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Operational excellence in Humanitarian Logistics and Supply Chain Management through leagile Framework: a case study from a non-mature economy

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Abstract

The past few years have continuously seen an increase in intensity and frequency of climate-related disasters in non-mature economies. Many of the losses caused by these events can be attributed to inefficient and ineffective management of humanitarian logistics and supply chains during the preparedness, response and reconstruction phases of disaster relief operations. Previous researches have focused primarily either on the response phase of humanitarian logistics or on the humanitarian supply chain coordination issues mostly within international or local NGOs. We present results of a research on how a novel integrated lean and agile (leagile) framework could be employed to efficiently and effectively manage humanitarian logistics and supply chain management (HLSCM) in a local jurisdiction (i.e. public sector) of a disaster-hit region in a non-mature economy. Through this leagile framework, we identify inefficiencies and opportunities of improvement within HLSCM. Our recommendations can be used by both public and private sector organisations dealing with humanitarian emergencies to increase the efficiency of their response and performance during a disaster. Our research also informs guiding principles of UN Sendai Framework for Disaster Risk Reduction to include a leagile framework for achieving both effective and efficient responses to disasters in its priorities for action. We suggest a future research agenda in order to augment the resilience of HLSCM operations in both public and private organisations.

Keywords: Supply chain disruptions, cyclone, resilient supply chain management, natural disaster, operational efficiency

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Introduction

"*The most deadly killer in any humanitarian emergency is not dehydration, measles, malnutrition or the weather. It is bad* management" by John Telford, (Hulm, 1994).

Over the last twenty years, there has been a continuous increase in intensity and frequency of climate-related disasters such as cyclones, typhoons, hurricanes, flood, drought, flash floods and landslides (UNISDR, 2018). According to a recent United Nations report, between 1998-2017, climate-related and geophysical disasters caused 1.3 million deaths, affected 4.4 billion people and resulted in direct economic losses of $2,245 billion in disaster-hit countries (UNISDR, 2018). Most of such losses occur in low and middle-income countries, also referred as non-mature economies (Jabbour et al., 2017). Such figures indicate that the impact of natural disasters in non-mature economies needs to be addressed effectively and efficiently to reduce losses of lives, natural resources and assets. Previous researches have documented that such losses can be partially attributed to poor planning and management of relief operations before, during, and after the disaster (Altay, 2008; Soneye, 2014; Dubey et al., 2018). In response to increasing disasters and resulting losses, United Nations General Assembly endorsed The Sendai Framework for Disaster Risk Reduction 2015-2030, following the Third UN World Conference on Disaster Risk Reduction (WCDRR) in 2015 (UN Sendai Framework, 2015). Though this framework outlines targets and priorities for managing disasters at a generic macro-level, it is mostly focusing on "effective" responses rather than achieving both effective and efficient responses to disasters.

An effective and efficient response to a disaster requires an understanding of both humanitarian logistics and supply chain management – HLSCM (Jabbour et al., 2017). HLSCM approach provides an understanding of both humanitarian logistics (HL) i.e. how quickly the relief material could be delivered to the victims during a humanitarian emergency, and humanitarian supply chains (HSC) i.e. how relief operations are managed from pre-disaster phase to post-disaster phase. HLSCM, therefore, provides an understanding of how relief materials are sourced, procured, moved, stored and delivered to the victims in ways that reduces losses of lives, resources and assets (Van Wassenhove 2006; Yang et al. 2016; Dubey et al., 2017).

While commercial supply chains have extensively used applications of agility and lean to become effective and efficient (Naylor et al., 1999; Christopher and Towill, 2000; Mason-Jones et al., 2000a, b; Christopher and Towill, 2001), most of the research in disaster relief

management has primarily focused on agility (Oloruntoba and Gray, 2006; Charles et al., 2010; Scholten et al., 2010; Kunz and Reiner, 2012). This is not surprising given that the priority in any disaster is to be effective in reaching out to victims and impacted areas with relief material in shortest possible time. However, many times lack of coordination among humanitarian supply chain actors delay timely response to the requirement of the victims, pre-disaster planning, high response lead time, push-supply chain model and poor inventory management resulting in loss of time, lives, resources and assets (Cozzolino, 2012; Kunz and Reiner, 2012). Therefore, a novel framework combining and rightly balancing agile and lean principles (i.e. leagile) is required for effective and efficient execution of HLSCM.

There are a growing number of researches in humanitarian supply chain focusing primarily on coordination issues in international and local non-governmental organisations (NGOs) (Scholten, 2010; Cozzolino, 2012; Yang et al., 2016; Wilson et al., 2018). However, the primary and immediate response to disaster is dealt by local jurisdiction or governmental organisations. There is a dearth of in-depth research focusing on the effectiveness and efficiency of HLSCM operations during a disaster utilising local jurisdiction (government and public sector) organisations as a case study. The primary reason for such gap could be the data confidentiality or distrust in information sharing by local governments regarding management of HLSCM operations during emergency operations.

In this paper, the authors address inefficiencies and explore opportunities of improvement using leagile framework in HLSCM with an in-depth focus on public sector organisation in one of the disaster-hit regions in India. In order to achieve this aim, we address three key research gaps identified recently by Jabbour et al., (2017):

RQ1 – *How can public sector supply chains be organized to support effective (agility) and efficient (lean) response to natural disasters?*

RQ2 – *How do public sector organizations coordinate with each other and aid agencies during natural disasters such as cyclones/ hurricanes in order to support the preparation and immediate response to disaster relief?*

RQ3 – *How can leagile strategies be prescribed as well as applied to different stages of HLSCM process to derive operational excellence?*

This article is structured as follows: Section 2 provides a critical literature review highlighting the research gaps in the HLSCM. Section 3 describes the methodology applied in this research whereas the Section 4 provides an in-depth qualitative analysis combined with

discussion, and followed by section 5 highlighting managerial implications. Section 6 includes conclusion and future research emerging from the limitations of this study.

2. Literature Review

2.1 *Humanitarian Logistics and Supply Chain Management*

A disaster can be described as a "*disruption that physically affects a system as a whole and threatens its priorities and goals*" (Van Wassenhove, 2006). Jabbour et al., (2017) considers managing HLSCM effectively and efficiently is central for successful disaster management because (a) HLSCM includes activities related to procurement, storage and distribution while serving as a connection between disaster preparedness and response; (b) HLSCM includes coordination among different supply chain actors who drive responsiveness, effectiveness and efficiencies of any given supply chains for implementing major humanitarian programs, such as health, food, shelter, water and sanitation; and, (c) failure to implement HLSCM efficiently can drive the overall expenses of relief efforts and operations.

The United Nations Sendai Framework (2015) has also been proposed for disaster risk mitigation. This framework highlights four priorities for action: (1) Understanding disaster risk; (2) Strengthening disaster risk governance to manage disaster risk; (3) Investing in disaster risk reduction for resilience; and (4) Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction. The framework highlights a few general macro-level guiding principles for achieving these priorities. However, this framework mainly focuses on an "effective" disaster risk reduction rather than building an understanding of how to achieve both effective as well as efficient response to disasters.

The successful delivery of HLSCM is imperative to ensure the flow of material, information and people in an efficient and effective way in order to save lives while efficiently managing the time and resources for minimising the human sufferings (Thomas 2007). In a disaster relief response, the maximum efficiency can be explained through a lean approach. A lean HLSCM can be referred as a strategy of managing HL and HSC with maximum impact (i.e. timely delivering the relief material to the victims) and minimum wastage through the efficient use of resources. However, there is a dearth of research which focuses on how this could be achieved.

HLSCM covers all three main phases of disaster management – preparedness and mitigation, response and recovery, and reconstruction. A Pareto analysis reveals that planning and management in first two phases of the disaster is central to reducing the impact of disaster on human lives (Nolz, et al., 2011) whereas management in the third phase is important in further reducing the impact and building resilience to future disasters. The UN Sendai framework (2015) also indicates that preparedness phase is critical to both response and reconstruction phases.

