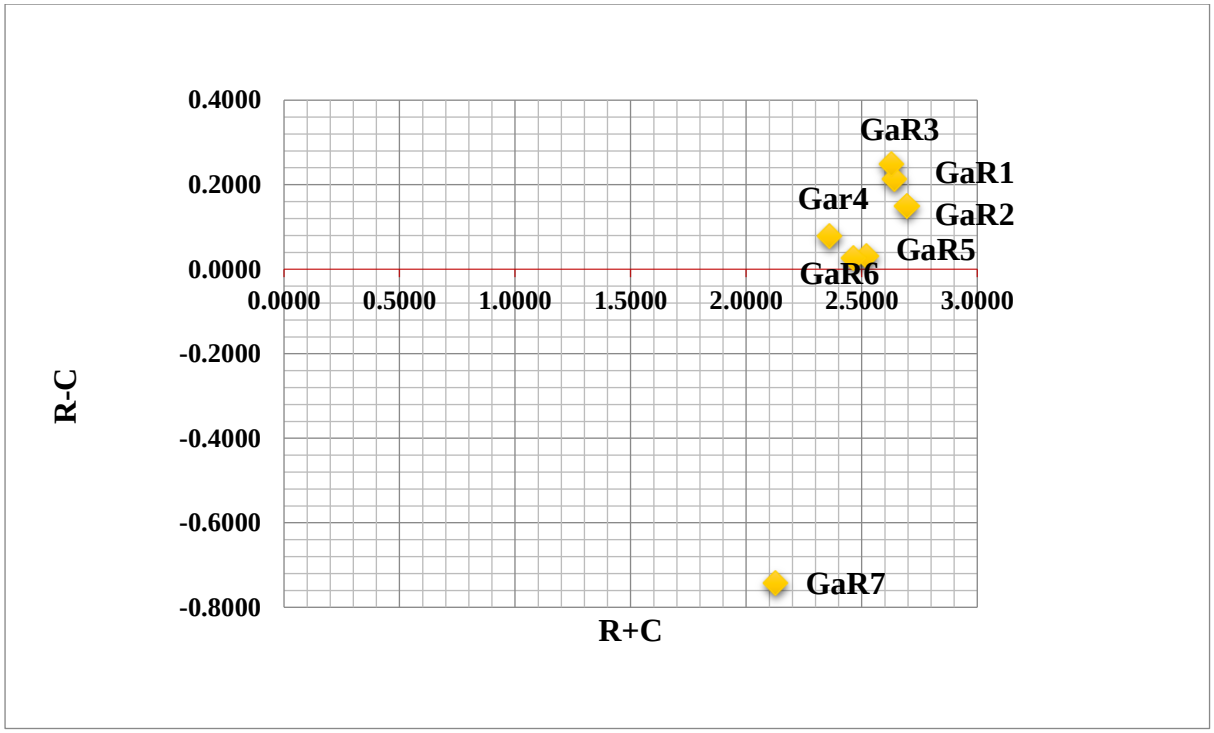

Figure C3: The cause and effect diagram for the challenges of Governance and regulatory (GaR) dimension to sustainability in HSLM

