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Application of project management to disaster resilience

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Abstract In this paper, we apply project management concepts and frameworks to the context of disaster resilience and examine how groups can increase the disaster resilience of a community. Based on our literature review and case study methodology, we develop a model that draws upon the relevant literatures in project management, operations management, disaster management, and organizational behaviour; we then compare that model with 12 disaster-related cases supported by four Non-Governmental Organizations (NGOs) in India. Our model measures disaster resilience using both an encompassing measure we refer to as Total Cost to Community (TCC) that captures the interrelatedness of level of recovery (deliverables), speed of recovery (time), and loss minimization (cost) at a community group level, as well as through learning (single domain or alternate domain). The model indicates that the external elements of the disaster management process (scale, goal complexity, immediacy, and stakeholder variance) influence the internal characteristics of disaster project management (information demands and uncertainty), which in turn influence disaster resilience. The level of community group processes (group strength, group continuity, and group capacity) also influences learning, both directly and indirectly, through internal characteristics of project management. In addition, the relationship between the external elements of disaster recovery and the internal characteristics of disaster project management is moderated by resources available. This model provides interesting new avenues for future theory and research, such as creating operations research models to identify the trigger points for groups becoming effective and exploring the quantification of TCC, a new construct developed in this research. Ultimately, this model can provide a roadmap for NGOs and government entities

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interested in building disaster resilience among micro-enterprises in vulnerable communities.

Keywords Disaster resilience · Learning · Groups · Project management

1 Introduction

Throughout the developing world, tiny businesses or micro-enterprises thrive within the informal economy unhindered by regulations and taxes. Unfortunately, these micro-enterprises are often unable to access formal systems and aid when disasters strike (Prasad et al. 2015). Disaster relief tends to be top-down and may not be available to the informal sector in which micro-enterprises operate. Also, many micro-enterprises are affected by small-scale disasters for which outside sources of funding are less likely to materialize. Hence, disaster resilience (i.e., the ability of entities to absorb and recover from shocks (OECD 2013) is crucial for such micro-enterprises.

In this research, we look at disaster resilience through the lens of project management. The disaster management process (i.e., activities conducted before, during, and after a disaster so as to minimize loss of life and damage to the economy (Altay and Green 2006) can be visualized in terms of a project—with specific deliverables, time constraints, and limited resources. Although the operations management/operations research literature has looked at disasters (e.g., Bhattacharya et al. 2014; Gabler et al. 2017), it has not thoroughly examined the relationship between project management and disaster resilience (Crawford et al. 2013). Therefore, the first aim of our research is to apply project management concepts and frameworks to the context of disasters, thus increasing our understanding of disaster resilience.

Second, we examine how community groups can be utilized to develop disaster resilience, an issue that has not been investigated in detail in the current literature (Kapucu 2008; Poddar 2013). Community groups have the ability to provide forums for sharing and learning; these can be used to facilitate disaster management and provide a degree of resilience to the community. Examining this phenomenon can add to our knowledge of disaster resilience.

Given the novel nature of this area of study, we rely on case study methodology based upon the applicable literature to help define constructs and relationships and to create an intervention model for disaster resilience. We first conduct a literature review to develop an initial model examining disaster resilience through the lens of project management. We use this initial model to examine twelve different cases in India, and we then propose a revised model. Finally, we utilize this revised model as a way to impact current and future interventions by Non-Governmental Organizations (NGOs).

This research can be of benefit to communities as it can help ensure that micro-enterprises, with their supporting NGO partners, adopt a project management methodology and take advantage of community group processes in their remediation efforts. The research can also be of value to the fields of project management and disaster management by bridging gaps between the two literatures.

This paper is organized as follows. The next section briefly examines the literature on disaster resilience, project management, and community groups. The sections that follow describe the methodology used and the model developed in this research. Finally, we discuss our findings and their implications for theory and practice.

2 Literature review

In this section, we examine the relevant literatures associated with disaster management process, resilience, project management, and groups in the context of developing countries. We followed a structured literature review process (Anaya-Arenas et al. 2014) to enable us to identify relevant resources. First, several factors that might be critical to the context of our 12 different cases were identified. Combining contextual factors with constructs and variables in the model, we identified key search terms including: disaster, "project management", resilience, humanitarian, "self-help", scale*, goal*, stakeholder*, immediacy, information, uncertain*, and group*. Using these terms as search criteria, we executed combinations of searches within the ABI/INFORM collection of databases. *Disasters* journal was not available within the database so was searched manually. Since the disaster/humanitarian logistics and supply chain literature has a relatively short history of being formalized as a field (Altay and Green 2006), we focused our search on articles published since 1990. Finally, we placed more emphasis on work published within the last 5 years in order to build upon the most recent developments in the field, and we expanded our literature review to capture any salient articles that were related to disaster management, resilience, project management, and groups.

2.1 Disaster management process and disaster resilience

There is a well-established history of research on disasters. One of the early works on disasters took a social psychology view of how both large-scale and small-scale disasters lead to community change (Prince 1920). More recently, these ideas were re-examined in the context of the original Halifax explosion (Prince 1920) and the Port Arthur massacre (Scanlon and Handmer 2001), noting how disasters can fundamentally change a community. As such, it is crucial to examine disaster in the context of the community evolution. Beyond the community, it is also important to recognize the roles of the various stakeholders and the impact of resource allocation in any disaster-related operation (Kovács and Spens 2007). Furthermore, managing such operations is difficult, as there are non-routine activities and uncertainty is present (Long 1997). The disaster management process can be considered a complicated system of problems that change over time (Blackman et al. 2016); a decision made at one point in the process may be irreversible (Pauwels et al. 2000). Thus, the disaster planning and decision-making process differs drastically from conventional decision making.

Many of today's humanitarian disasters occur in developing countries (Long and Wood 1995) and therefore, our focus is also within this context. Rather than focus on disaster recovery, a better approach is to help communities mitigate risk and help them better understand and manage the consequences of a disaster (Paton and Johnston 2017). This approach involves building resilience within a community and is particularly relevant to micro-enterprise communities operating in the informal sector in developing countries. This key issue associated with disaster has longer-term objectives designed to restore the affected entities to full recovery (Rapp 2011); it focuses on executing plans to ensure that businesses and communities return to minimally acceptable operational levels. This issue is often referred to as operations resilience, and it has been a key focus of both scholars and professionals as the emphasis shifts to longer-term recovery (Sahebjamnia et al. 2015). As such our research focuses on the recovery stage of a disaster.

Resilience has been examined in a number of diverse fields including psychology, disaster management, natural resources, business, and operations/production management. In the area of disaster management, resilience has been described as "the capacity of a system, community, or society potentially exposed to hazards to adapt, by resisting or changing in

order to reach and maintain an acceptable level of functioning and structure" (International Strategy for Disaster Reduction Online Conference 2004). At the business level, it has been defined as "a firm's ability to effectively absorb, develop situation-specific responses to, and ultimately engage in transformative activities to capitalize on disruptive surprises that potentially threaten organizational survival" (Lengnick-Hall et al. 2011). From an operations/production angle, resilience has been defined as "the ability of an element to return to a stable system after a disruption" and includes elements of preparedness, response and adaptation, and recovery or adjustment (Bhamra et al. 2011). Resilience can be associated at both the community and physical level (Bruneau et al. 2003) with speed of recovery, loss and post-level functioning (Norris et al. 2008).

In this research, we focus on the community level rather than on the physical context. Among the various fields, certain strands of ideas are relevant to community-level change. Specifically, organizational links (Norris et al. 2008) and overlapping relationships of connectedness (Arbon 2014) help in navigating non-linearity, uncertainty, and scale issues (Berkes and Ross 2013) associated with disaster management. Furthermore, groups within communities can help build upon local knowledge (Manyena 2006) and ensure learning (Berkes and Ross 2013).