***Preparedness*:** Success of overall disaster relief operations is dependent on various factors (Jabbour et al., 2017) during preparedness phase, such as: (1) supply chain coordination through effective and transparent information flow among the stakeholders for facilitating the preparation such as logistics, procurement and inventory related to relief material – food, medical supplies, water and sanitation before the disaster; (2) planning for storage (facility locations) and material flow using various routing options and transportation methods before the disaster; (3) requirement assessment of the region to be impacted in the preparedness phase. Estimating the needs of survivors and the likely capacities of the planned supply chains is critical in disaster preparedness (Wilson et al., 2018). This allows preparations regarding the capacities of facilities, and the availability of vehicles and personnel, for example. A well-prepared plan increases likelihood of saving lives, reduces amount of wastage in the system as well as make more efficient use of resources (Cozzolino, 2012).

***Response and Recovery*:** Success of overall disaster relief operations is also dependent on various factors during response phase (Pettit and Bereford, 2009; Jabbour et al., 2017), such as: (1) Efficient flow of information for maximum coordination among the supply chain actors (2) centralised verses autonomy of or localized decision-making power, (3) quick and effective delivery of resources such as relief materials and people to save victim lives, (4) Constant monitoring of needs of the survivors, (5) flow of funds and supplies for assisting in recovery of victims.

2.2 *Commercial supply chains vs HLSCM*

Commercial supply chains are established with known actors, reasonably predictable forecast for demand and supply and low acute disruptions (Bhattacharya et al., 2013). These supply chains are driven by competitiveness and profitability. Humanitarian supply chains on other hand are driven by social goals – to save human lives (Oloruntoba and Gray, 2006; Pettit and Beresford, 2009). They deal with unknown diverse group of actors, high staff (volunteers)

turnover rates, unpredictable supply and demand, and high acute disruptions of routes, infrastructure and material supplies (Kovács and Spens, 2007). A diverse group of stakeholders in HLSCM primarily includes host national government, local jurisdiction, militaries, private organisations, different aid agencies, local NGOs, international NGOs, donors and beneficiaries. They have their own unique missions, cultures and different ways of operating which often leads to duplication of effort, primarily due to lack of standardisation of operating procedures and codes of conduct for best practices in the humanitarian sector.

Unlike commercial sector, humanitarian aid agencies often receive inadequate supplies, which are not fit for purpose. For instance, Thomas and Fritz (2007) reported that in 2004, within two weeks of the tsunami, 288 freighter flights arrived without airway bills to drop off humanitarian cargo in Sri Lanka's Colombo airport. Many of these consignments carried unsolicited and unusable items such as used western clothes, high heels, baked beans and carbonated beverages. These remained unclaimed for months in the airport and warehouses – offering a poor service quality and wasting the space, time, resources, effort and money. Even worse, these cargo flights that brought unwanted relief material were refuelled and returned empty – as a consequence there was a fuel shortage for scheduled flights. This caused further wastage of resources in the time of crisis, highlighting a need of effective and efficient process management in humanitarian emergencies.

The humanitarian host government organisations who are the primary actors in the HLSCM faces many challenges to process excellence (Larson and Foropon, 2018). They are involved from preparedness and mitigation, response and recovery to reconstruction phase of disaster management. They do not have appropriate tools and techniques like commercial sector for managing the disruptions in logistics and supply chain management during humanitarian emergencies (Larson, 2014).

2.3 *Principles, tools and techniques of process management in HLSCM*

There are a number of principles, tools and techniques for managing processes and improving quality in commercial supply chains (Wagner et al., 2014; Wu et al., 2010). However, commercial supply chains operate in less disruptive environment when compared with HLSCM. Moreover, HLSCM have bureaucratic processes with multiple hand-offs, reviews and approvals, resulting in longer lead times for aids and supplies, poor service quality and higher costs (Parris, 2013).

Nevertheless, commercial sector offers a variety of principles, tools and techniques that

188 can support process management and improvement in HLSCM. Such tools and techniques
189 include: activity-based costing (ABC), balanced scorecard, benchmarking, ISO 9000, SCOR
190 model, lean and Six Sigma (Larson, 2014). Some of the most popular principles for operational
191 excellence in commercial supply chains include agility and lean that can be applied in HLSCM
192 to achieve effectiveness and efficiency in the system. Lean and agile have rarely been applied
193 in combination to achieve operational excellence in HLSCM (Cozzolino, 2012).

194 Lean thinking, which originated from Toyota Production System, refers to doing more
195 with less (Womack et al., 1990). The lean supply chain management approach would aim to
196 identify the non-value added activities (*muda* or lean waste) to minimise lead time of the
197 products, reduce inventory cost, to move towards a just-in-time for achieving maximum
198 efficiency and cost reduction. Such approach is more relevant when demand is relatively stable
199 and predictable so that either it can continuously replenish when lead-time is short or it can
200 plan and optimise when lead-time is long (Childerhouse and Towill, 2000; Christopher 2005).
201 While lean thinking focuses on eliminating non-value adding activities within a supply chain,
202 agility calls for rapid reconfiguration and the elimination of waste as much as possible (Gligor
203 et al., 2015) but without prioritising waste elimination as a prerequisite to achieve agility
204 (Naylor et al., 1999).

205 When the demand is unpredictable and is combined with a short lead-time, the agile
206 principle is applied. Unexpected shocks that disrupt supply chains have also utilised agile
207 principles for achieving operational excellence (Van Wassenhove, 2006; Lee, 2004). Van Hoek
208 et al. (2001) initiated the application of agility in supply chains which is generally defined as
209 the ability to respond to unanticipated changes (Sheffi, 2005). An agile supply chain aim to
210 quickly respond to short-term changes in demand and/or supply (Lee, 2004) as well as have
211 minimum impact from external disruptions (Charles et al., 2010).

212 Many previous studies have applied the agile principle to emergency and humanitarian
213 logistics and relief distribution in response phase of disaster management (Charles et al., 2010;
214 Scholten et al., 2010; Pettit and Beresford, 2009; Taylor and Pettit, 2009; Oloruntoba and Gray,
215 2006; Towill and Christopher, 2002). The agile principle extends beyond a single firm and
216 includes the whole supply chain where same rules is followed by all supply chain actors
217 (Christopher, 2005). These are maintaining regular contact with the partners about the
218 situation, creating a network of suppliers, postponement projection, low inventory, dependable
219 logistics system and a trained implementation team. However, agile approach could be
220 expensive as it requires periodic source of labour (Peck, 2005). This is in contrast to lean

approach which aims at being cost efficient (Towill and Christopher, 2002).

In HLSCM, lean and agile principles may coexist (Scholten et al., 2010), but how this may coexist in the specific phases of the HLSCM process have not been well addressed in the literature.

2.4 *Lean, agile and leagile framework in a HLSCM context*

Lean and agility are two strategies that are used to bolster supply chains in different situations. Lean is applicable where markets have foreseeable demand, limited variety and long product life cycle whereas agility is applied best in a volatile environment with large variety and short product life cycle (Rahimnia and Moghadasian, 2010; Agarwal et al., 2006). While lean was primarily implemented within a manufacturing environment in 1990s to transform wasteful old production strategies, agile was aimed at catering to the evolving customer demands. Previous researches (Christopher and Holweg, 2011; Van Wassenhove, 2006; Oloruntoba and Gray, 2006; Maskell, 2001; Prater et al., 2001; Christopher and Towill, 2001, 2000) have also defined agility as "the ability to thrive and prosper in an environment of constant and unpredictable change" – an emergency relief operation rightly falls into this category. Although, these two different strategies were targeted at two different goals, earlier researches (Mason-Jones et al., 2000b; Hormozi, 2001) state that both these strategies complement each other when lean is first applied, followed by agile. Mason-Jones et al. (2000a) further state that both lean and agile principles can be successfully deployed within a supply chain leading to emergence of a hybrid strategy, leagility or leagile.

