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Theory building using SAP-LAP linkages: an application in the context of disaster management

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Abstract Management of disaster relief operations is a complex task involving pre-disaster, during disaster and post-disaster operations. It requires the involvement and coordination of multiple actors and processes. Traditionally, operations research applications in general and specifically for disaster relief have been made, largely, on quantitative and analytical front. There is a lack of qualitative and interpretive approaches in operations research applications. This paper uses an interpretive method, SAP-LAP (situation, actor, process, learning, action, performance) framework and linkages, in the context of disaster management. It enables to develop a theoretical framework for disaster management answering the fundamental questions of theory building. The paper first provides a selective review of disaster management and identifies the gap in building theoretical framework for the same. It then describes the methodology in terms of SAP-LAP framework and linkages with a broad appreciation of its application in operations as well as strategic management. This methodology is applied to develop a theoretical framework for disaster management. The paper finally discusses both the theoretical and practical implications of the proposed framework and concludes with future directions of research.

Keywords Disaster management · SAP-LAP framework · SAP-LAP linkages · Theory building

1 Introduction

The larger set of applications of operations research is linked with quantitative modelling and analysis of different problem contexts. The central thought process in these applications is related with hard systems thinking, i.e. optimization. Whereas, theory building studies seem to be scant. The same is true in the context of disaster management as well. The disasters

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(both natural and man-made) affect a wide population in a region and require both preventive and corrective measures. A case situation of a disaster is analyzed by McEntire (2002) to identify both the factors constraining and factors contributing to multi-organizational coordination. Another case analysis of multi-organizational coordination in Indian context has been reported by Raju and Becker (2013) that has used semi-structured interviews of the actors involved to identify the need for coordination, role of government, knowledge networking, and goals. The challenges faced in humanitarian logistics have been explored by Gustavsson (2003) and recommendations have been made regarding enhancement of knowledge, broadening the scope of funding, and investment in technology. A topical literature review on humanitarian logistics is presented by Kovács and Spens (2007) covering preparation for a disaster, immediate response, and reconstruction. This also covered the actors in humanitarian aid, characteristics of humanitarian logistics and a framework for disaster relief logistics which have been used as a basis for the theoretical framework proposed in this paper. Dubey and Gunasekaran (2015) developed an ISM model of agility, adaptability and alignment of humanitarian supply chain which can be taken as an approach towards theory building using interpretive methods. An attempt towards theory building for disaster management will provide a holistic view to understand and generate the learning from individual cases for larger application.

Theory building requires both analytical and interpretive approaches. In general, in operations research literature, there lies a gap in application of qualitative and interpretive approaches for theory building which are helpful in the conceptualization phase. Some interpretive methods applied for theory building are interpretive structural modelling (Warfield 1974), total interpretive structural modelling (TISM) (Sushil 2012, 2016a) and grounded theory (Corbin and Strauss 1990). Dubey et al. (2015) applied TISM for theory building for sustainable manufacturing. SAP-LAP (Sushil 2000b, 2001a) is another interpretive method that can be applied for theory building, but has largely been used for case analysis in past. In this paper, a generic framework is proposed for theory building based on SAP-LAP framework and linkages (Sushil 2009a), which has been illustrated in the context of disaster management. The contribution of the paper is largely methodological to use SAP-LAP framework and linkages for theory building. The application of SAP-LAP to disaster management would encompass all the basic questions of theory building that can be applied to any phase of disaster management. The twin objectives of the paper are:

(i) To propose a generic framework for theory building using SAP-LAP linkages.
(ii) To illustrate the proposed framework in the context of disaster management.

The paper initially gives a broad review of disaster management and brings out the gap areas. It then gives an overview of SAP-LAP framework and linkages as a base methodology for theory building and gives an outline of its select reported applications. It then utilizes this framework to provide an illustration for theory building for disaster management. The theoretical and practical implications of this theoretical framework for disaster management are discussed and finally the paper is concluded with future directions of research.

2 Disaster management: a selective review

A lot of human misery in terms of injuries, disabilities, and loss of life and property has been coming to notice owing to different types of disasters (both natural and man-made) from different parts of the world. Some of these fall under well known categories such as earthquakes, tsunamis, cyclones, floods, famines, etc., whereas some others could be quite unique and unforeseen. In any case, it requires taking both preventive and corrective measures to manage them in a systematic manner, as these disasters not only affect us, but also damage fauna and flora, and degrade the environment in a manner that is beyond the coping capacity of the affected region. The term disaster has been defined in different ways by different national and international agencies; it is defined by UNISDR (2009) as "a serious disruption of the functioning of a community or a society involving widespread human, material, or environmental losses and impacts which exceeds the ability of the affected community to cope using only its own resources". It requires both effective response and recovery mechanisms as well as preventive and mitigative measures. The framework of an agile supply chain for humanitarian aid is presented by Oloruntoba and Gray (2006) that considers both inventory and information decoupling. Another paper touching the strategy to have agile, adaptable and aligned supply chains in humanitarian settings is by Van Wassenhove (2006). Whereas, Schmitt et al. (2007) have given a report on the role of IT for improving disaster management in a comprehensive manner, covering short-term opportunities, key IT capabilities, and roadmap. Whybark (2007) reviewed the characteristics of acquisition, storage and distribution for disaster relief inventories, which can serve as an agenda for future research. Another review on disaster waste management is carried out by Brown et al. (2011). The research in the area of disaster management is fairly diverse in nature, but the use of operations research methods for disaster management is somewhat sporadic. Some notable studies are by de la Torre et al. (2012) as a review of OR models for disaster relief and by Davis et al. (2013) presenting a stochastic programming model for supplies in a network.