We focus on the disaster resilience of micro-enterprise community groups, and measure this concept based upon the following items: loss minimization, speed of recovery, level of recovery, and the degree of learning and development to mitigate future disasters.

2.2 Project management

Project management has been used to execute complex intra- and inter-organizational deliverables within a given time frame and budget. This field has been influenced by the rationality of decision theory, which focuses on optimizing plans, contracts, and charts, as well as by sociological theories that focus on the nature of social relations and processes that occur in projects (Kenis et al. 2009; Lundin and Söderholm 1995). Although the research and literature on project management is relatively young and does not yet capture the complex nature of projects seen in practice, we can apply some of the concepts and frameworks developed in this literature to the disaster management process.

Unfortunately, the literature shows little formal connection between the areas of project management and disaster management (Crawford et al. 2013), although project management has been recognized as a possible methodology by a few. For example, Tun and Pathranarakul (2006) suggest that disaster management is a form of public project management and that all phases of disaster management may benefit from a project management approach. Similarly, the Project Management Institute has stated that knowledge of project management can have several practical implications for FEMA in its disaster relief efforts (Learnard 2011). Preito and Whitaker (2011) and David Swanson and Smith (2013) note that in the disaster project management context, activities should include partnership and planning between government entities, NGOs, and the local micro-enterprise community prior to the onset of a disaster.

Applying project management to the disaster context, however, is not straightforward. Traditional project management approaches tend to be linear, top-down, and best suited for projects with clear goals, tangible outcomes, and a focus on monitoring with the project work carried out under conditions of rationality (Mota et al. 2012). Since these characteristics are the antithesis of disaster management projects, which typically tend to be complex and non-linear with intangible outcomes, traditional project management approaches, with their clearly-defined structures and assumptions of stability, are unlikely to

be directly applicable to the disaster management context (Gupta 2016). Therefore, we have to adapt project management constructs and frameworks to be more flexible and context-sensitive.

This paper examines several internal characteristics of disaster project management: recognition of the need to make decisions based on immediacy, limited information, and a high degree of uncertainty (Pedraza-Martinez and Van Wassenhove 2016; Prasad et al. 2013).

2.3 Community groups

There is a growing body of research demonstrating support for the critical role that local communities play in recovery and reconstruction efforts, with an increasing focus on the importance of community involvement and proactive capacity building in effective disaster management (Kapucu 2008; Kumar and Havey 2013; Noori and Weber 2016). Evidence suggests a localized disaster project management approach consisting of tight coordination with local governments and local agencies best positions the efforts to effectively execute a more optimal disaster response (Arouri et al. 2015).

Examining the role of the micro-enterprise community involves looking at community group processes. Based on Mafuta et al. (2016), we refer to community groups as formal and informal collectives within the community. These groups enable micro-enterprises to recover quickly by leveraging social relationships that can be mobilized to facilitate action (Blackman et al. 2016); they help individuals access resources not only for their own benefit, but also for the benefit of their families and their micro-enterprise communities. For example, community group actions can help to improve sanitation, transportation, and infrastructure in the entire community. One type of community group prevalent in developing countries such as India is Self-Help Groups (SHGs); these groups have had an enormous impact on the lives of women, helping them move out of poverty, gain empowerment, and participate in the economic development of the community (Poddar 2013).

In this research, we look beyond the immediate benefits to community group members to examine the impact of groups on community resilience in the context of disaster management by investigating the extent to which groups can improve the project management process. To that end, we examine several characteristics of community group processes that can have a positive impact on the disaster project management process and on disaster resilience: group strength, group continuity, and group capacity.

3 Case study methodology

In the operations management/research field, case methodology has been considered a valuable approach that helps identify relevant constructs and relationships among constructs (McCutcheon and Meredith 1993; Meredith 1998; Prasad et al. 2016; Voss et al. 2002). In this research, we rely on a qualitative case study that "primarily uses contextually rich data from real world settings" (Barratt et al. 2011, p. 329) to examine disaster resilience. Case study research relies upon inductive logic and is especially useful for exploratory research (Barratt et al. 2011). Given the nature of case study (Barratt et al. 2011), we believe that our theory has a high degree of practical relevance to NGO managers and individuals, families, or communities facing disasters.

3.1 Unit of analysis and role of existing theory

The unit of analysis is at the community group level. Since the use of *a priori* constructs can help to shape the initial design of the theory-building process, a literature review was first conducted to identify possible constructs and to create a tentative model. This model was then compared with disaster resilience cases to develop theory and influence action at the field level.

3.2 Sampling, case selection, and number of cases

Twelve disaster cases were utilized in this study. These cases were selected given the long-term relationships that the authors had with four NGOs in India; these relationships allowed access to data and individuals and enabled some elements of action research to shape the field intervention based upon the theoretical model derived. Twelve cases from four NGOs can be considered sufficient for our research (Eisenhardt 1989). The cases represent a diversity of disasters affecting a range of communities in different parts of India in both urban and rural settings (Table 1). This diversity allows for greater generalizability in the Indian context and assures proper analysis.

3.3 Data collection and analysis

Following the protocol of case study methodology, we relied upon multiple sources of data to triangulate our findings. These included field observations, interviews, documents, and even artifacts to provide a degree of reliability. Data sources included structured interviews, semi-structured interviews, observations, archival data and presentation material (Table 1).

The case study helped identify and refine some of the relevant constructs and measurement items, as well as the general relationships between external elements, internal characteristics of disaster project management, community groups, and disaster resilience. Our theoretical model was developed by examining "similarities and differences across cases" (Ketokivi and Choi 2014, p. 234) and using the method of "agreement and difference" (Ketokivi and Choi 2014, p. 234) across a multitude of communities within different external conditions with a range of stakeholders, resources, and infrastructures. Based upon the data, we classified the respective construct items on a scale from very low to very high in order to identify patterns. In this pattern-matching process, the emerging data from cases was compared with the initial model derived through the literature (Barratt et al. 2011). The process of data collection and analysis was iterative with the constructs and relationships adjusted as new cases were added. At times, we were "surprised" by the data and had to make sense of it (Ketokivi and Choi 2014). For example, if a certain construct or relationship was not compelling or did not fit the prescribed model, we reached out to the NGOs or the individuals that were directly affected by the disaster for clarification. This clarification would entail a possible revision of constructs or relationships. Some "surprises" resulted in a change of practice by the NGOs or the individuals affected by the disaster. The analysis was conducted manually.

3.4 Cases

In our research, we examined several disaster-related operations of four NGOs, including Indian Pollution Control Association (IPCA), Operation Asha (A), Sodhana Charitable Trust (S), and an entity we call Hub 'n' Spoke. These NGOs are helping individuals, families, and communities become resilient to small and large disasters.