Both these principles can work within the same supply chain at different moments by considering "decoupling" approach through postponement in unpredictable demand with longer lead times (Scholten et al., 2010; Christopher, 2005; Childerhouse and Towill, 2000). The decoupling point in a supply chain separates the part of the supply chain oriented towards customer orders or victims in context of HLSCM from the part of the supply chain based on planning or preparedness phase in context of HLSCM (Naylor et al., 1999). In a volatile or uncertain situation, a hybrid 'leagile' strategy has been proposed by Naylor et al., (1999) where leanness can be decoupled from downstream supply chain process and applied upstream whereas agility could be applied downstream to meet the demands of shorter lead time and demand variability from the end-users. However, there is a dearth of in-depth research studying how the application of "leagility" or "leagile" could be successfully implemented in HLSCM.

3. Research design and methodology

This research utilised a qualitative exploratory single in-depth case study approach in one of the cyclone-hit regions in India in 2018. A case study approach provides an opportunity to gain a deeper understanding of processes by getting '*a good picture of locally grounded causality*' (Miles and Huberman 1994). Such method allows studying the problem and the context to deduce both cause and effect (Leonard-Barton 1990) and this could be very helpful in formulating strategies of improvement for a given case. This approach also provides a holistic view to researchers through the use of sources of evidences while observing a certain chain of events within a case study scenario (Yin, 2003; Mohd Noor, 2008). Moreover, based on the nature of questions being asked in this research, for instance, *how* public sector organisation functions during the preparedness and response phases of disaster or *how* a hybrid leagile approach could be incorporated in the current system, a qualitative in-depth exploratory single case study approach seems to be more suitable (Saunders *et al.*, 2009; Silverman, 2013). The real motive to select this method was the diligence and wholeness of the data collected through qualitative methods that allows any inconsistencies and irregularity to be captured (Saunders *et al.*, 2009; Holloway and Wheeler, 2010). This sense of comprehensiveness in data also helps in effectively establishing the context surrounding the observations (Miles *et al.*, 2014; Cassell *et al.*, 2006). A meta-analysis of humanitarian literature by Kunz and Reiner (2012) also noted that case-study research are scant within the field of HLSCM research and that such methods would provide a greater insight into the inefficiencies and ineffectiveness within humanitarian operations. Therefore, there is a clear need to conduct a detail qualitative case study research for building the knowledge of how a combined lean and agile strategies could be applied for delivering both effective and efficient response to disasters.

Semi-structured interviews were conducted to collect data from the respondents to facilitate informality and openness about the information sharing regarding the current practices and inefficiencies in the system as well as experiences of the different stakeholders including the beneficiaries (Eriksson and Kovalainen, 2008; Saunders *et al.*, 2009). Such interview also provides the flexibility to interviewers to investigate some of the pre-defined questions in detail while skip or omit questions where appropriate (Saunders *et al.*, 2009). Limitations such as researcher's biasness as well as participants' reluctance to be completely honest to a stranger (Salkind, 2006) were addressed through opportunities created by the interviewers for capturing extemporaneous conversation, covering themes that were considered important to concerned respondents (Mason, 2002).

285 Twenty-five semi-structured interviews with HLSCM stakeholders were conducted
286 (see Table 1). The interviewees included 10 local government officials, 3 private sector
287 organisations, 4 logistics providers, 2 local NGOs and 6 beneficiaries to map the current relief
288 operation process, identify inefficiencies in HLSCM, and suggest improvements after in-depth
289 qualitative content analysis of interviews along with in-country reports (2) and UN reports (2).

290 A mixed purposeful sampling technique was used to interview participants who were
291 either the victims during the disaster or were involved in preparedness and response to disaster
292 (cyclone) phases in one of the regions in India. This technique offered the flexibility in meeting
293 the needs of different stakeholders and facilitated the data triangulation by combining three
294 sampling strategies for deriving evidences to achieve the objectives of the study in an
295 exploratory case study (Patton, 2002). In this case it involved critical case sampling combined
296 with expert sampling and maximum variation sampling to increase the credibility of the results.
297 A hybrid coding (both pre-set and open) method was employed in for template analysis using
298 NVivo. A pre-set codes were derived from the research theme and interview questions and this
299 was followed by another set of codes that emerged during template analysis. Interviews
300 focussed on four key themes: (1) stakeholder mapping and process mapping including
301 identification of bottlenecks, material flow and information flow, (2) identification of non-
302 value added and value-added activities, (3) operational efficiency and effectiveness of HLSCM
303 (4) identifying decoupling points for the leagile framework as well as root cause of
304 inefficiencies in the system. All the interviewees were explained about the context of study and
305 the research themes. Most of the interviews were taken face-to-face (except two with higher
306 authorities that was taken through telephone). Interviews lasted for approximately 45-120
307 minutes.

308 **Table 1.** Demographic details of the interviewees

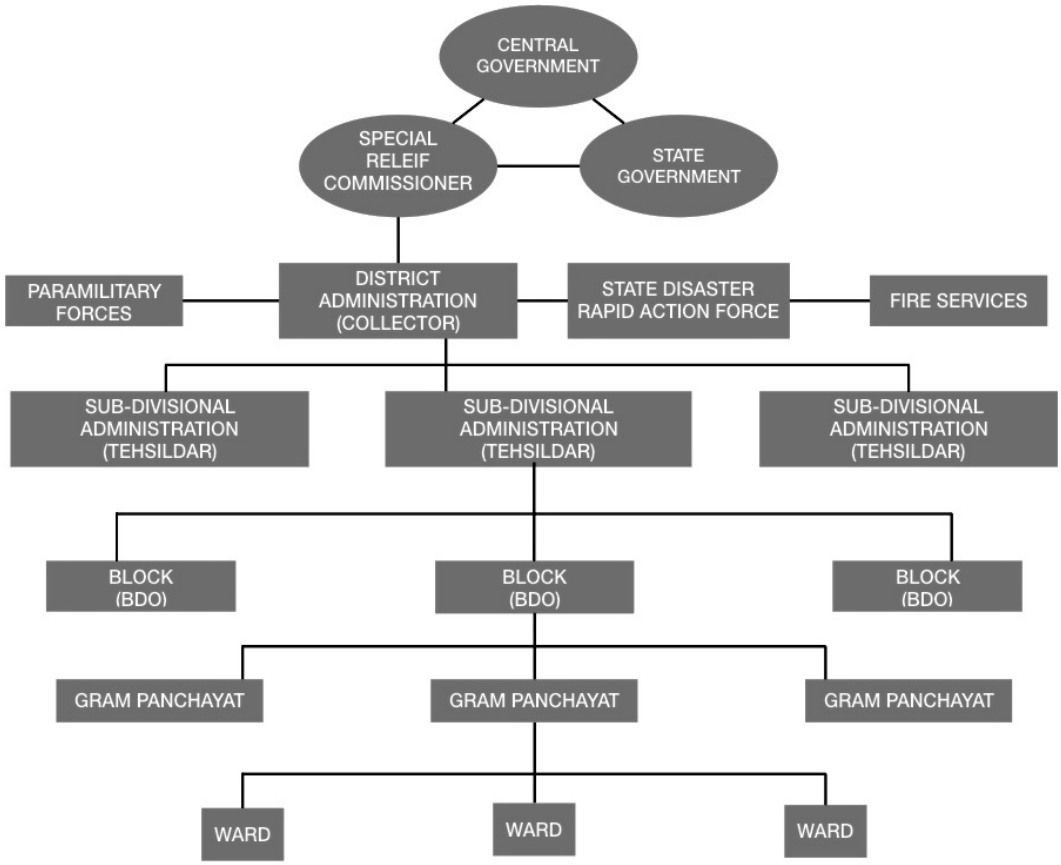
Organisation/ Sector	Role	Gender	Age	Experience (Years)
Local Government	District Admin	Male	41	11
Local Government	Sub-divisional Admin	Male	34	6
Local Government	Block Development Officer	Female	30	4
Local Government	Block Development Officer	Male	55	8
Local Government	Gram Panchayat Official	Male	50	3