Some select reported studies covering various aspects of disaster management covering largely the post-disaster relief operations and humanitarian supply chain are summarized in Table 1 along with the operations research and systems techniques applied by them and key issues addressed. It is interesting to note from this select review that the major work in past is reported in the areas of post-disaster relief operations and humanitarian supply chains. The research related to preventive measures and learning from past disaster management cases is comparatively limited. The key issues largely addressed in past studies include challenges, practices and enablers of humanitarian logistics, coordination mechanisms, reduction of loss/damage, role of IT, performance measurement, channelization of supplies and inventory management, agility, adaptability and alignment, supply chain relationships, humanitarian supply chain design, disaster waste management, and use of operations research and systems techniques for disaster management. Further, it is evident that in the context of disaster management there have been limited operations research applications and use of systems thinking for theory building. The operations research techniques applied are stochastic programming and multi-objective optimization among others. The systems based techniques in this area involve application of interpretive structural modelling (ISM), total interpretive structural modelling (TISM), C&E diagrams, structured analysis and design technique (SADT), system archetypes, and so on. The larger sets of studies are based on reviews, cases, and experiences of experts. The theory building for different aspects of disaster management has been dealt with in an indirect and limited manner. The gap area of systems thinking for theory building in disaster management is being addressed in this paper.

3 Methodology for theory building: SAP-LAP linkages

Whetten (1989), in his exposition on theory building, highlighted the fundamental questions that constitute a good theory, i.e. 'what', 'how', 'why', 'who', 'when', and 'where'.

Table 1 Review of select studies on disaster management

Types of research	Author (year)	Operations research/systems technique(s) used and key issues addressed
Preventive measures and learning	McEntire (1999, 2002)	Problems and solutions, coordination
	Schmitt et al. (2007)	Role of IT
	Thevenaz and Resodihardjo (2010)	Conditions hampering response
Post-disaster relief operations	Kent (2004)	Role of UN
	Patterson (2005)	Reduction of loss and damage
	Kovács and Spens (2007)	Disaster relief operations
	Whybark (2007)	Disaster relief inventories
	Brown et al. (2011)	Disaster waste management review
	de la Torre et al. (2012)	Review of OR models for disaster relief
	Karunasena et al. (2012)	Post-disaster waste management case
	Davis et al. (2013)	Stochastic programming model for supplies in a network
	Raju and Becker (2013)	Multi-organizational coordination
Humanitarian supply chain	Gustavsson (2003)	Challenges
	Thomas (2003)	Enablers
	Oloruntoba and Gray (2006)	Factors for agile supply chain
	Van Wassenhove (2006)	Agile, adaptable and aligned
	Beamon and Balcik (2008)	Performance measurement
	Balcik et al. (2010)	Coordination mechanisms
	Christopher and Tatham (2011)	Humanitarian logistics
	McLachlin and Larson (2011)	Supply chain relationships practices
	Agostinho (2013)	Challenges of humanitarian logistics
	Pateman et al. (2013)	HRM practices
	Dubey and Gunasekaran (2015)	Agility, adaptability and alignment (ISM)
	Ransikarbum and Mason (2016)	MOIRR model of relief supply and network restoration
Theory building and systems thinking	Sandwell (2011)	Qualitative methods, C&E diagram
	Heaslip et al. (2012)	Structured analysis and design technique (SADT) and system archetypes
	Kabra and Ramesh (2015)	SAP-LAP linkages

Table 1 continued

Types of research	Author (year)	Operations research/systems technique(s) used and key issues addressed
	Kunz and Gold (2015)	Theory building for humanitarian supply chain design
	Trivedi et al. (2015)	ISM for disaster waste management
	Yadav and Barve (2015, 2016)	ISM, TISM for challenges

Wacker (1998) has addressed the similar fundamental questions in theory building research in operations management. He classified them into four criteria, i.e. conceptual definitions of variables ('who' and 'what'), limiting the domain ('when' and 'where'), relationship building ('how' and 'why'), and predictions.

In the conceptualization phase of theory building for disaster management, it is proposed to use SAP-LAP (situation, actor, process, learning, action, performance) as a basic methodological framework for theory building. In this section, first the basics and evolution of SAP-LAP framework are outlined with an exposition of its select past applications. It is then enhanced as SAP-LAP linkages to propose a generic framework for theory building.

3.1 SAP-LAP framework: basics and applications

While deliberating the evolution of flexible systems management paradigm, the SAP (situation, actor, process) framework was first introduced by Sushil (1997) and subsequently the situation, actor and process options were elaborated (Sushil 2000a). It has then been enhanced to integrate LAP (learning, action, performance) as a full-fledged SAP-LAP framework and its basic models (Sushil 2000b, 2001a, b). This framework is systemic in nature as it integrates the analysis–synthesis cycle; SAP represents the analysis of a given context and the synthesis of the same is presented in LAP part of this framework. LAP is "learning" centric as per the soft systems thinking (Checkland 1981). SAP-LAP framework has been widely used for analyzing different management contexts as per the following basic elements:

- A 'situation' to be managed representing 'what' is existing.
- An 'actor' or a group of actors 'who' deal with the existing situation.
- A 'process' or processes that are handled by actors giving 'how' the situation is being managed.
- 'Learning' from analysis of situation, actor and process results in 'why' the situation occurred in its current form.
- 'Action(s)' emerging out of reflection of learning to plan 'when' and 'where' these are to be implemented, relating with 'who' would be responsible and 'how' it will be carried out.
- The actions result into 'performance' as intended 'what', which gives feedback for further learning.