Table 1 Cases, community group, NGOs and sources of data

Disaster case	Community groups	NGO	Source of data
Fire burnt *godown*	Pickers	India pollution control association	Semi-structured interviews with NGO officers, godown owners, and pickers
Eviction by authorities	Pickers		Visits to picker *godowns*
Demonetization—Noida sector 73	Pickers		Access to internal documents
Demonetization—Indirapuram	Pickers		
Demonetization—agriculture	Farmers	Hub 'n' spoke	Semi-structured interviews with field supervisors, NGO officers, and farmers
			Visits to farms affected by disaster
Demonetization—rural	Farmers	Sodhana charitable trust	Semi-structured interviews with field supervisors, NGO officers, farmers, villagers, and group members
Cyclone—damage to crops and housing	Farmers		Visits to localities affected by disaster
Cyclone—potential school flooding	Rickshaw colony		Access to internal documents
Escherichia coli	Villagers		
Social expectations	Villagers		
Tuberculosis (DS-TB cases)	Urban dwellers	Operation assha	Semi-structured interviews with field supervisors, NGO officers, and monitors
Multi Drug Resistant Tuberculosis (MDR TB)	Urban dwellers		Visits to field operations
			Access to presentation material and data

Indian Pollution Control Association (IPCA) works primarily within the solid waste informal sector and organizes pickers into community groups to improve the sorting, distribution, and yield of the solid waste being processed. Pickers working with IPCA have faced some potentially devastating disasters including fires, the effects of demonetization, and eviction. In 2014, a fire ravaged one of the picker *godowns,* destroying their living quarters, workplace, and inventory. More recently, a demonetization effort by the central government in India led to a liquidity shock with the withdrawal of some 90% of the currency from circulation. This liquidity crunch affected the entire informal solid waste stream by delaying payments and lowering prices for recycled waste material. Many pickers found their cash savings in jeopardy if they were not able to transfer the funds into the formal banking sector. Finally, many

of the pickers work and reside on plots of land that belong to the state and, as such, are vulnerable to eviction; authorities will inform the picker residents a certain number of times before the bulldozers come in.

Operation Asha's primary focus is to cure Tuberculosis (TB). Outbreaks of TB can be disastrous to families and community groups given the loss of productive work and possibility of death; in addition, the disease is likely to spread to close family members. TB is treatable, but patients must methodically take the prescribed dosage of medication. Unfortunately, patients often stop taking antibiotics during the course of treatment and eventually succumb to Multi-Drug-Resistant TB (MDR TB). This form of the disease is very difficult and expensive to treat, spreads to other family members, and becomes a major health crisis to the community.

Sodhana Charitable Trust has been working to improve conditions in rural Andhra Pradesh. One of the critical elements of Sodhana's program is the creation of women's self-help groups (SHGs) to generate income. Sodhana and the SHGs have played a key role in providing support in the face of several disasters including Cyclone Hudhud, the effects of demonetization, and a large scale infection of *Escherichia coli*, as well as protecting from devastating social expectations. Cyclone Hudhud devastated many of the SHG members' crops and, in some cases, their homes. A virulent form of *E. coli* severely affected approximately 35% of the villagers and required the hospitalization of over 100 villagers. Finally, among the resident population, there are social expectations, such as dowry-giving, opulent weddings, and expensive celebrations when a daughter reaches puberty. Often, families fall significantly into debt as they try to meet such societal expectations. Sodhana discourages such expensive practices, while SHGs provide inexpensive loans to members to cover costs.

The Hub 'n' Spoke agricultural intervention was designed to provide help and support to indigenous agricultural workers in rural Andhra Pradesh. These individuals have faced extreme events (disasters) including flooding, drought, and even brush fires, often resulting in migration to cities for work. The intervention seeks to increase agricultural productivity to prevent long-term seasonal migration; this phenomenon is very disruptive to communities, as many children who accompany migrating parents end up leaving school and working on construction projects in large cities.

4 Toward a model of disaster project management

In this research, we first developed a preliminary model of disaster resilience based on the literature. Then we used our case study to examine the relevance of the constructs and relationships identified in the preliminary model, resulting in a case-based revised model (Fig. 1 and Tables 2, 3).

4.1 Model constructs

A number of project management variables are identified in the literature. In this study, we rely not only on the project management literature (e.g., Fox and Grösser 2015; Mojtahedi and Oo 2017; Pimchangthong and Boonjing 2017; Prasad et al. 2013) but also draw upon findings from the operations management, disaster management, and organizational behavior areas (e.g., Aughey et al. 2017; Coombs 2007; de Gooyert et al. 2017; Gupta et al. 2016) to develop our preliminary model. These variables are grouped within the following categories: external elements of disaster recovery, internal characteristics of disaster project management, community group processes, and disaster resilience.

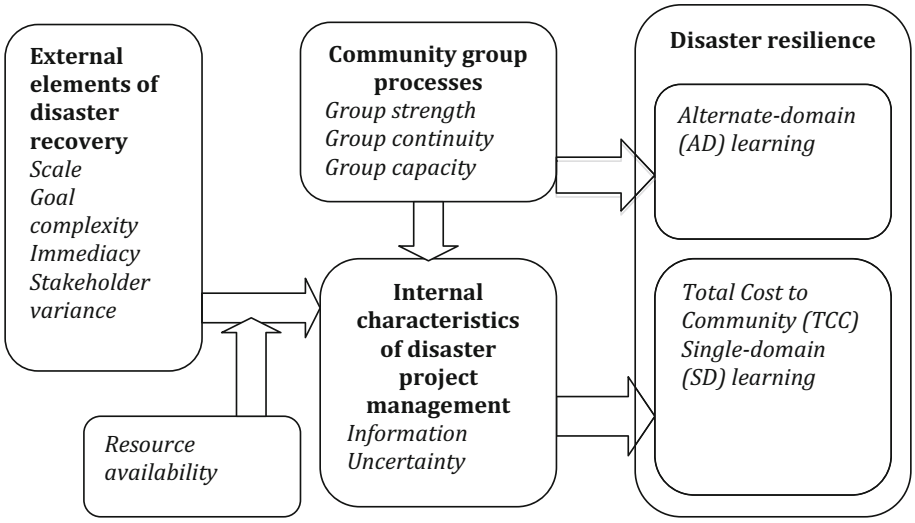


Fig. 1 Case based revised model

Several variables have been identified in the literature and grouped as external elements of disaster recovery: size or scale, goal clarity, resource availability, and stakeholder variance (Aughey et al. 2017; Chang et al. 2010; Pimchangthong and Boonjing 2017; Prasad et al. 2013). Internal characteristics of disaster project management include immediacy, information demands, and uncertainty (Fox and Grösser 2015; Kunz et al. 2014; Lei et al. 2015). The literature identifies a number of variables related to group processes, including group strength, group continuity, and group capacity (Day et al. 2012; Romig 1996). Finally, disaster resilience is defined by speed of recovery; net loss to individuals, families, enterprises or communities; level of recovery; and the degree of learning and development (see Fig. 1). The following sections describe the constructs of this model based on the literature, along with the case study findings (see Tables 2 and 3).

4.1.1 External elements of disaster recovery

Applying the concepts and frameworks developed in the project management literature (Aughey et al. 2017; Chang et al. 2010; Pimchangthong and Boonjing 2017; Prasad et al. 2013) to the disaster management process, we identify several external elements of disaster recovery: size or scale, goal clarity, resource availability and infrastructure, and stakeholder variance.

4.1.1.1. Scale

The scale of the disaster management project can be defined by the magnitude of the disaster, the number of people affected by the disaster, and the amount of property loss during the disaster (Pimchangthong and Boonjing 2017). The project management literature suggests that smaller projects may be easier to manage, whereas large projects may consist of numerous interrelated parts that must function together and may be dispersed around the globe (Prasad et al. 2013). In support of this, Le Masurier et al. (2006) explored case studies of disasters in New Zealand and found a difference in the process required for small-scale versus large-scale disasters.