Local Government	Gram Panchayat Official	Female	40	4
Local Government	Ward member	Male	48	5
Local Government	Ward Member	Male	57	8
Local Government	Ward Member	Female	42	6
Local Government	Ward Member	Female	36	2
Private Organisation	Wholesaler (District level)	Male	51	19
Private Organisation	Petrol Pump Owner (Block level)	Male	55	20
Private Organisation	Mill operator (Sub-divisional level)	Male	58	22
Logistics	Logistics Company Owner	Male	60	24
Logistics	Logistics Company Owner	Male	35	6
Logistics	Driver during relief operation	Male	25	4
Logistics	Driver during relief operation	Male	24	1
Local NGO	Coordinator	Female	47	12
Local NGO	Project Officer	Female	34	8
Public	Beneficiaries	Male	63	N/A
Public	Beneficiaries	Male	36	N/A
Public	Beneficiaries	Female	44	N/A
Public	Beneficiaries	Male	28	N/A
Public	Beneficiaries	Female	23	N/A
Public	Beneficiaries	Female	54	N/A

3.1. The case study: state governmental agencies of a non-mature economy

Being prone to various types of natural calamities regularly, the selected organisation in one of the states in India has been working towards building a comprehensive disaster mitigation plan to improve their performance in preparedness, responsiveness and reconstruction. The rationale for choosing this organisation in this particular state was mainly based on frequency of occurrence of disasters (cyclone in this case) and a noticeable

316 improvement shown as the reduction in the number of causalities over the last two decades.
317 Notwithstanding the gradual improvement in last few years, there is a tremendous requirement
318 of performance improvement within the organisation with context to current practice of
319 HLSCM. The stakeholders were identified through stakeholder mapping with experts (Figure
320 1) and interviews were mostly in line with earlier researches (Mitchell et al., 1997).



321

322 **Figure 1:** General structure of the case organisation

323 Depending on the type and place of natural disasters, the stakeholders varied as per the
324 need-of-the-moment during the humanitarian operations. However, the major as well as
325 common stakeholders that were identified within the case organisation, based on Mitchell et
326 al., 1997, included the chief minister, chief secretary, functional secretaries, special relief
327 commissioner, State Disaster Rapid Action Force (SDRAF), National Disaster Response Force
328 (NDRF), fire services, para military forces, military forces, district administration (Collector),
329 Sub-divisional administration, block administration (Block Development Officer – BDO,
330 Tehsildars), village administration or Gram Panchayats (Sarpanch – Head of a village, ward
331 members), victims, medical team, veterinary services, private logistic providers, wholesalers,
332 petroleum product stockists, food processing units (rice mills etc.), media, NGOs, donor

agencies, concerned agencies of the United Nations, private corporations, police forces, and volunteers among others. It was also revealed during the stakeholder mapping and from the stakeholder interviews that the central government or federal government including the prime minister, home secretary and other functional secretaries get involved in the process when a disaster was measured to be in the scale of a national calamity. However, this research primarily focuses on the state-level disaster preparedness and response and, therefore, the interviews were taken from the stakeholders identified in Table 1.

4. Results and discussions

4.1 *Current Management Practices and Stakeholders*

Many themes have emerged from the analysis of the data collected through stakeholders' interviews that elaborate the current HLSCM practices within the case organisation. The themes have been categorised in line with some of the previous researches (Altay and Green, 2006; Pettit and Beresford, 2006; Van Wassenhove, 2006; Lee and Zbinden, 2003; Thomas, 2003; Nisha de Silva, 2001; Long, 1997) during any disaster operations into:

- ⇒ Preparedness
- ⇒ Emergency Response
- ⇒ Reconstruction

Since the interviews were aimed at understanding the current operational paradigms of the case organisation in context with their effective (agility) and efficient (lean) response to natural disasters, analyses were done only on preparedness and response phases to answer the research questions (gaps) discussed in the literature review section.

The analyses started with stakeholder mapping exercise with experts to identify the roles of stakeholders in managing preparedness and response to disaster. This exercise also helped in identifying relevant interviewees for this exploratory case study research. It was identified during the analysis that the roles of the stakeholders during any humanitarian operations lack clear definitions which would lead to into either overlapping of certain responsibilities whereas few lapses in other roles. This requires a clear definition of roles and responsibility along with a clear communication strategy to ensure effective delivery of humanitarian operations. This research identified that RACI matrix (Responsible, Accountable, Consulted, and Informed matrix), used widely in other industry sectors for strategic and programme management, could be an useful tool for making sure that the

humanitarian operations are effectively planned with good stakeholder engagement and efficient communication (Waters, 2014). Therefore, the concept of implementing a RACI matrix for clear definition of operational roles was rightly suited in this case where a large number of stakeholders involved in the operations (Table 2).

Table 2: RACI matrix – defining stakeholders' roles in HLSCM

Stakeholder	Responsible	Accountable	Consulted	Informed
Chief Minister			x	x
Chief Secretary	x		x	x
Special Relief Commissioner	x	x	x	
Functional Secretaries			x	x
Collector/Magistrate	x	x	x	
BDO/Tehsildar	x	x	x	
Sarpanch – Head of Village	x	x	x	
Ward Members				x
Police	x			x
Medical Team	x		x	x
Fire Services	x		x	x
Private Mills				x
Wholesalers/Stockist				x
Energy Resellers/Fuel Stations				x
SDRF/NDRF	x		x	x
Government Employees				x

RQ1: How are public and private sectors supply chains involved and organized to support effective (agility) and efficient (lean) response to natural disasters?

Under the current practices meagre evidence was found regarding the direct involvement of private sector supply chains to strategize the response to a natural disaster. This was further evidenced by public authorities elaborating the fact that there are no standard

operating procedures which can formalise regular coordination, knowledge exchange and utilisation of private sector supply chain capabilities during a disaster. However, informal use of private sector infrastructure through the special power of state and district administrators during a disaster could be found within the organisation. The officers monitoring disaster preparedness were issued administrative power for requisition of private vehicles, wholesalers, energy outlets (petrol pumps), and food processing units such as rice mills for procurement, storage and delivery of relief materials. All private players were put on stand-by mode for contributing towards disaster preparedness and response in exchange of a fair price for the goods and services they render. While the whole process of humanitarian operations maintained required inventories at various stages of the supply chain, the procurement of required relief material on the basis of local demand provided some agility in the supply chain. However, no clear strategy to rightly balance lean and agile during a humanitarian operation was evident from the current process – leading to wastage of food supplies and other materials at the warehouses. Although there is a documented "Standard Operating Procedure for Responding to Natural Disasters" in National Disaster Management Plan - NDMP (2019) prescribed by the federal government, stakeholders interviewed agreed of large-scale deviation from it owing to impracticality of some of the procedures during emergency operations. Moreover, this plan also adopts the UN Sendai framework guidelines for addressing mostly effective response to disasters rather than both efficient and effective responses.

4.2 *Current management strategy*

The current management strategy within the organisation is the result of HLSCM practices evolving in the last few years largely through experiences, learning, and policy changes. However, no unified system could be found that could use metrics to measure or benchmarks their performances. Most of the stakeholders supervising emergency relief operations agreed that there are no visible key performance indicators they follow during the operations. However, they agreed that on-time delivery of materials and rescue are two important indicators they follow while being in the field. Furthermore, no evidence was found from the analyses, which established lack of link between academic or scientific research and on-field performance measurement and monitoring. With context to decision making, the organisations followed a generic hierarchy which can be linked with documented procedures of National Disaster Management Division (NCDM, 2019). However, our analysis corroborated the fact that decision making was hybrid – but mainly centralised decision making with power mainly tilting towards the higher ranked officials. This results in various types of

409 lean waste (Womack et al., 1990) – longer lead time, waiting time, waste of items – during the
410 operations and impacts the stakeholders or the affected people. In order to clearly state the
411 management practices, the authors divided the humanitarian operations into three main phases
412 as mentioned above. Various forms of waste were identified by the researchers during the
413 analysis (see Table 3).