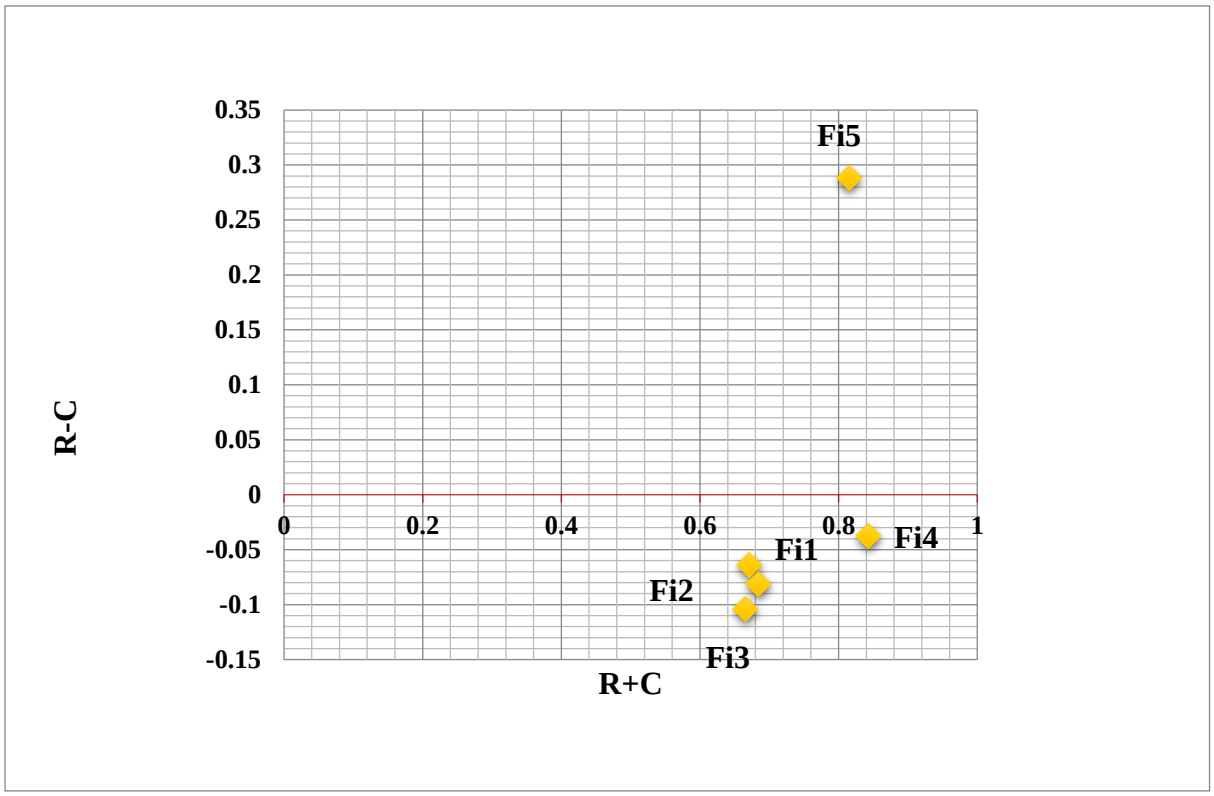

Figure C4: The cause and effect diagram for the challenges of Financial (Fi) dimension to sustainability in HSLM