Table 2 External elements of disaster recovery operations, resources, and group processes for disaster cases

Case	External elements of disaster recovery operations					Resources	Group processes
	Scale of disaster	Goal complexity	Immediacy	Stakeholder variance	Combined		
Fire burnt *godown*	Medium: fire burnt godown and all housing. Families moved to Noida sector 73	Medium: move to another locality. Prevent future fires with proper facilities for processing waste	High/medium	Low: variance between owner and IPCA. Medium: variance between sub-groups and owner	Medium	High: strong infrastructure within NCR. IPCA helped by providing $7500 in support	Low: families working for the owner are tight sub-groups, but owner is not part of the group processes
Eviction by authorities	Medium: eviction by authorities. Families moved to Indirapuram	Medium: move to another locality. Improve ability to move inventory. Continue low cost of operations	Medium	Medium: variance between families and IPCA	Medium	Medium: part of IPCA network but did not use them. Had approximately $1,500 in internal resources	Weak
Demonetization Noida sector 73	Low: demonetization of currency	Low: Change old currency to new currency	Medium	Low: variance between IPCA and families. High: variance between IPCA and government	Low/medium	High: *Godown* owner had bank accounts and income tax ID. Could handle all currency exchanges for pickers	Low: families working for the owner are tight sub-groups, but owner is not part of the group processes
Demonetization Indirapuram	Low: Demonetization of currency	Low: change old currency to new currency	Medium	Low: variance between moneylender and families	Low low/medium	Medium: families had approximately $1,500 in internal resources	Weak

Table 2 continued

Case	External elements of disaster recovery operations					Resources	Group processes
	Scale of disaster	Goal complexity	Immediacy	Stakeholder variance	Combined		
Demonetization and agriculture	Medium: interaction of demonetization and agriculture	High: create disaster resilient communities including improving yields, creating seed bank, and reducing migration	High medium	High/medium: variance between Hub 'n' Spoke and farmers	High/medium	Low: hub 'n' Spoke provided coordination, while government provided technical information on crop productivity but not on markets. Weak infrastructure. Few family resources	Weak
Demonetization—rural	Low: demonetization—rural	Low/medium: change old currency into new currency. Set up bank account if needed	Medium	Low: variance between Sodhana and SHG members. Low: variance between Sodhana and government	Low low/medium	High: Sodhana helped with the paper work. Put pressure on bank officials	High: SHG members
Cyclone—damage to crops and housing	Medium/high: cyclone—damage to crops and housing	Medium: obtain government insurance for crops and housing	Medium	Low: variance between Sodhana and SHG members. Low: variance between Sodhana and government	High/medium	High: Sodhana helped with the paper work and follow up to ensure officials approved the applications quickly	High: SHG members
Cyclone—potential school flooding	Medium/high: cyclone—potential school flooding in rickshaw colony	Medium: provide proper material to improve drainage around the school building	Low	Low: variance between Sodhana and families. Low: variance between Sodhana and government	Low/medium	Very high: able to tap government schemes. Rickshaw colony members provided partial funding	High: SHG members

Table 2 continued

Case	External elements of disaster recovery operations					Resources	Group processes
	Scale of disaster	Goal complexity	Immediacy	Stakeholder variance	Combined		
E. coli	High: a virulent form of *E. coli*—sickens an entire village	High: treat patients at the village and hospital. Obtain clean water supply	Very high	Medium: variance between Sodhana and village. Low: variance between Sodhana and government	High high/medium	Medium/high: resources from Sodhana and government health care system. Provided testing and repair of facilities, as well as hospitals, and physicians	Medium/low: although SHGs are present, village is politically divided
Social expectations	Medium: social expectations	Medium: daughters' marriages and celebrations for puberty	Low	Low: variance between Sodhana and families			High: SHG members provide low cost loans
Tuberculosis (DS TB cases)	High: Tuberculosis (DS TB cases)	High: Recover from TB. Increase income and decrease migration. Gain acceptance by the family and community	High	High: variance between families and government. Low: variance between Asha and government. Medium: variance between families and Asha	High high/medium	Very high: resources from Operation Asha and government health care network	Weak

Table 2 continued

Case	External elements of disaster recovery operations					Resources	Group processes
	Scale of disaster	Goal complexity	Immediacy	Stakeholder variance	Combined		
Multi Drug Resistant Tuberculosis (MDR TB)	Very high: multi drug resistant TB	High recover from TB. Increase income and decrease migration. Gain acceptance by the family and community, and endurance for the disease	Very high	High: variance between families and government. Low: variance between Asha and government. Medium: variance between families and Asha	Very high/high	Very high: resources from Operation Asha and government health care network	Weak

Table 3 Internal characteristics of disaster project management and resilience for disaster cases

Case	Internal characteristics		Resilience	
	Information demands	Uncertainty	Total cost to community (TCC)	Learning (single-domain [SD] or alternate-domain [AD])
Fire burnt *godown*	Medium/low: identification of where to move after the fire	Medium: difficulty in finding the right building with proper facilities and in the right location	Medium: loss of $52,000 by owner. Loss less than $150 by each sub family. Took 5–20 days to move	High-[SD]: type of structure to prevent future fires and avoid problems with neighbors within residential districts
Eviction by authorities	Medium: finding a good location to accommodate inventory. Low cost	Medium: not clear when the eviction will occur. Families debated whether they should move back to Bihar	Medium: cost $300 to move but needed to pay rent of $120/month. Took 2 weeks to move	Low
Demonetization Noida sector 73	Low: owner provided exchange of funds	Low: owner assured sub-groups of no disruptions	None: no loss and immediate access to new currency	Medium/low [SD]: value of being tied to formal banking system. Owner encouraged sub-groups to start accounts
Demonetization Indirapuram	Low: how much exchange loss to incur from moneylender	Low: locating moneylender and fixing exchange rate	Medium: use moneylender to exchange currency. Loss of 30% of value	Low
Demonetization and agriculture	Medium: price of crop in market	High: additional uncertainty due to the interaction of crop, market locations and lower prices	High: total loss due to the inability to sell in the market for a fair price. Unable to stop migration	High-[SD]: learning for agricultural productivity but not for marketing or dealing with demonetization
Demonetization—rural	Low/medium: account information. Proper identification	Low/medium: variance in documentation and requirements	Medium/low: no loss in exchange; just a delay. Loss in market price of some cash crops. Now recovered	High-[SD]: learning—ability to interact with the formal banking sector. Medium/low [AD]: enter into formal economy
Cyclone—damage to crops and housing	Medium: forms to fill. Documentation of damage	Medium: follow up with officials to make sure approval process is used. Uncertainty in each stage of the approval process	Medium: loss of approximately 20%. Able to rebuild farms and houses in shorter lead-time (1/2 time)	High-[SD]: follow through on future crop loss insurance documentation. High/medium-[AD]: able to help fellow villagers (non-SHG) members

Table 3 continued

Case	Internal characteristics		Resilience	
	Information demands	Uncertainty	Total cost to community (TCC)	Learning (single-domain [SD] or alternate-domain [AD])
Cyclone—potential school flooding	Low: with the preventative nature of the intervention there was no information or uncertainty to deal with when the disaster struck		None: no loss. Quality construction within specified timeline. All the children were able to attend school uninterrupted	High-[AD]: creation of community bathrooms
E. coli	Medium: treatment to take. Specific repair work to be identified. Identification of the disease	Medium: source of disease. Duration of illness	High: over 30% of the village severely sick with over 100 hospitalizations	Medium-[SD]: boiling water. Once the new water line was put in the villagers stopped boiling water. No preventative measures were being followed.
Social expectations	Low: SHG demand. Low documentation of members	Low: SHG members are aware of the financial resources available	Medium/low: able to repay loans and get out of debt in 3 years	Medium-[SD]: reduction in expenditure. High-[AD]: daughters going to college
Tuberculosis (DS TB cases)	Medium/high: DS TB Protocol and adherence to the treatment. Intense and frequent counseling during treatment and follow-up. Diagnosis	Medium/high: uncertainty of stopping the treatment in between. Where to get tested, where to take the treatment, and how long the treatment will run	Medium/low: low loss of income if patient recovers. An 87% of recovery rate for TB patients. Once recovered there is no transmission of disease to community. Individual productivity loss of $13,935 is reduced	High-[SD]: how to treat other family members afflicted by TB. For other diseases, families learn about the importance of adhering to the treatment
Multi Drug Resistant Tuberculosis (MDR TB)	High: MDR TB protocol and adherence to the treatment. Intense and frequent counseling during treatment, follow-up. Diagnosis	High: uncertainty of stopping the treatment in between. Where to get tested, where to take treatment, how long the treatment will run, side effects associated with treatment, when to stop medicines, where to go in case of side effects, etc.	Medium: multi Drug Resistant TB not only devastates families but can become uncontrollable in the community. Total cost to treat can be nine times that of DS TB cases	High-[SD]: how to treat other family members. afflicted by TB. For other diseases families learn about the importance of adhering to the treatment protocol

In our case study (Table 2), we found this construct to be relevant; it ranged from minimal impact in the case of demonetization of the pickers in Noida (sector 73) to very large impact in the case of family members infected with Multi-Drug Resistant Tuberculosis. Therefore, we keep this construct in our revised case-based model.