414 **Table 3:** Types of lean waste found in HLSCM process of the case organisation

Waste Type	Phase	Processes
Transportation	Preparedness	• Transportation of relief material from a central warehouse
Inventory	Preparedness	• Inaccurate storage of relief materials • High inventories at block level
Movement/motion	Response	• Unplanned vehicle movement
Waiting	Response	• Delay in reaching affected areas • Inefficient route planning • Causalities due to delay in rescue operations
Overproduction		• Excess storage of material
Over-processing	Preparedness and response	• Centralised decision making
Defect	Preparedness and response	• Spoilage of food material • Food waste in the warehouses • Spillage during distribution • Loot in transit • Political favouritism
Non-utilising talent / misutilisation of talent	Response	• Use of unskilled workers for skilled jobs such as rescue operations

415

416 ### 4.3 *Effective (agility) and efficient (lean) response to natural disasters*

417 The concept of agility significantly influences the way supply chain network interact
418 with each other and provide their best foot forward on the basis of shared information
419 (Christopher 2005). Whereas preparedness requires accurate information, evaluation of the

situation, fact-based planning and timely mobilisation of resources, there is evidence of frequent lack of planning in HLSCM (Byman et al., 2000), which leads to various inefficiencies such as overstocking, understocking, incorrect route planning, poor coordination, longer lead times among others. Due to uncertainties attached to a natural disaster, accurate planning emerged to be the most challenging task for the relief administrators. Furthermore, agility came out to be an imperative strategy at the time of response owing to uncertainties during such catastrophic events. At the same time, it was unvaryingly important for the organisation to be lean in order to avoid inefficiencies and bottlenecks within the process. Since pre-positioning relief material at different locations of the state was foremost part of the preparedness, any challenges related to this had potential to impact the capabilities to deliver any relief aid in sufficient amount and within a short time frame (Balcik and Beamon, 2008). However, under the current practices it was found that food items such as rice were procured through the public distribution system, rice flakes and jaggery were stored at a central warehouse, and drinking water, pulses, and biscuits were procured aftermath of the disaster. Similarly, items such as medicines, clothing, blankets, mosquito nets, utensils, bleaching powder among others were stored at regional warehouses. It was evident from the analysis that in case of large-scale disasters these strategies have failed many time to fulfil all the requirements of victims while causing various types of bottlenecks in carrying out humanitarian operations.

The logistical operations mainly depended on private vehicles that were reserved using special powers of the collectors and magistrates during natural disasters. It was difficult to get accurate data against the proportion of items stored in warehouses and procured locally. However, the information obtained through the interviews indicate an approximate ratio of 60:40 for the stored items and the items procured locally. Notwithstanding the fact that storing less items or having reduced inventory is a step towards lean operations (Womack and Jones, 2003; Womack et al., 1990), having a right balance between lean and agility is key towards improving performance of humanitarian operations. Most of the stakeholders acknowledged that it was important to establish strong network among the donors, rescue operation teams, private sectors, NGOs and other administrative teams for thorough preparedness for any disasters. However, it also emerged that it is against the Government of India's policy to appeal for any international aid without any approval in principle – barring the current exclusion of such policy during the COVID-19 pandemic (The Times of India, 2020). This has left limited roles of the private sectors and NGOs to get involved in planning for the emergency operations

452 or preparedness – leaving the governmental machinery to get overburdened with rescue and
453 operations duties during a catastrophic event.

454

455 ***RQ2: How do public sector organizations coordinate with each other and with aid agencies***
456 ***in order to support the preparation and immediate response phases of disaster relief?***

457 Be it during the preparedness or response, efficient communication and coordination
458 between important actors involved in an emergency humanitarian operation is imperative to
459 achieve desired goals (Balcik and Beamon, 2008; Van Wassenhove, 2006; Maon et al., 2009;
460 Tomasini and Van Wassenhove, 2009; Kova´cs and Spens, 2009). The coordination between
461 various humanitarian agencies is important in order to avoid unwanted spending with duplicate
462 processes, to avoid competition for transport, storage, and skilled staff during a crisis. The
463 coordination is also an important enabler of information sharing that not only orchestrates their
464 operational capabilities but also augments their response capabilities. During start of a response
465 operation it is "the speed at any cost" and first 72 hours are very crucial to rescue and operations
466 in terms of limiting the impact and saving lives (Van Wassenhove, 2006). This makes flow of
467 information an intrinsic part of the coordination efforts by various stakeholders. Based on the
468 analysis of sourced data we mapped the information during the preparedness of an emergency
469 relief operation or natural disaster. While the flow of information during preparedness showed
470 top-to-bottom direction (Figure 2) within the hierarchical structure of the organisation it was
471 completely opposite during the response, which however lacked any clear strategy, structure,
472 pattern and coordination for augmenting the responsiveness. Further analyses revealed that
473 information flew from the central command or higher-ranking officials with instruction of
474 adequate preparation whereas information was gathered from the affected areas aftermath of
475 the catastrophic event to plan immediate response and initiate appropriate rescue operations.

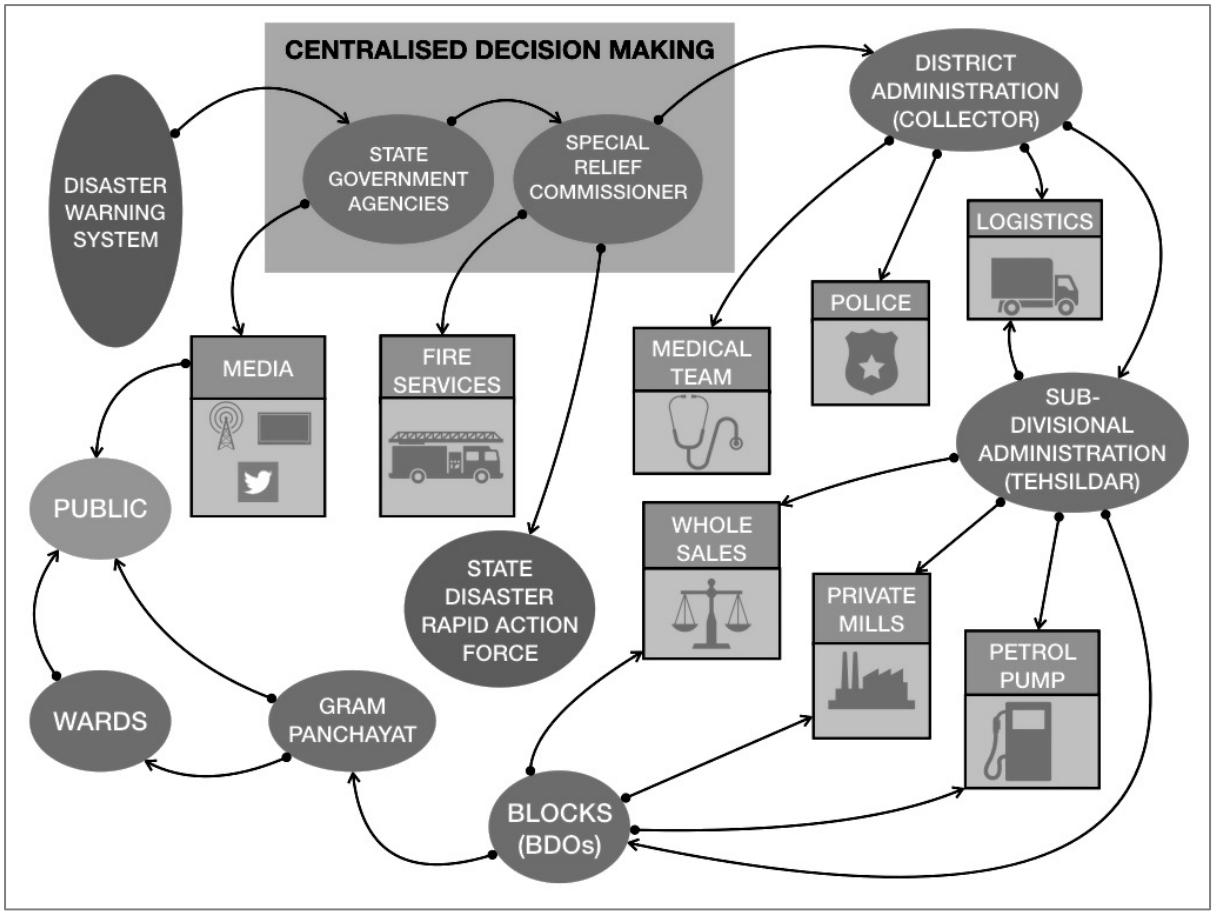


Figure 2: Information flow during preparedness and response

Not only it demonstrated a foretaste of centralised decision making but also it lacked clear role definitions during the emergency operations. It was further evidenced from cross analyses of data, which was exemplified by delayed decisions affecting timely delivering of relief materials and execution of rescue operations. In addition to efficient information flow there was also a requirement of decoupling from information flow that can help stakeholders to shift between push and pull communication for effective decision making. Based on the stakeholders mapping and situational requirements, researchers could design a new information flow map (Figure 3) that holds potential to solve most of the inefficiencies attributed towards information flow within the case organisation. The findings state that there should be two-way communication between various nodal agencies delivering humanitarian operations. While the top-down information flow would help the stakeholders to follow administrative guidelines for preparedness, the synthesis of information through bottom-up approach would further help higher ranking official to make efficient decision regarding preparedness and response planning (Figure 2). This would provide autonomy at downstream nodes such as blocks to make some timely decisions based on prevailing situations on the

ground, rather than waiting for instructions from high ranking officials at upstream. The assessment of the situations and procurement of relief material locally would shorten the supply chain and add agility to response planning.