The basic framework of SAP-LAP has been enhanced to dynamic SAP-LAP that analyzes the situation, actor and process in a dynamic sense over different phases; the most popular application is pre and post analysis. For example, the pre-disaster SAP and post disaster SAP. The naive or atomic models of SAP-LAP have then been integrated by examining their interactions in the form of SAP-LAP linkages (Sushil 2009a), which has then been further innovated to deal with multiple case situations in the form of SAP-LAP hills (Banwet and Pramod 2010a) and interpretive ranking process (IRP) (Sushil 2009b, 2017) to rank different actors, processes, or actions.

SAP-LAP framework has largely been applied as a case research method to analyze the case contexts. A wide variety of applications have been reported in the areas such as manufacturing management, information management, supply chain management, technology management, services management, waste management and green approaches, strategic management, organizational management, and humanitarian supply chain and disaster management. Select reported applications of SAP-LAP have been summarized in Table 2. Out of the reported applications of SAP-LAP, the predominant ones are in the areas of information management, supply chain management, and strategic management. Some early case applications in information management are by Majumdar and Gupta (2001) analyzing e-business strategy of car industry and Rawani and Gupta (2001) for IS planning in banking sector. Some other applications in this area included information system flexibility in SME sector (Palanisamy 2012); information security management (Singh et al. 2013); ERP business value (Roshan 2014); and development of a framework for strategic planning and implementation of e-governance (Suri and Sushil 2017).

In the context of supply chain management, Arshinder et al. (2007) and Shukla et al. (2011) examined supply chain coordination issues, whereas the exploration and optimization of supply chain are dealt with by Soni and Choudhary (2013) and Gupta (2014). Some other applications of SAP-LAP framework for supply chain management include performance issues (Charan 2012); issues in SME sector (Kumar et al. 2012); frozen corn manufacturing supply chain (Mahajan et al. 2013); reverse logistics (Ravi 2014); and sourcing process in apparel manufacturing (Venkatesh et al. 2014).

An early application of SAP-LAP in strategic management is to analyze core competence and flexibility in pharmaceutical organizations by Kak (2004). Some recent applications on this front are on international strategic alliance capability (Likhi and Sushil 2013); execution of flowing stream strategy (Sushil 2013); product flexibility (Shalender and Singh 2014); and value chain of a beverage giant (Karnatak and Mitra 2015) among others. The applications of SAP-LAP framework for theory building have been rare. It has been taken as an underlying framework for developing a theory of flexible systems management (Sushil 2016b).

3.2 SAP-LAP linkages for theory building

The ‘SAP-LAP linkages’ is an advancement of the SAP-LAP framework that deals with interactions of situation, actor, process, learning, action, and performance. In this paper, this has been utilized for the first time to evolve a generic framework for theory building as shown in Fig. 1. This gives various cross-interaction linkages that are developed further in Fig. 2. The cross-interaction of SAP gives the relationships among existing situation, actor(s), and process(es) answering ‘what’, ‘who’, and ‘how’ respectively. The linkages 1 and 2 exhibit the influence of situation on actor(s) and process(es) respectively, whereas linkage 3 interprets the roles played by various actors in different processes in the form of an interpretive matrix (Sushil 2005). The linkages 4, 5 and 6 portray the insights gained from existing situation, actor(s) and process(es) respectively to define the causality in terms of ‘why’ it is happening in that manner giving the learning from the analysis of existing context.

The learning in terms of ‘why’ about the existing system provides the base for intended theory building in the form of LAP linkages. The linkage 7 gives details of the leads provided by the learning to action answering ‘when’ and ‘where’ the action(s) is to be taken, ‘who’

Table 2 An outline review of SAP-LAP framework and linkages

Type of paper	Area	Authors
Basic papers	SAP-LAP framework and models	Sushil (1997, 2000a, b, 2001a, b)
	SAP-LAP linkages	Sushil (2009a)
Advancements	Dynamic SAP-LAP	Sahoo et al. (2010), Siddiqui et al. (2012)
	SAP-LAP hills	Banwet and Pramod (2010a)
	Interpretive ranking process	Sushil (2009b, 2017)
Applications	Manufacturing management	Sharma (2001), Chauhan and Singh (2013)
	Information management	Majumdar and Gupta (2001), Rawani and Gupta (2001), Suri (2005), Suri and Sushil (2008, 2017), Palanisamy (2012), Singh et al. (2013), Roshan (2014)
	Supply chain management	Arshinder et al. (2007), Banwet and Pramod (2010b), Shukla et al. (2011), Charan (2012), Kumar et al. (2012), Kumar and Chand (2012), Soni and Choudhary (2013), Mahajan et al. (2013), Gupta (2014), Ravi (2014), Venkatesh et al. (2014)
	Technology management	Husain and Sushil (1997) Husain et al. (2002), Sahoo et al. (2011), Momaya and Chachondia (2013)
	Services management	Chaudhuri and Patil (2009), Birla and Taneja (2010), Iyengar et al. (2016), Gangotra and Shankar (2016), Sastry (2016)
	Waste management and green approaches	Mangla et al. (2014), Luthra et al. (2014)
	Strategic management	Kak (2004), Likhi and Sushil (2013), Sushil (2013), Shalender and Singh (2014), Singh and Shalender (2014), Karnatak and Mitra (2015)
	Organizational management	Bhardwaj and Momaya (2006), Ghosh and Sahney (2010), Bhardwaj et al. (2011), Agarwal and Vrat (2014)
	Humanitarian supply chain and disaster management	Lijo and Ramesh (2012), Kabra and Ramesh (2015)
Theory building	Flexible systems management	Sushil (2016b)