4.1.1.2. Goal clarity

Goals can help express and implement the meaning behind the vision of the disaster management project. The traditional project management literature suggests that the purpose of the goal-setting phase is to reach agreement on project objectives and set time schedules (Miller and Hobbs 2002). This, however, might not always be possible in disaster recovery projects in which planning tends to be more about communication and symbolism than about calculating.

An extensive body of research has described the connection between goal-setting and improved performance on a variety of tasks and projects (Aughey et al. 2017; Romig 1996). In our case, study we found that the diversity and range of goals were better constructs than goal clarity. For example, in the agricultural intervention, the goals were broad and included improved yield, banking with seeds, reduction in migration, and improved health of villagers. On the other hand, in the cases of re-monetization of currency (pickers and SHG members), the goals were very specific and narrow (Table 2). Thus, based on the case study, we redefine this construct as *goal complexity* in order to capture the diversity and range of goals.

4.1.1.3. Resources

Disaster project management can be influenced by the availability of resources (Chang et al. 2010; Zuo et al. 2009); that is, the accessibility of financial, physical, and human resources. Human resources (i.e., experience, training, and capacity of the affected micro-enterprise communities and other stakeholders) are especially important because individuals with prior experience in managing similar issues are more likely to have the competencies necessary for each phase of the disaster management project.

When disasters occur, the operational environment is complex and dynamic; thus, traditional ways of managing resources may not be effective (Söderlund 2004). Disaster management projects are likely to suffer from a shortage of resources, disruptions of supply chains, cost overruns, and profiteering (Chang et al. 2010; Zuo et al. 2009); these can have a negative effect on the community groups. Resource availability after disasters is likely to be influenced by market conditions as well as by the state of the transportation system, since high costs of transportation and lack of alternate modes of transport may contribute to resource scarcity.

In our case study (Table 2), we found that NGOs bring valuable infrastructure and resources to help individuals and communities. For example, Operation Asha not only provided personnel to ensure that patients were treated but also relied on an electronic portal to monitor and track the progress of patients. On the other hand, the Hub 'n' Spoke project had limited resources available to support the farmer. Furthermore, we found that individuals, families, and communities have internal resources (cash, access to credit, assets) that can be tapped in case of a disaster. Pickers' collectives and SHG members had more cash resources, while the farmer groups in the Hub 'n' Spoke intervention had very meager cash reserves. Finally, physical infrastructure provided by the government, ranging from roads to MDR TB clinics, can also be considered a valuable resource. Therefore, we keep this construct in our revised model.

4.1.1.4. Stakeholder variance

Stakeholders are defined as entities (individuals or groups) with varying degrees of responsibility and authority that are influenced by or can influence a project (Carroll and Buchholtz 2012; de Gooyert et al. 2017). Since human aspects and social relations are important elements of the project management process (Lundin and Söderholm 1995), the effectiveness of disaster management projects requires an understanding of the influence and expectations of stakeholders who are likely to have distinct interpretations of the situation.

Although the literature recognizes the relevance of stakeholders in disaster management, it is unclear about the specific role of these stakeholders in the process (Mojtahedi and Oo 2017). Therefore, it is important to understand the perspectives of multiple stakeholders such as the communities affected by the disasters, government officials, NGOs, and volunteer organizations (Crawford et al. 2013). This endeavor is made difficult by the complexity of the stakeholder environment; the perspectives of multiple stakeholders may be affected by cultural differences that result in conflict and misunderstanding and these differing perspectives could interfere with the disaster management process (Prasad et al. 2013).

In our case study (Table 2), we found that there were three primary stakeholders: individuals/families/communities, government entities and NGOs (Table 2). In certain cases, we observed minimal stakeholder variance as, for example, between the *godown* owners and the NGO (IPCA). In other cases, a relatively high degree of variance was found, as between family members and the government in the case of the treatment of MDR TB. Therefore, we keep this construct in our revised case-based model.

4.1.2 Internal characteristics of disaster project management

We apply project management frameworks (e.g., Prasad et al. 2013; Shenhar and Dvir 2004) to the disaster management context to identify internal characteristics of disaster project management: immediacy, information demands, and uncertainty.

4.1.2.1. Immediacy

Speed is essential to disaster management decisions (Lei et al. 2015). Shenhar and Dvir (2004) define pace as the urgency of the project and the strictness of its schedule; we use this to identify the characteristic of immediacy for disaster project management. Immediacy refers to the critical nature of time pressure involved in making disaster project management decisions (Coombs 2007). It influences the lead time available to make decisions.

In our case study (Table 2), we found that in the case of the *E. coli* infection, there was a very high degree of immediacy affecting the project management process. On the other hand, in the case of dowry and wedding expenditures, families have years to make decisions. As we examined the various cases, immediacy appeared to be an external element of disaster recovery that could potentially affect the internal characteristics of disaster project management. For example, in the case of MDR TB, the disease needs to be treated immediately to prevent death and further propagation within the community. Thus, we consider immediacy to be one of the external characteristics of a disaster, affecting information demands and uncertainty.

4.1.2.2. Information

Information can be thought of as the degree of shared understanding and knowledge available and required for a project to be successful (Prasad et al. 2013); it is the knowledge communicated or received concerning a disaster. A post-disaster scenario can be a chaotic and politically-charged environment in which information might be very complex and ambiguous, and normal information flows could be disrupted (Sagan 1993). Clarity of information (i.e., the extent to which the information can be easily understood), depth of information

(i.e., the extent to which the information is complete), and timeliness of information (i.e., the extent to which the information is current and received when needed), as well as the usefulness of the information and its communication, are vital to establishing a shared understanding between the stakeholders involved in the disaster management process (Fox and Grösser 2015). Understanding the challenges associated with disaster recovery and the factors that drive vulnerability to disasters can both be particularly useful in building disaster resilience (National Research Council 2012).

In managing disaster-related projects the information demands vary. For example, in our case study (Table 3), we found information demands to be minimal in the case of social expectations among SHG members, but very high in treating MDR TB, a condition that requires a great deal of information concerning strict adherence to protocols, intense and frequent counseling, diagnoses, and hospitalization to monitor for side effects.

4.1.2.3. Uncertainty

During disasters, the unpredictability of the situation is often exacerbated by political constraints, corruption, and unreliable sources of funding (Paul and Hariharan 2012; Thomas and Kopczak 2005). Uncertainty refers to the amount of ambiguity associated with the disaster project management situation; the larger the amount of ambiguity in a disaster situation, the higher the level of uncertainty (Coombs 2007).

Understanding and managing uncertainty is crucial to building disaster resilience. Managing uncertainty involves identifying dangers, assessing potential risks, and developing strategies to manage those uncertainties and risks (Kunz et al. 2014). Certain disasters are associated with a low degree of uncertainty, while others can generate a high degree of uncertainty. For example, in our case study (Table 3), there was minimal uncertainty among the rickshaw colony members concerning the potential for school flooding, given the preventive nature of the intervention. However, MDR TB was associated with a very high degree of uncertainty due to a combination of numerous factors: the likelihood of stopping treatment, length of treatment, side effects of drugs, timing of stopping medications, and availability of clinics and hospitals.