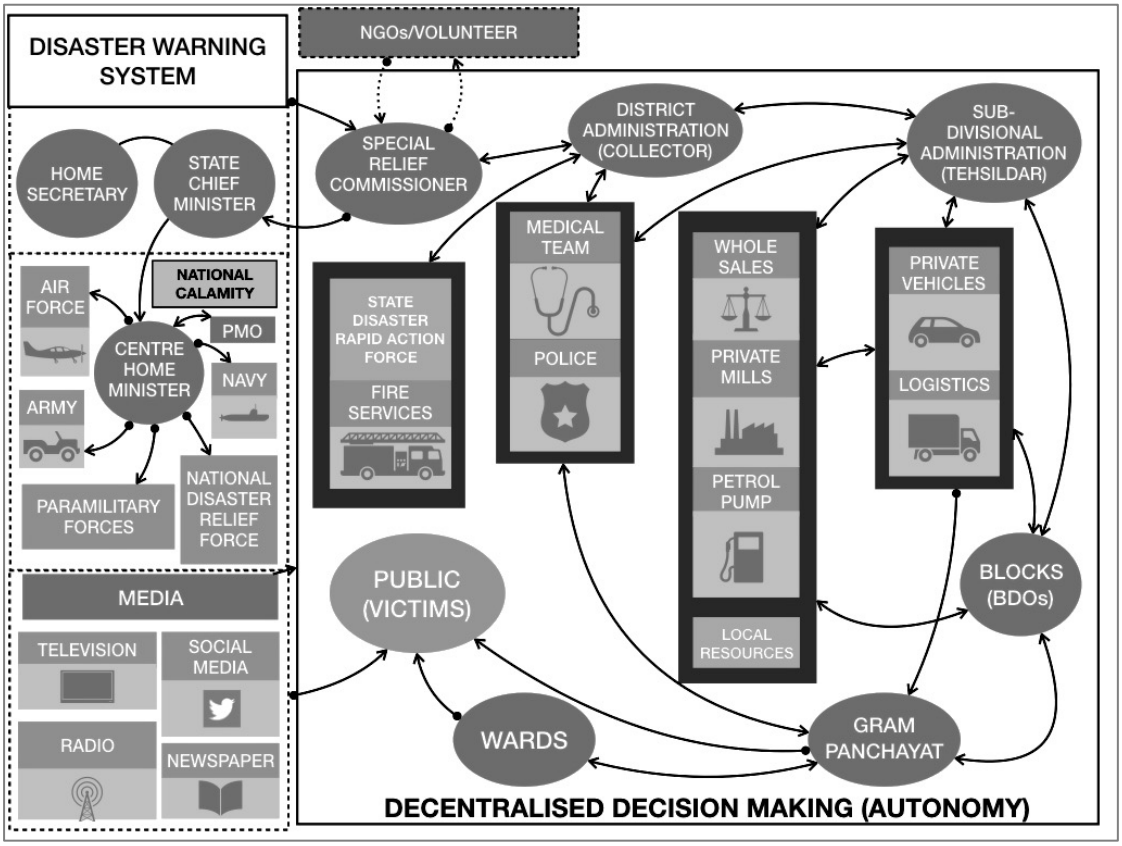


Figure 3: Recommended Information flow during preparedness and response
(PMO: Prime Minister Office; BDO: Block Development Officers)

RQ3: How can leagile strategies be prescribed/ applied to different stages of HLSCM process to derive operational excellence?

4.4 *Leagile strategy*

Both information flow as well as material flow constitute important parts of any HLSCM. The lean strategy aims at eliminating waste along the supply chain, agility and concept of postponement are implemented to achieve effectiveness within a supply chain (Hoek et al., 2001, Narasimhan et al., 2006). While lean strategy does not imply the inclusion of agility within it, any agile process certainly demonstrate many facets of leanness within the process. Both commercial supply chains as well as humanitarian supply chains benefit from the implementation of lean and agile strategies (Childerhouse and Towill, 2000). However, due

to the amount of volatility and uncertainty attached to HLSCM, the right balance between lean and agile strategy is required to fulfil the requirements.

The process map of information flow in the case organisation has shown that the information flow was primarily top-down approach with instructions-led communication, which is why, the enrichment of information and right balance of lean and agile approach is required to enhance the agility of HLSCM (Gunasekaran et al., 2008).

Within the case organisation, the emergency relief material was partly procured from the upstream government warehouses and partly from the local standby reserves – included wholesalers, rice mills, food processing units and petrol pumps. It came out from the analyses that accurate assessment of the amount, variety, frequency and proportion of material required from government warehouses and private standby reserves was a great challenge to ensure seamless and timely delivery of relief material (Figure 4). This led to a variety of lean wastes (see Table 3) such as longer lead time, wastage of perishable items, high inventory of some items and at the same time unavailability of some important material for the victims.

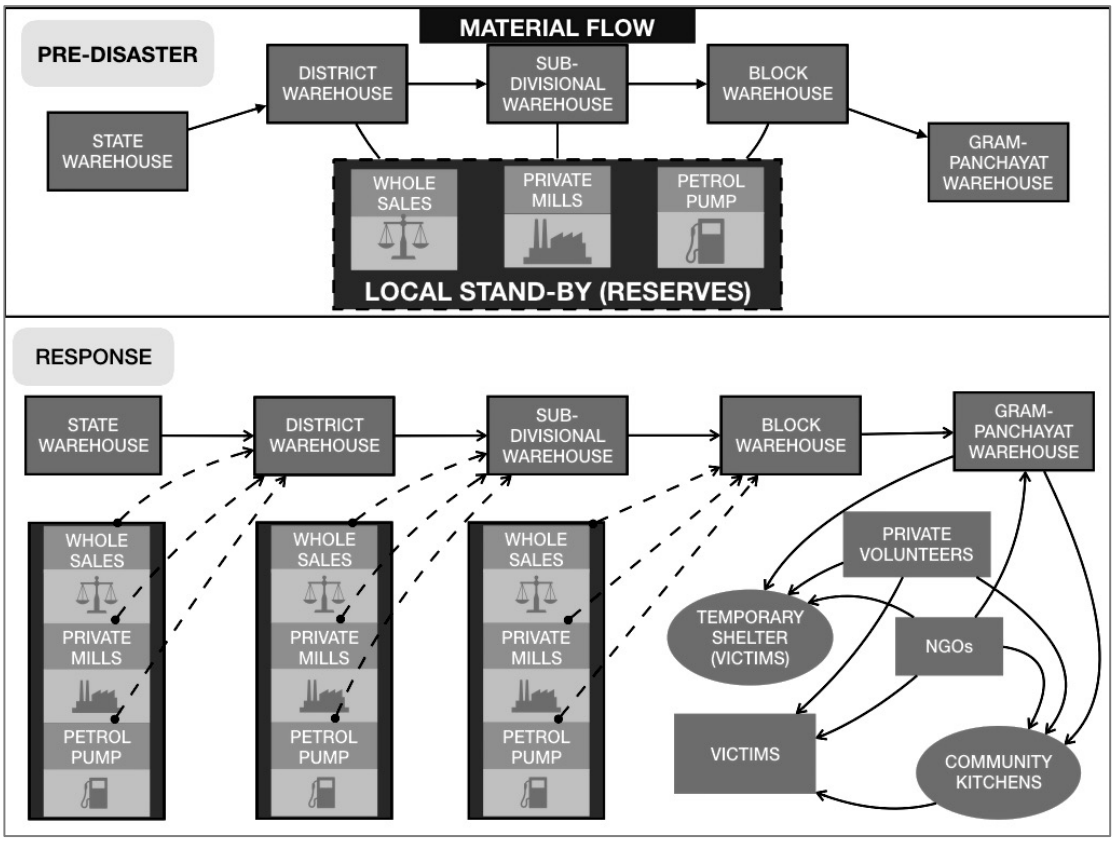


Figure 4: The current-state material flow during the relief operations in the case organisation