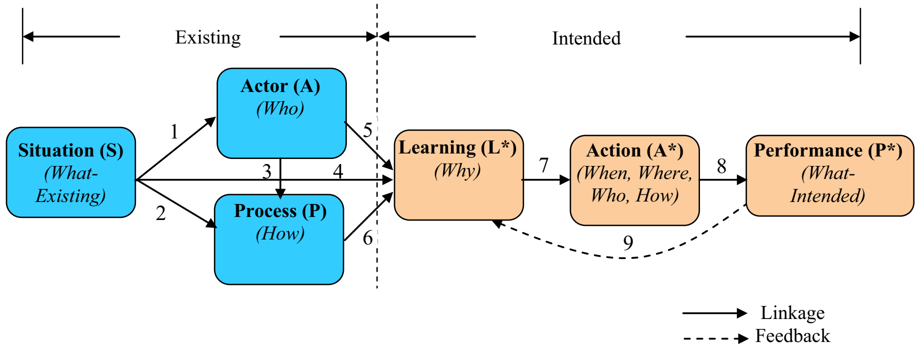

Fig. 1 Generic framework for theory building using SAP-LAP framework. (*Note* number on links shown are linkage numbers elaborated in Fig. 2)

will perform it, and 'how' will it be performed. The linkage 8 gives the impact of action on performance, i.e. intended 'what' to be achieved. Finally, linkage 9 gives the feedback from performance to further learning. Thus, the SAP-LAP linkages first provide the relationships of existing 'what', 'who', and 'how' and give insights to answer all the basic questions (why, where, when, who, how and what) that provides the conceptual framework of the theory to be tested.

In addition to cross-interaction matrices, there are self-interaction matrices among individual components of SAP-LAP. To aid in theory building, minimum two self-interaction matrices for 'action' and 'performance' should be developed. Self interaction matrix for 'actions' (binary as well as interpretive) depicts the interplay of actions in terms of their driver-dependence relationships that can be modelled using TISM (Sushil 2012, 2016a). Similarly, self-interaction matrix of performance elements will provide the intent structure of what is intended to be achieved.

4 Theoretical framework for disaster management: an illustration

In this section, first a broad theoretical framework for disaster management is outlined based on the generic framework discussed in the previous section. This is further used as a base to detail it out as a typical illustration in the context of post-disaster relief operations.

4.1 Broad theoretical framework

The generic framework for theory building proposed in the previous section has been applied to develop a theoretical framework for disaster management. The broad elements of SAP-LAP components along with the theory building questions are identified in the context of disaster management as a whole, as summarized in Table 3.

The SAP-LAP components for disaster management are briefly described as follows:

Situation

The situation answers the basic question 'what' for the existing system. The disaster situation under investigation may be any one out of well known ones like floods, famines, tsunami, earthquakes, and so on. It may also be possible that the situation might be unique and an