4.1.3 Community group processes

Scholars (e.g., Kenis et al. 2009; Lundin and Söderholm 1995) have suggested that social relations and human interaction can be crucial to project management; often, the real challenge in disaster management projects is understanding the specific nature of social relations, structures, and processes (Lucini 2013). One aspect of social relations that is applicable to our context is the role of community groups. Several characteristics of group processes are examined: group strength, group continuity, and group capacity.

4.1.3.1. Group strength

We define group strength as the level of shared experiences and participation, consistency in membership, intense interaction, and cohesiveness among group members. Group learning and change occur when members believe in the group and its ideology. The strength of a community group increases as members become more involved as givers and receivers of support and information.

Groups often create processes to enhance social support and coordination of project activities through techniques such as face-to-face meetings as well as telephone and video conferences. Intense face-to-face interaction occurs when group members see each other on a frequent basis; this increases strength, mutual support, and solidarity, resulting in a greater impact on members in terms of learning and change. Regular meetings of community groups

provide settings for members to learn from each other and obtain social support. Such structures help enhance close relationships among members at meetings, increasing commitment to each other and to the group entity.

4.1.3.2. Group continuity

Continuity refers to consistency in group membership, which enables the group to become cohesive and remain united in pursuit of goals and objectives. The longer the history of the group and the higher the level of continuity and trust, the more committed the group members are to the group. The project management literature suggests that trust is crucial to the success of a project (Day et al. 2012) and is especially important in a disaster environment characterized by uncertainty. Continuity of group membership can also result in shared language and vocabulary, that is, the means through which people exchange information. Shared language helps build relationships, and shared narratives result in shared culture. This allows groups to quickly exchange and interpret crucial information in times of disaster.

4.1.3.3. Group capacity

Community groups such as SHGs encourage social empowerment (equal status and participation in decision making), economic empowerment (access to resources and increase in income), and capacity building (increase in skills and knowledge) through processes that increase both human capital (skills) and social capital (micro-enterprise community networks) (TNCDW 2000). Group members, thus, tend to have a higher capacity to respond to disasters.

4.1.3.4. Group process characteristics

In our case study (Table 2), we found the degree of community group process characteristics (strength, continuity, and capacity) to vary. The most robust group processes were found in the SHGs supported by Sodhana Charitable Trust. There was a lack of significant group strength, continuity and capacity among the Hub 'n' Spoke operations and the patients of Operation Asha. In the village that was afflicted by *E. coli,* SHG members were functioning, but they were unable to overcome the political divisions at the village level, resulting in extremely low levels of group strength, continuity, and capacity.

4.1.4 Disaster resilience

Project success is often referred to as achieving planned performance under time and on budget (Prasad et al. 2013). Since our focus is on disaster resilience, we examine this construct based upon the following items: level of recovery, loss minimization, speed of recovery, and degree of learning and development.

4.1.4.1. Level of recovery

Level of recovery refers to the extent to which a micro-enterprise community can bounce back from a disaster (National Research Council 2012). Responses to disasters can be thought of as lying on a continuum. At one end of the continuum lie micro-enterprise communities that bounce back with enhanced capacities and are better able to deal with future shocks and stresses; at the other end lie communities that collapse with a drastic reduction in capacity to cope with future shocks to the system. In the middle of these two extremes are communities that return to their pre-disaster states, as well as those that recover but with reduced capacities.

4.1.4.2. Speed of recovery

Speed is an indicator of the time that it takes the micro-enterprise community to recover from a disaster (Coombs 2007); some communities have the ability to recover rapidly from shocks

and stresses, while others take a lot longer to do so. Scholars have suggested that speed of recovery is essential for business and community survival (National Research Council 2012).

4.1.4.3. Loss minimization

A key focus for disaster management is cost control. In disaster management situations, cost assessment can be done using either an *ex ante* (forecasting prior to the event) or *ex post* (estimation after the event) approach. Research on disaster management illustrates that cost assessments are often biased and incomplete (Meyer et al. 2013), with only direct and tangible costs considered in estimating the total loss. However, the costs of business disruption are also of significant concern (Rose 2004). Similarly, damage to ecosystems may be particularly costly if individuals and communities rely on the support of the ecosystem as a source of revenue; therefore, the range of potential disasters, lack of comparable and reliable data, and uncertainty in cost estimation are all cost calculation concerns (Meyer et al. 2013; Molinari et al. 2014).

4.1.4.4. Total cost to community

To capture the resilience capability of a community group, we need to develop an integrative measure of the level of recovery, speed of recovery, and loss minimization. This measure needs to be able to capture direct and indirect costs, business interruptions, intangible costs, and even risk mitigation costs (Balbi et al. 2015) in addition to taking time into consideration (Vugrin et al. 2011). Resilient communities have the ability to cushion the costs associated with the disaster, thus decreasing the total magnitude of the losses (Vugrin et al. 2011) and enabling individuals and groups to conserve and reuse resources (Rose and Liao 2005).

We adapt the *Total Cost of Ownership (TCO)* concept commonly utilized in the supply chain literature to the disaster management context and term it Total Cost to Community (TCC). TCC encapsulates direct costs, indirect costs, business losses, intangibles, risk mitigation costs, and conservation or reuse of resources over time and as the disaster propagates throughout the community. Within this construct are elements of delivery and quality of rebuilding or recovery.

In our case study (Table 3) we found all five broad cost categories including direct costs (buildings), business interruption costs (demonetization), indirect costs (loss of productivity due to TB), intangible costs (migration and disruptions in children's schooling), and risk mitigation costs (flood-proofing school building) (Meyer et al. 2013). We also found that disasters can propagate cost through the community over time as in the case of TB. For example, direct loss was indicated by a *godown* leader who stated: "I lost 33 lakhs (rupees) due to the fire. My worker families lost less than 10,000 rupees as their homes burnt down," and business interruption costs were noted by a farmer with Sodhana, who said: "there was a loss in market price of some cash crops due to the demonetization." Finally, we also noted elements of quality construction and lead time in improving drainage around the school building for the rickshaw community.

4.1.4.5. Degree of learning and development

Disasters present opportunities to learn, question, and reflect on events; learning and development can help reduce response and recovery costs in future disasters and increase resilience. The literature indicates that people learn from their experiences with specific disasters and obtain relevant information about how they can take collective action to protect themselves so as to be better prepared to cope with future disasters (Yamamura 2010; Anbarci et al. 2005). For example, Bahinipati and Patnaik (2015) examined the influence of disaster-specific and generic adaptation measures in reducing the damages resulting from cyclones and floods in India and discovered a learning effect. This learning helps a community increase its aware-

ness, skills and ability to confront future disasters in a collective approach (López-Marrero and Tschakert 2011).

In our case study (Table 3), two forms of learning were identified. The simpler form of learning is related to activities that help individuals, families, and communities cope with similar types of potential disasters in the future (single-domain learning). For example, in the treatment of TB, there is a requirement to follow strict protocols in terms of medications. Patients and families that have successfully treated TB are more likely to follow proper treatment protocols for other types of diseases. On the other hand, a more sophisticated form of learning (alternate-domain learning) occurs when an experience with a disaster leads to the individuals, families, and communities developing capacities in unrelated areas. For example, in the case of the rickshaw colony, the community, after ensuring that their children's school was protected from flooding, also went ahead and built community toilets in order to prevent future diseases.