In terms of material flow, the low predictability combined with high variety and variability in response requirements makes the HLSCM process volatile and necessitating agile

528 strategy. It is significantly important in case of emergency relief operations where there is a
529 maximum possibility of fluctuation in demand and capacity. The effective management of
530 demand and capacity during a disaster can shorten the supply chain to deliver the relief material
531 quickly in the impacted regions. While lean can be used to maintain the threshold capacity for
532 HLSCM operations, agility can be implemented to set out priorities of material flow at a time
533 of disaster to ensure rapid response is maintained at the impacted locations.

534 In case of HLSCM where information, material and the efficiency of delivering them
535 at the right time and right place plays a vital role in shaping the success of execution in an
536 emergency operation, both lean and agility have a significant role to play in contributing
537 towards the efficiency as well as effectiveness. While lean can deliver maximum results using
538 minimum resources available, agility would ensure faster responsiveness at the time on
539 uncertainty and evolving nature of the impact and timing of the disaster along with
540 requirements of the impacted population. In a supply chain context, efficient flow of
541 information and its accuracy also has potential to influence the responsiveness of supply chain
542 and its agility.

543 For HLSCM, it is beneficial to identify decoupling points (DP) primarily to maintain
544 seamless flow of materials during a disaster. According to Christopher and Towill (2000),
545 managing decoupling points (the point where the demand is fed upstream into a supply chain
546 and can be used to amend forecasts) for both the material and the information (the point where
547 real demand is fed upstream into a supply chain and can be used to amend forecasts) presents
548 a powerful opportunity for developing agility. In similar lines since the public sector
549 organisations face a lot of operational uncertainties, a leagile strategy devised by identifying
550 decoupling points with the HLSCM process can be seen having potential to enhance
551 effectiveness as well as efficiency within the HLSCM. Therefore, the lean strategy could be
552 applied to upstream whereas agility could be beneficial in the downstream (Childerhouse and
553 Towill, 2000).

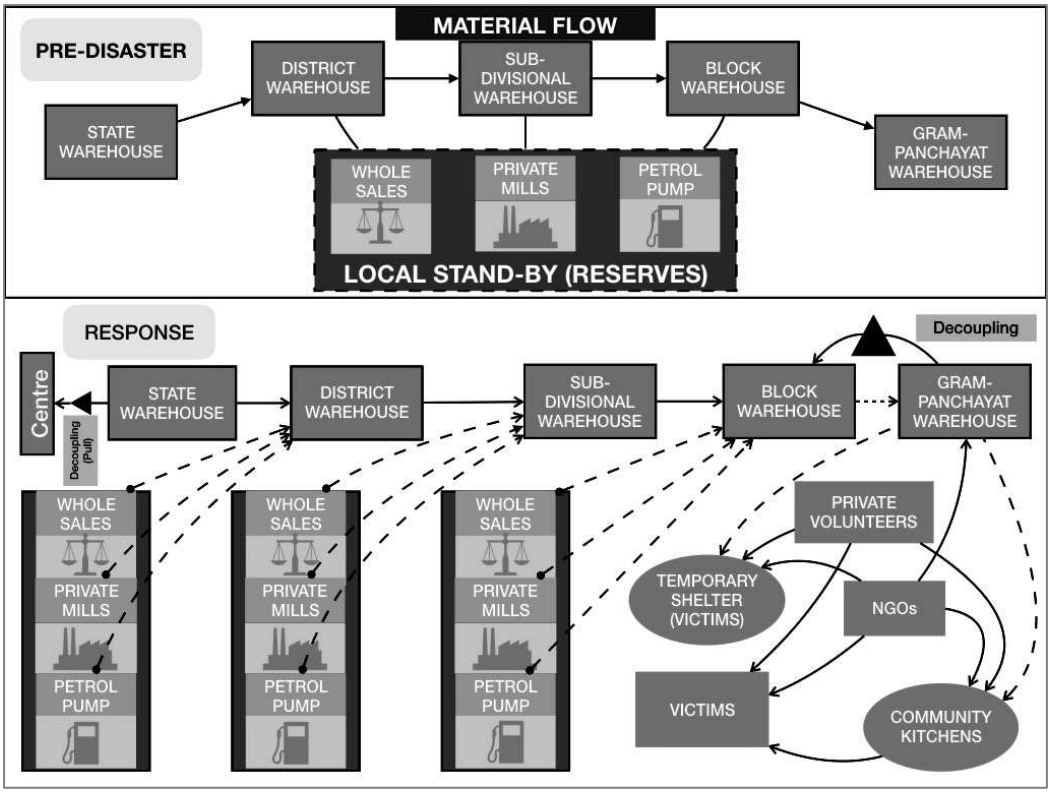


Figure 5: The future-state material flow during the relief operations in the case organisation

By proposing a leagile framework – future state material flow (Figure 5), the research aims to achieve both leanness and agility for the case organisation through recommended changes. As part of this, decoupling points were identified were subject to vary on the basis of the scale and impact of a disaster. The decoupling points identified in this research (see Figure 5) aimed at demonstrating two scenarios – one with a disaster with limited impact on few of the districts within the state and another resembling to a national calamity where assistance of the federal government is sought. For the first instance the decoupling point was identified at the gram panchayat – the lowest level of governance – with direct interface with the victims or the public. In a commercial supply chain context, the victims here could be termed as the customers and the decoupling point identified was nearest to the customers. Having a decoupling point here not only added agility by increasing the accuracy of the forecast for the relief material but also helped in increasing responsiveness at the upstream. While the rest of the upstream nodes maintained leanness by stocking less inventory, the downstream supply chain achieved agility by meeting the requirements of relief materials through a forecast driven model. This was further substantiated by the stand-by resources at various levels in the upstream who delivered at the time of fluctuation in material demand.

5. Managerial Implications

Using in-depth interviews and lean tools, this research identifies the inefficiencies in both information and material flow and recommend balanced use of lean and agile methodologies to overcome ineffectiveness as well as inefficiencies found within the inherent processes of an emergency humanitarian operation in the case organisation. Within the information flow, it was identified that most of the communications occurred primarily during the preparedness phase, 4-5 days before of the potential impact. Table 4 identifies the different types of information that are exchanged between the officials during the preparedness and response phase. The information flow was observed regularly between the chain of command consisting of bureaucrats and disaster mitigation officials, local and state government officials, police and stakeholders constituting as a core part of the team. Telephone, email and meetings were three major modes of information flow that could be found out from the interviews. The officials admitted the presence of a central database that is used at times for information exchange. However, due to involvement of multiple agencies and lack of interoperability among the data gathered, an advanced data governance model required to increase the efficiency of coordination and information exchange during such emergency operations. Furthermore, both the frequency of the communication as well as mode of communication remarkably changed aftermath of the disaster, primarily because of damage to power grids, telecommunication networks and major roads connecting to the affected areas. This research suggests to use a hybrid strategy for information flow combining both the top down and bottom up approaches (see Figure 2) enabling dual channel of communication for acquisition as well processing of those information for timely decision making.