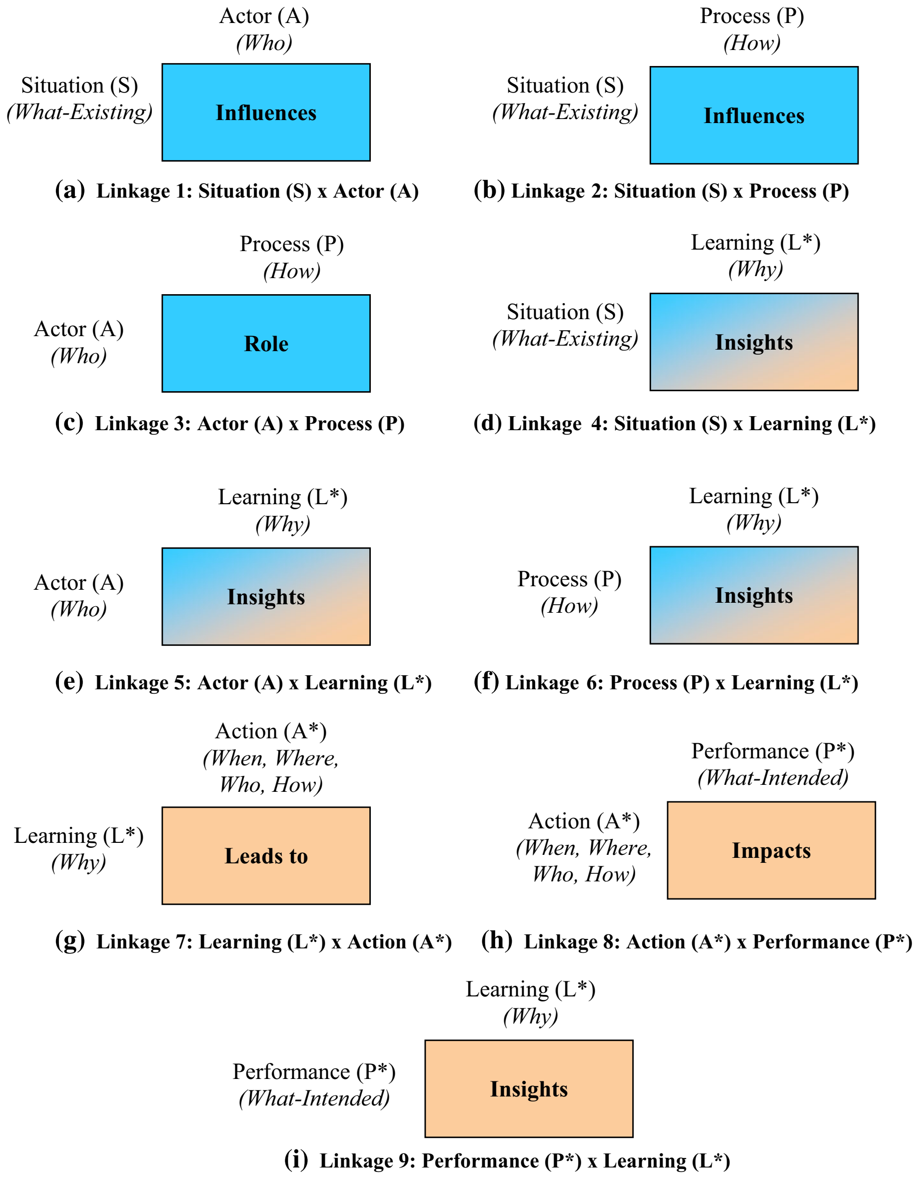

Fig. 2 Generic framework of SAP-LAP linkages for theory building

unforeseen event like 9/11 (as a terrorist attack in US) is to be examined, which needs to be handled spontaneously without any prior knowledge. The types of disaster could be an act of nature like tsunami, earthquakes, forest fires, etc., or it may occur due to man-made reasons such as leak of poisonous gases from a sensitive plant (like Bhopal gas tragedy in India), nuclear plant leakage (like Chernobyl in Japan), etc. The theory for dealing each one of these would be different. Some other situational elements could be state of available infrastructure,

Table 3 Theory building with SAP-LAP framework for disaster management

SAP-LAP components	Theory building questions	Elements in context of disaster management
Situation	What? (Existing)	Known[a]/unforeseen events
		Types of disaster (natural[a], man-made)
		State of infrastructure
		Level of funding /donation
		Preparedness
Actor	Who?	Affected population
		Training providers
		Disaster relief agencies
		Government bodies
		Insurance agencies
Process	How?	Predictive process
		Preventive process
		Protective process
		Response and recovery process[a]
Learning	Why?	Challenges or inhibitors in existing systems
		Opportunities and enablers in existing systems
Action		Pre disaster
	When?	During disaster
		Post disaster[a]
	Who? How?	On site[a]
	Where?	Remote
		Virtual
Performance	What? (Intended)	Impact reduction
		Zero loss of life
		Minimum injury
		Reduce timeframe for rescue
		Sustainable relief

[a] Scope for a typical illustrative example

level of funding/donation and preparedness to handle the situation that would influence the future course of action.

Actor

The basic question 'who' is answered in terms of the relevant actors or stakeholders. The fundamental actor in any disastrous situation is the affected population, whose rescue and relief is to be taken care of. Other actors that enable the handling of situation, in a proactive as well as reactive manner, would be training providers on disaster management, insurance agencies to cover up the risk, various disaster relief agencies, different government bodies that provide the aid, instruments and support in rescue and relief operations among others depending upon the situation to be managed. The roles, capabilities, worldviews and coordination mechanisms of all the actors are to be investigated for understanding the existing state of these actors for providing a theoretical base to the action plan.

Process

The processes answering the ‘how’ to handle the situation form the focal point to uniquely identify the theory around it, as it would be defining the scope of the study. Some examples of disaster management processes are predictive, preventive, protective and response processes. The predictive process will be able to forecast the happening of an event such as tsunami so that preventive actions could be initiated well in time to take the people to safer places and rescue and relief arrangements can be made before the occurrence of the disaster. The preventive process, for example for floods, would involve de-silting of rivers and drainage systems, etc. The protective process is to cover up the risk of crop damage, loss of property etc. by way of insurance schemes. The ultimate process (despite all these predictive and preventive actions) would be to respond to the disaster in terms of rescue and relief operations. This may involve rescuing entrapped people, providing onsite medical support, supply of food packets, drinking water and medicines, setting up relief camps, removal of demolition waste, etc. The disaster response and recovery processes should have agility, adaptability and alignment (Dubey and Gunasekaran 2015).

Learning

By the insights gained from SAP analysis of the existing system of disaster management, the learning answers ‘why’ reflecting on the current state in terms of both challenges/inhibitors and opportunities/enablers in the existing system. Yadav and Barve (2016) identified 15 post-disaster challenges of humanitarian supply chain, some of which are linked with immediate relief and others with long-term recovery and rehabilitation. Kabra and Ramesh (2015) identified eight learning (challenges) for use of ICT in humanitarian supply chains. These provide a basis to define action points so as to alleviate these challenges. At the same time, there could be some opportunities or enablers such as availability of trained manpower for rescue and relief, sufficient medical facilities in the region, alternate sources of drinking water, etc. Due to challenges, the post-disaster relief operations become difficult to implement, whereas the opportunities facilitate their smooth implementation. There is a need to initiate preventive activities to alleviate the challenges in order to manage future disasters (if any) more effectively.

Action

The actions emerge out of the learning insights which should be defined in terms of ‘when’ the actions are to be carried out (time frame) and to be implemented ‘where’ (location). Further, for sound action plan, it needs to assign the responsibility answering ‘who’ and the modalities (how) in which the activities are to be performed. Some typical actions in post-disaster operations would be setting-up relief camps, providing food and clothing to the affected population, and so on. Since multiple agencies are involved in rescue and relief work, effective communication and coordination would result in better performance.

Performance

The performance is to express the intent (what) to be achieved so as to carry out the operations in a focused manner. Some generic performance objectives for disaster management could be to reduce the impact of disaster, save loss of life (ideally zero), minimize injuries, etc. The actual performance in a particular disaster management situation would give feedback to document the learning for future corrective actions. The learning from each disaster management case would be synthesized to reflect on the action constructs that may be generalized for higher performance.

For defining the scope of any study, the prime components are the process and situation that would help in selecting the type of actions as marked by [a] in Table 3 for an illustrative example discussed in the next section.

4.2 Illustrative example

A sample illustration is made for a known type of natural disaster and the response process leading to post disaster and on-site rescue and relief operations. The SAP-LAP elements for the example are shown in Table 4, which are used as a base for developing SAP-LAP linkages. The linkages depicted in the generic framework (shown in Figs. 1 and 2) are illustrated in the selected situation and are portrayed in Appendix (Exhibits 1 to 9). The self-interaction matrices for action and performance are also shown in the Appendix (Exhibits 10 and 11). The summary conceptual framework for the chosen post-disaster relief operations case is depicted in Fig. 3.