4.2 Model relationships

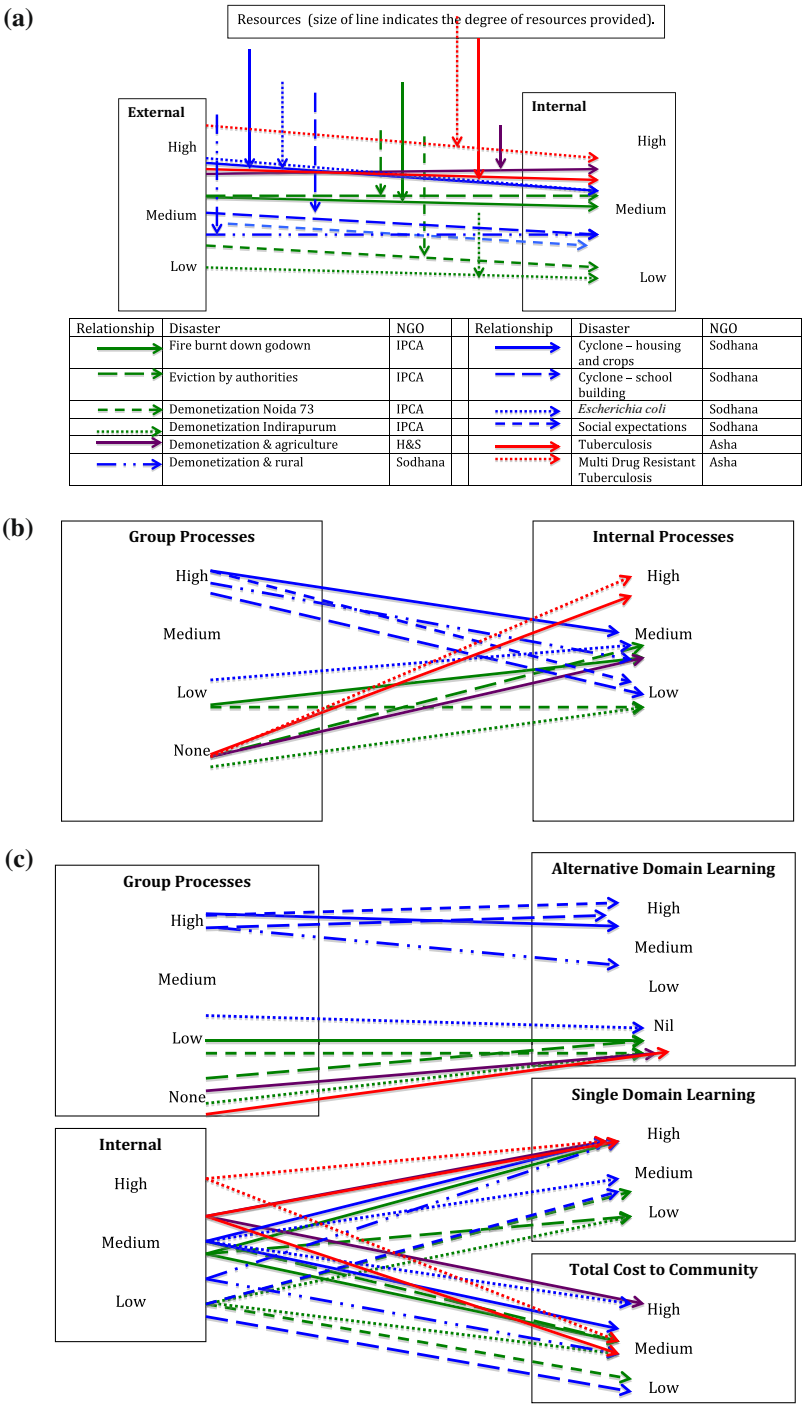
The previous section discussed the constructs of our proposed model of disaster project management. This section examines the relationships among those constructs. Based on the literature and our case study, we identify the influence of external elements of disaster recovery operations on internal characteristics of disaster project management. We describe the influence of internal characteristics on disaster resilience as well as the moderating influences of resources and community group processes. The following sections discuss these relationships and present propositions. We also graphically show these relationships in Fig. 2a–c.

4.2.1 The influence of external elements on internal characteristics of disaster project management

The ability of a micro-enterprise community to deal with stresses such as disasters depends on the scale or magnitude of the disaster, the degree to which the community will be affected by the disaster, and the immediacy of the disaster. The scale of the disaster can affect the degree of uncertainty as well as the quality of information that is available to stakeholders, with large-scale disasters more likely to result in uncertainty and lack of information compared to small-scale disasters (Le Masurier et al. 2006; Pimchangthong and Boonjing 2017). In addition, disaster management projects with simple goals are likely to have relatively lower levels of uncertainty and information demands, whereas those with more complex goals are likely to have higher levels of uncertainty and information demands (see Fig. 2a). Therefore, we posit that external elements of disaster recovery can influence internal characteristics of disaster project management.

This relationship between external elements of disaster recovery and internal disaster project management can be influenced by the availability of resources and the infrastructure. Availability of resources, especially human resources, can influence the extent to which accurate information is available in a timely manner, resulting in a higher level of shared understanding among stakeholders. External stakeholders have access to a range of information that can reduce the uncertainty prevalent in a disaster situation; relationships with such stakeholders can help access this information and knowledge and reduce uncertainty.

In our case study, when we examined how demonetization was handled by the picker community located in Noida sector 73, we found the disaster to be minimal in scale and goal complexity with a moderate level of immediacy. Furthermore, the available resources were large and the stakeholder variance was relatively minimal. These low levels of scale,



Relationship	Disaster	NGO	Relationship	Disaster	NGO
→	Fire burnt down godown	IPCA	→	Cyclone – housing and crops	Sodhana
- - →	Eviction by authorities	IPCA	- - →	Cyclone – school building	Sodhana
- - →	Demonetization Noida 73	IPCA	···→	*Escherichia coli*	Sodhana
···→	Demonetization Indirapurum	IPCA	- - →	Social expectations	Sodhana
→	Demonetization & agriculture	H&S	→	Tuberculosis	Asha
-·-→	Demonetization & rural	Sodhana	···→	Multi Drug Resistant Tuberculosis	Asha

Fig. 2 **a** Relationship between external and internal processes with moderation effect of resources. **b** Relationship between group processes and internal process. **c** Relationship between group processes and internal processes on learning and total cost to community

complexity, and stakeholder variance resulted in relatively minimal information demands and uncertainty faced by the pickers' community as it embarked on the project to exchange currency.

In contrast, the disaster faced by the farmers in the agricultural intervention was classified as being of moderate scale coupled with highly complex goals, moderately high immediacy, and large stakeholder variance (i.e., difference between the supporting NGO and the rural community). This resulted in a moderate degree of information demands and a high degree of uncertainty. Unfortunately, there were limited resources available to moderate this relationship.

On the other hand, in the treatment of MDR TB, the scale and complexity of the disaster was very large and was coupled with a very high degree of immediacy. The information demands and uncertainty were correspondingly extremely high for an unsupported family/group (no NGO resources and larger variance between family and government entities), and the networking with government entities indicated moderate levels of stakeholder variance. However, the significant resources provided by Operation Asha were able to reduce the information demands and uncertainty. Based on this case study analysis, we suggest that resources moderate the relationship between scale, complexity, immediacy, and stakeholder variance on the one hand, and information demands and uncertainty on the other (see Fig. 2a). Hence we proposed:

Proposition 1 *External elements of disaster recovery operations are likely to influence internal characteristics of disaster project management. Specifically, the scale or size of the disaster recovery, goal complexity, immediacy, and stakeholder variance are likely to be positively correlated with uncertainty and information demands.*

Proposition 2 *The relationship between external elements of disaster recovery and internal characteristics of disaster project management is likely to be moderated by the resources available. Specifically, lower levels of resources will exaggerate the relationship, and higher levels of resources will attenuate the relationship.*

4.2.2 The influence of internal characteristics of disaster project management on disaster resilience

Disaster resilience (i.e., the ability to prepare and plan for, absorb, recover from, and successfully adapt to adverse events (National Research Council 2012) can be influenced by the internal characteristics of disaster project management. The accessibility of information, along with its clarity, depth, timeliness, and usefulness, can play a major role in how quickly an entity recovers after a disaster; those factors can influence the extent of its recovery as well. Information can influence learning or the extent to which the micro-enterprise community has enhanced capacity after a disaster and is able to deal with future shocks to the system. Similarly, the availability of time to make disaster project management decisions can influence both how quickly an entity recovers after a disaster and the level of its recovery. When time is limited and uncertainty is high, the decision made might not be in the best long-term interests of the micro-enterprise community; in fact, it may result in processes that increase long-term vulnerability.