Table 4. Type of information flow during preparedness and response phases

Top-down	Bottom-up	Mode of communication (s)
Potential impact areas	Impact assessment	Telephone, email, meetings
Scale of calamity/impact	Resource availability	Telephone, meetings
Time of impact/landfall	Manpower requirements	Telephone, email
Duration of impact	Machineries availability	Telephone, email
Highly vulnerable clusters	Stock taking of relief material	Email, telephone
Operations planning	Preparedness status update	Meeting, telephone
Operational instructions	Risks and bottlenecks	Telephone, email
Resource mobilisation	Stakeholders engagement	Telephone, meeting
Reporting guidelines	Routine updates	Telephone

As stated earlier while the research found right balance in implementing lean and agile strategy within the HLSCM along with the concept of decoupling – in both information as well as material flow – the concept of postponement is also beneficial for the case organisation keeping in mind the scale of uncertainty and various inefficiencies are met during any humanitarian operations. By using principle of postponement, public sector humanitarian organisations can apply effective demand led inventory management as a cost-effective substitute for pre-positioning supplies. It could enable the assignment of relief supplies as agile as appropriate. As discussed in previous sections, the right balance between lean and agility is required for the public sector humanitarian organisations to overcome various issues and challenges they are currently experiencing. Some important issues and challenges that were identified by the researchers are described below (see Table 5).

Table 5: Key issues and challenges within the HLSCM of case organisation

Issues/challenges	Operational Phases	Recommendations
Accuracy in forecasting, evaluation and planning	Preparedness, Response	Principle of postponement
Several types of inefficiencies/wastes	Preparedness, Response	Leagile strategy, six sigma, process redesigning
Distribution and storage	Preparedness, Response, Reconstruction	Agile supply chain – decoupling
Performance measurement, monitoring and improvement	Preparedness, Response, Reconstruction	Continuous improvement framework, Adherence standard practices, Benchmarking (absolute and relative)
Resource mobilisation Lack of trained manpower/high turnover	Preparedness, Response	Knowledge management Community Training
Longer lead time – rescue operations	Response	Information infrastructure, Decentralised decision making
Poor quality supplies	Response, Reconstruction	Quality assurance
Poor coordination and decision making	Preparedness, Response, Reconstruction	SOPs, training, reference manual

Evacuation	Preparedness	Awareness, motivation
Identification of beneficiaries/affected	Response, Reconstruction	Inter-agency coordination
Political interference – vote bank politics	Response, Reconstruction	Diplomacy
Cash flow	Response, Reconstruction	Emergency cash pile
Social media / fake news / mob	Preparedness, Response, Reconstruction	Communication management, Information sharing

609

610 Furthermore, building and adherence to standard performance measurement systems,
611 assessment framework, process improvement framework and international standards of
612 accountability and transparency would certainly help the case organisation in measuring,
613 improving and maintaining its performance during any humanitarian operations.

614 In addition to the bottleneck identified within Table 5, the research revealed that most
615 of the ineffectiveness and inefficiencies observed during the response phase can be attributed
616 to various causes (see Figure 6, fishbone). From interviews with victims and NGO officials,
617 the research revealed breakdown of road networks, communication network and corruption
618 were three major bottlenecks that averted relief materials reaching victims timely. While the
619 breakage of road networks delayed the transportation of material, the lack of clear
620 communications created bottleneck around correct assessment of the materials required.
621 Similarly, partisan approach, nepotism, kinship ties and corruption during the materials
622 distribution by some of the officials disturbed the harmony of the local community and trust of
623 some of victims during these operations. Therefore, it is recommended that an integrated
624 strategy is required to be formulated to address the ineffectiveness and inefficiencies within
625 various processes of HLSCM in the case organisation. A foundation to a such strategy can
626 certainly be built around the recommendations proposed in this research (Figures 3, 5 and Table
627 5).

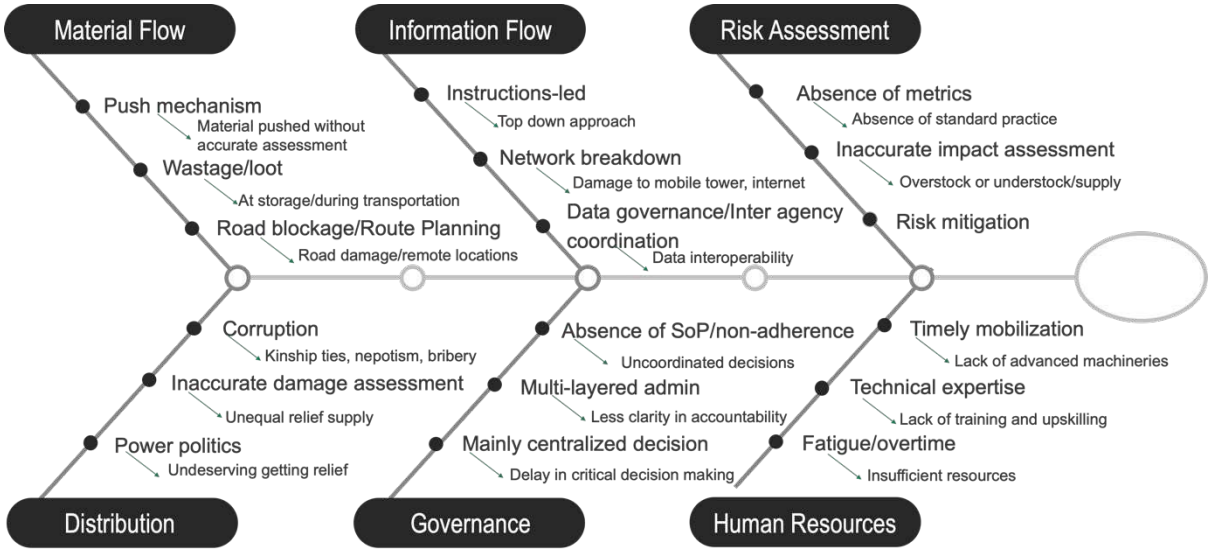


Figure 6. Root-cause analysis of major bottlenecks in HLSCM

6. Conclusions and future research

This research undertook an in-depth exploratory case study research on a public-sector organisation in India that is responsible for managing state-level disasters. This study contributes to the literature, which is scant, on humanitarian logistics and supply chain management (HLSCM) with a granular investigation on inefficiencies within the operations and supply chain of the case organisation. Findings from this research has a potential to be used by the decision makers within concerned intergovernmental agencies and key stakeholders in consideration with efficient and effective flow of material as well as information during a disaster mitigation operation. The hybrid nature of our proposed leagile framework has a potential to enhance the operational efficiencies not only within a governmental agency but also at a commercial organisation where decoupling or postponement is required to cater to the unpredictable customer demand and increase the market competitiveness.

The findings of this article must be interpreted against the backdrop of methodological as well as sampling limitations, which offers opportunities for future research. Owing to prevailing complexities within HLSCM, this research has attempted to congregate the flow of all materials during an emergency relief operation into one and termed it as ‘material flow’ while mapping the process of flow – aiming to simplify the process map. The involvement of multiple stakeholders, multi-layered decision making and multiple governmental agencies, made it out of scope to map separate process flow for individual relief material such as drinking water, food particles, clothing, emergency shelter/tarpaulin sheet among others. Additionally,

651 the sheer complexity and as well as structure and composition of disaster response team
652 involving multiple governmental agencies with overlapping responsibilities, the scope for
653 mapping the HLSCM process was limited to a major disaster relief operation in the case
654 organisation. The choice of interviewees were limited due to sensitiveness of the information
655 and more sample size could have revealed granularity around decision making process at a
656 time of emergency operation. Mapping of the reconstruction was kept out of scope primarily
657 because of the multi-layered decision-making process as well as involvement of private
658 contractors in the rebuilding process, which included material flow and cash flow.

659 Any future research could include the post disaster reconstruction or rebuilding phase
660 to get a holistic view of the process while understanding operational efficiency of the whole
661 process. It would be interesting to explore interrelationships between various agencies and if it
662 influences the efficiencies of such operations. The possible future direction could also look into
663 location of the 69 district warehouses within the case organisation for route planning and
664 efficient logistical operations at a time of disaster. Lastly, the future research is needed to
665 explain decoupling points along with the leagile framework in other disaster settings that
666 actively involves international donor agencies and non-governmental organisations.

667

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