Thus, the proposed theory for disaster relief operations has the following five research propositions (RPs). The LAP linkages in Appendix (Exhibits 7, 8 and 9) give specific hypothesized relationships.

RP1: The learning (why) derived from SAP analysis will lead to identify actions for disaster relief.

For example, a lack of coordination among different relief agencies would lead to quick improvisation by volunteers for rescue, initiating communication by all modes by local administrators, and committed supervision by executives and political leadership. The lack of resources would require to channelize supplies and sending professional rescue teams. Other learning–action linkages are portrayed in Appendix (Exhibit 7).

RP2: The actions (when, where, who, how) proposed for disaster relief will positively impact the performance indicators (what).

The action-performance linkages are shown in Appendix (Exhibit 8). Accordingly, it is expected to reduce loss of life, injury and timeframe for rescue by quickly sending professional rescue teams. The committed supervision will help in let the aid reach the site in a timely manner.

RP3: The achievement of performance indicators will act as a feedback for further learning to refine the actions.

The attainment of the intended performance in terms of reducing timeframe for rescue and relief, relief from injuries, loss of life and property, and timely aid would give a feedback as learning on different fronts of coordination, resources, assessment of needs, training and top management commitment for preventive actions in future.

RP4: Action mediates the influence of learning on performance.

The learning in terms of lack of coordination, resources, training, etc. is not supposed to translate directly into performance. The actions emanated of these learning would mediate to reduce timeframe, loss of life and property, etc.

RP5: Learning mediates the feedback of performance to take further action.

The actual achievement of performance would not be translated directly into desired actions but are mediated to reflect upon and gain insights in the form of learning to suggest relevant actions to be taken up.

Table 4 SAP-LAP elements for illustrative example of post-disaster relief operations

SAP-LAP components	Elements
Situation	S1 State of infrastructure
	S2 Level of funding
	S3 Preparedness of the region
Actor	A1 Affected population
	A2 Disaster relief agencies (NGOs/Military)
	A3 Volunteers
	A4 Government bodies
Process	P1 Agile humanitarian supply chain
	P2 Rescue and relief operations
	P3 Disaster waste removal
	P4 Communication process
Learning	L1* Lack of coordination
	L2* Lack of resources
	L3* Inadequate assessment of needs
	L4* Insufficient training
	L5* Top management commitment
Action (post-disaster, on-site)	A1* Improvisation for rescue *(volunteers)*
	A2* Communication with all modes *(local administration)*
	A3* Activate medical support *(local bodies/Hospitals)*
	A4* Channelize supplies *(NGOs/government bodies)*
	A5* Sending professional rescue teams *(Military/NGOs)*
	A6* Committed supervision *(executives/political leadership)*
	A7* Clearing the site *(trained professionals)*
Performance (intended)	P1* Loss of life
	P2* Loss of property
	P3* Timeframe for rescue/relief
	P4* Relief from injuries
	P5* Timely reach of aid

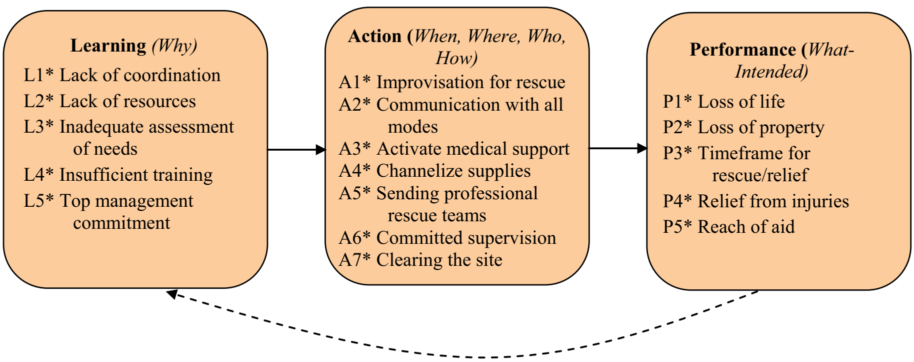

Fig. 3 Summary theoretical framework for post-disaster relief operations

This theoretical framework can be subject to empirical validation for building a sound theory for post disaster relief operations in terms of the validated LAP linkages.

5 Discussion

Theory building efforts in the context of disaster management have been done in a limited manner and that too in recent past. A notable contribution is by Sandwell (2011), in which qualitative methods and C&E diagrams have been applied to explore the challenges of humanitarian organizations in the form of a model consisting of organizational layer, operational layer, and a profile of logistics. A more comprehensive work is by Heaslip et al. (2012) that has used the system analysis and design technique (SADT) to explain the coordination of various organizations in disaster relief. This paved the way to develop a system dynamics model using system archetypes, but falling short of building a theory of disaster management. An exploration of new theoretical frameworks for sustainable humanitarian supply chain management is reported by Kunz and Gold (2015) that can be used by relief organizations during the disaster rehabilitation phase. Trivedi et al. (2015) have developed an ISM model for waste management in humanitarian response. Whereas a TISM model of challenges of humanitarian supply chain is presented by Yadav and Barve (2016). Thus, it can be noted that the theory building efforts in the context of disaster management had been dealing with different aspects and phases of disaster management, thereby lacking a holistic theory that can deal with all the basic questions in one model. The SAP-LAP linkages based framework deals with the six basic questions, i.e. what, who, how, why, when, and where in this context. The first attempt to use SAP-LAP linkages for analyzing ICT related issues in the context of humanitarian supply chain management was done by Kabra and Ramesh (2015), but this has more been an application of this framework for analysis rather than touching on theory building. This gap for a methodological framework on theory building for disaster management as a whole has been addressed in the current paper.