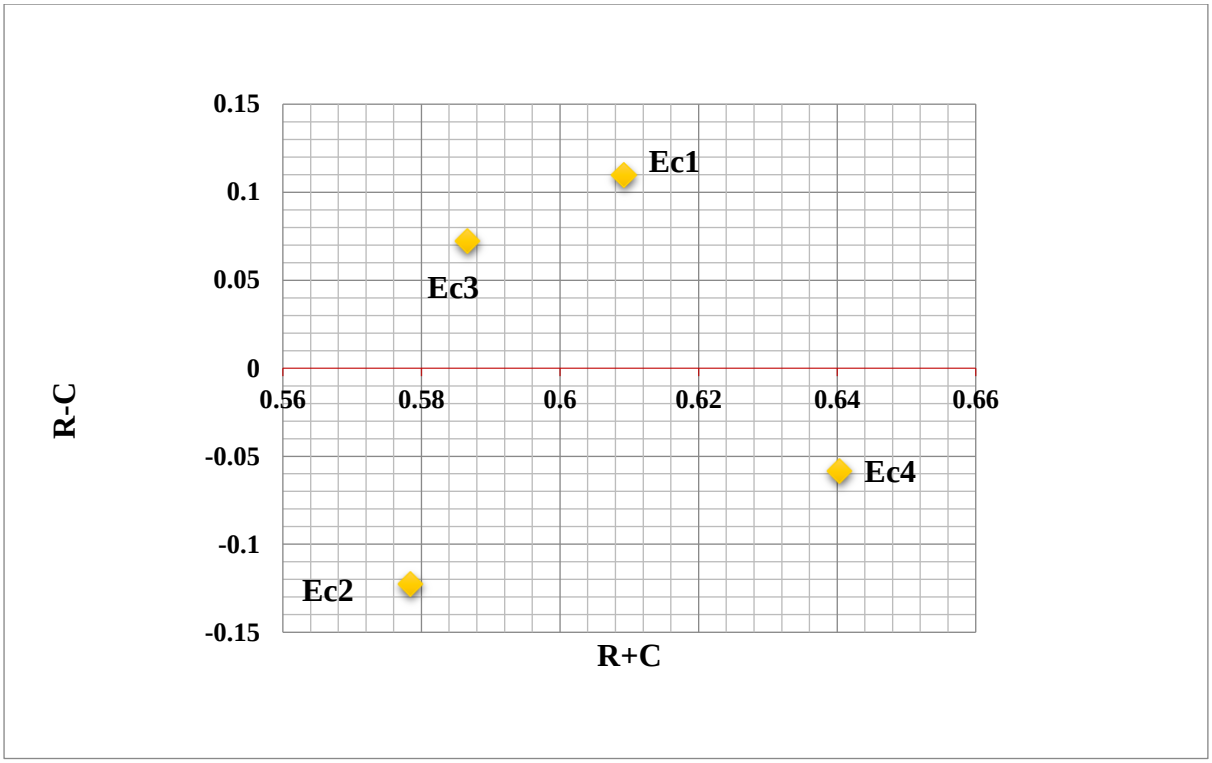

Figure C5: The cause and effect diagram for the challenges of Ecological (Ec) dimension to sustainability in HSLM

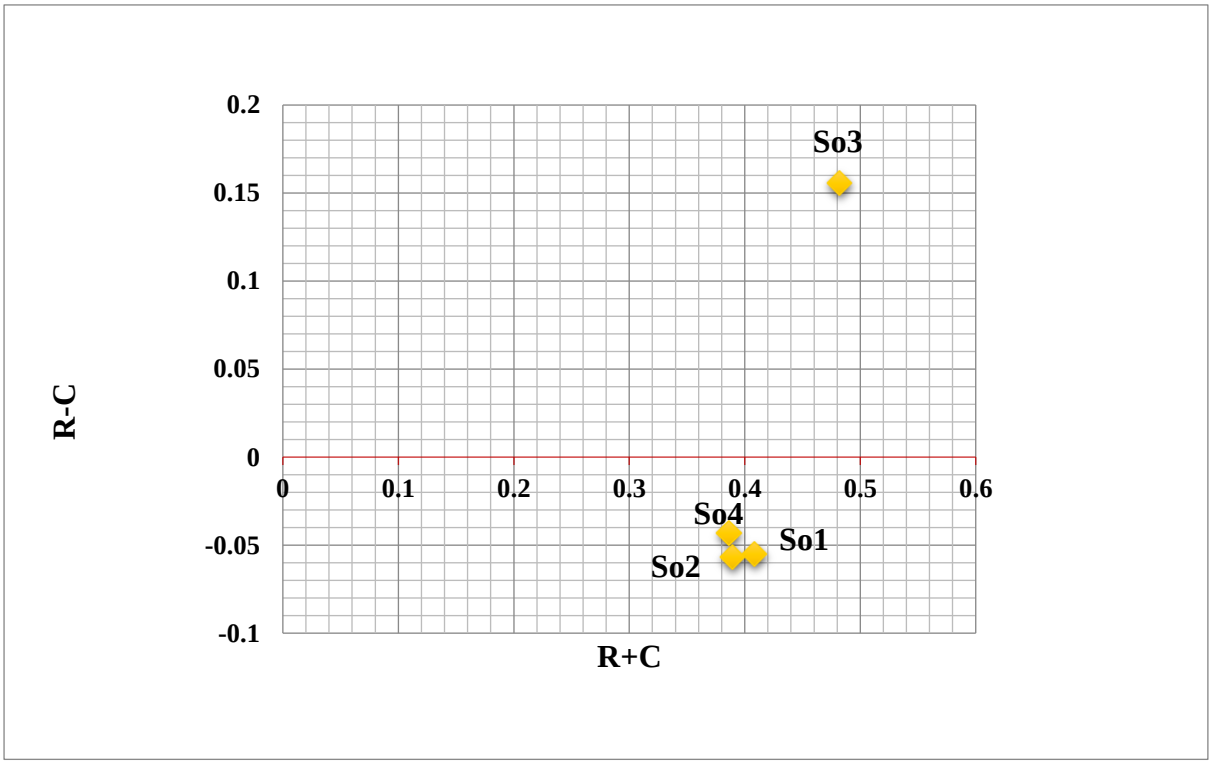

Figure C6: The cause and effect diagram for the challenges of Social (So) dimension to sustainability in HSLM