The broad theoretical framework proposed for disaster management can be implemented in multiple ways. First, a situation in terms of the type of disaster is to be chosen. The linkages could be different for natural disaster situation from the man-made situation. The theory for the selected type of disaster would also vary as per the process to be examined, i.e. predictive, preventive, protective or response process, as the nature of actions would vary in each case. We may first choose a typical context as illustrated in the example in the previous section. For the similar context, a couple of cases may be identified and subject to SAP analysis, which would be synthesized to gain insights in the form of learning elements to conceptualize a field-based theory. The research propositions and linked hypotheses can be empirically validated. On the other hand, the conceptualization may take place from expert opinion (e.g. through a Delphi study) and the conceptual framework may be examined in a member of similar cases and compared to test the research propositions. For example, if the natural disaster is selected, then it has to be further stated as earthquake, tsunami, floods, famines, and so on. A number of cases may be compared and contrasted to test the proposed theory on the ground. It can also be subjected to big data analytics by taking real time data from multiple sources to make it an evidence based theory.

A theoretical framework rooted into interpretive logic will be helpful in developing disaster management capabilities of concerned actors and improving the related processes. The insights gained will help in achieving high level of performance in terms of minimizing loss of life and property and providing sustainable relief with high degree of preparedness under any unforeseen circumstances in future. It will make us understand and cross-learn from other situations to prepare a suitable action plan for effective disaster relief. It would help to prioritize the actions by practicing professionals in different post disaster situations to enhance different performance parameters.

6 Conclusion

The paper contributes to the body of knowledge of operations research in terms of using the interpretive method of SAP-LAP linkages for theory building. Here, it has been demonstrated in the context of disaster management giving a broad theoretical framework with a specific illustration. The generic framework of theory building deals with the basic questions (what, who, how, why, when, where) through SAP-LAP linkages in a holistic manner, which can be applied in a variety of contexts. Though the paper gives a broad theory building framework for disaster management, it has been illustrated in a generic sense with an example of post-disaster relief operation. Thus, the main limitation of the study is related to its real life testing and validation. The framework would be refined in due course with its implementation in unique situations. Other interpretive methods such as total interpretive structural modelling (TISM) and interpretive ranking process (IRP) may be integrated with this in future to capture the requirements of theory building in specific contexts. The paper opens up new directions of research both in theory building and in disaster management. It is expected that the incorporation of interpretive methods will add value in the practice of operations research.

Appendix: SAP-LAP linkages for the illustrative example

Exhibit 1: Cross-interaction matrix—Situation (S) × Actors (A)

(a) Binary matrix

Situation \ Actor	A1	A2	A3	A4
S1	1	1	0	1
S2	1	0	0	1
S3	1	0	1	1

(b) Interpretive matrix

Situation \ Actor	A1	A2	A3	A4
S1	Adversely affected by poor infrastructure	Infrastructure enables relief operations	-	Government support required
S2	Adversely affected by lack of funding	-	-	Government aid
S3	Awareness and training	-	Aware and trained volunteers	Facilitates working

Exhibit 2: Cross-interaction matrix—Situation (S) × Process (P)

(a) Binary matrix

Situation \ Process	P1	P2	P3	P4
S1	1	1	1	1
S2	1	1	1	1
S3	1	1	0	0

(b) Interpretive matrix

Situation \ Process	P1	P2	P3	P4
S1	Supply chain infrastructure	Camps, Hospitals, etc.	Waste handling equipments	Communication infrastructure
S2	Funds required	Funds required	Funds required	Funds required
S3	Supply chain relationships	Awareness and training	-	-

Exhibit 3: Cross-interaction matrix—Actor (A) × Process (P)

(a) Binary matrix

Actor \ Process	P1	P2	P3	P4
A1	0	1	0	1
A2	1	1	1	0
A3	0	1	1	1
A4	1	1	1	1

(b) Interpretive matrix

Actor \ Process	P1	P2	P3	P4
A1	-	Self help for rescue	-	Use of communication devices
A2	Channelize supplies	Perform rescue and relief	Clearing the site	-
A3	-	Help in rescue /relief	Help in clearing site	Communicate to local bodies
A4	Channelize supplies	Provide aid	Provide aid and equipment	Upkeep of communication infrastructure

Exhibit 4: Cross-interaction matrix—Situation (S) × Learning (L*)

(a) Binary matrix

Situation \ Learning	L1*	L2*	L3*	L4*	L5*
S1	1	0	0	0	1
S2	1	1	0	0	1
S3	1	0	1	1	1

(b) Interpretive matrix

Situation \ Learning	L1*	L2*	L3*	L4*	L5*
S1	Communication infrastructure	-	-	-	Support for infrastructure building
S2	Funds required for development and maintenance	Demand for resources	-	-	Generation of funds
S3	Awareness helps in coordination	-	Untrained professionals	Untrained citizens	Organize awareness training

Exhibit 5: Cross-interaction matrix—Actor (A) × Learning (L*)

(a) Binary matrix

Actor \ Learning	L1*	L2*	L3*	L4*	L5*
A1	0	0	0	1	1
A2	1	1	1	1	0
A3	1	0	0	1	0
A4	1	1	1	1	1

(b) Interpretive matrix

Actor \ Learning	L1*	L2*	L3*	L4*	L5*
A1	-	-	-	Needs training	Expects commitment
A2	Coordination mechanisms	Require resources for execution	Help in need assessment	Provide external support	-
A3	Help in coordination	-	-	Local support	-
A4	Need to be activated	Need to be activated	Need to be activated	Need to be activated	Visible commitment needed

Exhibit 6: Cross-interaction matrix—Process (P) × Learning (L*)

(a) Binary matrix

Process \ Learning	L1*	L2*	L3*	L4*	L5*
P1	1	1	1	0	0
P2	1	1	1	1	0
P3	1	1	0	0	0
P4	1	0	1	0	1

(b) Interpretive matrix

Process \ Learning	L1*	L2*	L3*	L4*	L5*
P1	Supply chain coordination	Lack of supplies	Assessment of supplies	-	-
P2	Rescue and relief coordination	Lack of facilities	Assessment of facilities	Untrained professionals	-
P3	Poor assessment due to lack of coordination	Lack of equipments	-	-	-
P4	Commitment and supervision for coordination	-	Communication about needs	-	Establish communication process

Exhibit 7: Cross-interaction matrix—Learning (L*) × Action (A*)

(a) Binary matrix

Learning \ Action	A1*	A2*	A3*	A4*	A5*	A6*	A7*
L1*	1	1	0	0	0	1	0
L2*	1	0	0	1	1	0	0
L3*	1	1	1	1	0	0	1
L4*	1	0	0	0	1	0	1
L5*	0	0	1	1	1	1	1

(b) Interpretive matrix

Learning \ Action	A1*	A2*	A3*	A4*	A5*	A6*	A7*
L1*	Look for alternatives	Communicate for coordination	-	-	-	Supervision enables coordination	-
L2*	Local innovation	-	-	Augment resources	Trained manpower needed	-	-
L3*	Test alternatives	Communication will help assessment	Be ready to meet sudden demand on medical facilities	Supplies for unknown demand	-	-	Trained professionals to handle unknown damage
L4*	Volunteers for self help	-	-	-	External support of trained manpower	-	External support of trained manpower
L5*	-	-	Involvement of local bodies and medicos	Coordinate with NGOs for supplies	May involve military for rescue	Visible commitment	Involve professionals

Exhibit 8: Cross-interaction matrix—Action (A*) × Performance (P*)

(a) Binary matrix

Action \ Performance	P1*	P2*	P3*	P4*	P5*
A1*	1	0	1	1	0
A2*	0	0	1	0	1
A3*	1	0	0	1	0
A4*	1	1	0	0	1
A5*	1	0	1	1	0
A6*	1	0	1	1	1
A7*	0	1	0	0	0

(b) Interpretive matrix

Action \ Performance	P1*	P2*	P3*	P4*	P5*
A1*	Quick rescue	-	Quick rescue	Quick rescue	-
A2*	-	-	Reduces timeframe	-	Need for aid is communicated
A3*	Life saving treatment	-	-	Quick treatment of injuries	-
A4*	Timely supply of food and medicines	Repair and maintenance	-	-	Supply of funds in time
A5*	Life saving rescue operation	-	Timely rescue	Prevent injuries	-
A6*	Directs life saving rescue and relief	-	Supervision reduces timeframe	Activates timely medical support	Channelizes aid
A7*	-	Timely repair and renovation	-	-	-

Exhibit 9: Cross-interaction matrix—Performance (P*) × Learning (L*)

(a) Binary matrix

Performance \ Learning	L1*	L2*	L3*	L4*	L5*
P1*	1	1	1	1	1
P2*	1	1	1	1	1
P3*	1	0	1	1	0
P4*	0	0	1	1	0
P5*	1	1	1	0	1

(b) Interpretive matrix

Performance \ Learning	L1*	L2*	L3*	L4*	L5*
P1*	Coordination between rescue team and medical facility	Not having adequate medical facilities	Life threatening causes not assessed	Due to lack of training of rescue team	Zero tolence to life threatening situations
P2*	Coordination between supply chain and operations	Lacking resources for recovery and repair	Property damage not assessed	Untrained relief personnel	Commitment for recovery operations
P3*	Lack of multi-agency coordination	-	Rescue requirement not assessed	Untrained rescue team and volunteers	-
P4*	-	-	Medical support requirement not assessed	Lack of training of medical personnel	-
P5*	Coordination between government bodies and supply chain	Lack of funds and physical resources	Aid required not assessed	-	Commitment for quick aid

Exhibit 10: Self-interaction matrix for actions (A*)

(a) Binary matrix

1	**0**	**0**	**0**	**0**	**1**	**A1***
1	1	1	1	1	**A2***	
0	1	1	1	**A3***		
1	1	1	**A4***			
1	1	**A5***				
1	**A6***					
A7*						

(b) Interpretive matrix

Alternative quick waste removal	-	-	-	-	Communicating local innovation	**A1***
Deploying waste handling equipments	Supervision impacts communications	Deployment of rescue teams	Activate supply chain	Help in activation of medicos	**A2***	
-	Supervision supports medical attendance	Include medical personnel in team	Need for medicines	**A3***		
Supply of work handling equipment	Supervision assesses need of supplies	Supplies available to rescue team	**A4***			
Rescue team work for recovery side by side	Supervision quickly deploys teams	**A5***				
Supervision mandates clearing in time	**A6***					
A7*						

Exhibit 11: Self-interaction matrix for performance (P*)

(a) Binary matrix

1	1	1	0	**P1***
1	0	1	**P2***	
1	1	**P3***		
1	**P4***			
P5*				

(b) Interpretive matrix

Aid in time for better medical support	Some injuries could be fatal	Quick rescue saves life	-	**P1***
Aid in time for recovery operations	-	Quick recovery mechanism	**P2***	
Aid in time for quick rescue/relief	Quick rescue prevents injuries	**P3***		
Better medical support	**P4***			
P5*				

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