As community groups work through the process of managing a disaster project, they learn. Generally, this learning is along the lines of the type of disaster they are managing. In our case study (Table 3), patients successfully recovering from TB were not only able to ensure that their immediate group members were properly treated for TB, but they also learned the

importance of following proper treatment protocol to ensure resilience to other diseases in the future. We refer to this type of learning as single-domain (SD) learning. As in the case of TB, we found that, as communities navigated through a larger degree of information demands and uncertainty, the degree of learning was correspondingly greater. On the other hand, in the case of demonetization among pickers (sector 73 and Indirapuram), the information demands and uncertainty were quite minimal and, correspondingly, single-domain learning was minimal. Thus, we propose that the higher the information demands and uncertainty in the disaster management process, the greater is the single-domain learning for future resilience (see Fig. 2c).

In our case study (Table 3), we also found that information demands and uncertainty were related to the Total Cost to Community (TCC). In the case of demonetization experienced by picker groups in Noida (sector 73), there were minimal information demands and minimal uncertainty. Correspondingly, there was little or no loss. On the other hand, the demonetization disaster facing the farmer groups (agricultural intervention) had a high degree of uncertainty and a moderate level of information demands. This was correlated with an inability to sell the cash crop, and the community not only suffered a large financial loss, but there was a potential for other losses to the community, such as continued long-term migration and disruptions in schooling for farmers' children, to occur in the long term. Therefore we proposed:

Proposition 3 *Internal characteristics of disaster project management are likely to influence disaster resilience. Specifically, uncertainty and information demands are likely to be positively correlated with single-domain learning and with Total Cost to Community (TCC).*

4.2.3 The influence of community group processes on internal characteristics of disaster project management

The strength, continuity, and capacity of groups can increase the social networks and competence of the leaders and individuals affected by a disaster and play a significant role in obtaining information after a disaster and in reducing uncertainty. Stronger networks lead to better information gathering and more accurate understanding of issues and solutions. Thus, group strength, continuity, and capacity can influence the clarity, depth, timeliness, and usefulness of the information accessible; these characteristics can also reduce the uncertainty associated with disasters (Knowles et al. 2013).

In our case study (Table 3), we also found the role of community groups to be critical in the way they influence information demands and uncertainty. For example, after Cyclone Hudhud, individuals needed to apply to the government for compensation, a process that involved extensive documentation regarding damage to homes and crops; this was followed by a change of approval through the government's administrative system. Community group members were able to help each other in terms of answering questions about the documentation process (e.g., forms, officers to contact, etc.) and in ensuring that the correct documentation was provided in the proper format. This, in turn, reduced the information demands and uncertainty in managing the disaster process, suggesting that strong group processes are likely to result in a lower degree of information demands and uncertainty (see Fig. 2b). Thus we proposed:

Proposition 4 *Community group processes are likely to influence internal characteristics of disaster project management. Specifically, group strength, continuity, and capacity are likely to negatively influence uncertainty and information demands.*

4.2.4 The influence of community group processes on disaster resilience

The strength, continuity, and capacity of community groups can also influence how well its members cope with the consequences of a disaster and take advantage of opportunities. "Greater disaster resilience can be achieved through learning, innovating, and developing skills and resources at the individual, community and operational level that can be applied to responding to and recovering from a wide range of disasters" (cited in Crawford et al. 2013, p. 318). Community groups can thus be integral in disaster management decisions; their social networks can help micro-enterprise communities bounce back after disasters with an increased ability to deal with future shocks.

In our case study (Table 3) we found that group processes can affect learning directly, especially in terms of alternate-domain (AD) learning. Community groups have the unique ability to provide individuals, families, and communities with the ability to learn and develop capacities to mitigate for disasters in alternate domains beyond the form of disaster they experienced. For example, among the rickshaw community, SHG members were able to protect their children's school from flooding after Cyclone Hudhud and to ensure uninterrupted schooling. Furthermore, this capacity to work with the government, NGOs, and other stakeholders gave them the ability to execute the construction of community toilets. Also, among rural SHG members, we found that groups had the ability to help contain certain negative social expectations. Not only did these groups help with dowry/wedding expenses through low-interest-rate loans, they also helped families understand the value of a girl's education. Today, almost 30% of the families in these groups have sent their daughters to college. Education of women, in the long run, can result in a shift in social expectations; potential social, economic, and political transformation at the village level; and greater resilience at the community level.

In contrast, when community groups do not function effectively and have low levels of strength, continuity, and capacity, AD learning is less likely to occur. In the case of the *E. coli* disaster, the community was unable to bring learning to alternate domains. *E. coli* was the result of a water main leak that was subsequently repaired. Ideally, the village should have learned from the waterborne disease disaster and invested in maintaining their water systems by, for example, setting up a process to periodically clean the village's water tanks. Unfortunately, no effort has been made in this direction, partly because the community remains politically divided and the groups are unable to effect change (see Fig. 2c). Hence we proposed:

Proposition 5 *Community group processes are likely to influence disaster resilience. Specifically, group strength, continuity, and capacity are likely to be positively correlated with alternate-domain (AD) learning.*

5 Discussion

In this research, we examine how project management concepts and frameworks can be applied to the context of disaster resilience, and we explore the role of community groups in this context. Based on our literature review and case study, we developed a model of disaster resilience that connected project management to disasters. This model suggests that the external elements of disaster recovery (scale, goal complexity, immediacy, and stakeholder variance) influenced the internal characteristics of disaster project management (information demands and uncertainty); this relationship was moderated by resources available. The internal characteristics of disaster project management, in turn, influenced disaster resilience. The construct of disaster resilience includes two elements: the first is an encompassing measure

referred to as Total Cost to Community (TCC) that captures the interrelatedness of level of recovery (deliverables), speed of recovery (time), and loss minimization (cost) at a community level. The second element is learning (single-domain and alternate-domain) on the part of the community. Finally, we found that community groups can influence disaster resilience. Our model identifies a relationship between the level of group processes (group strength, group continuity, and group capacity) and learning; community groups influenced learning both directly and indirectly through internal characteristics of project management. Moderately effective groups were able to provide a degree of learning applicable to similar types of disasters (single-domain (SD) learning), while highly effective groups were able to add directly to community resilience for a range of disaster types through alternate-domain (AD) learning.

5.1 Impact in the field

We also discovered that the case study provided for a natural mechanism to influence the intervention at the field level. As the model was being developed, we communicated our findings to the NGOs involved to help them improve their processes. For example, in the case of Operation Asha, the significance of group processes was suggested for their next series of interventions, and the use of the TCC was highlighted as a better way to measure Operation Asha's deliverables. In the case of the picker communities, the focus was also on group processes; a discussion was held with recently evicted family members in Indirapuram about the value of creating small community groups with fellow pickers and building a common fund for the group through minimal monthly contributions by each member. A discussion was also held with the owner of the godown in Nodia 73 to help evolve the family sub-groups within the godown into more effective units.

In case studies, we look for surprises from the field data that can reveal new patterns and constructs for the model. We found that this case study was also able to surprise the intervention at the field level. For example, in the case of Sodhana Charitable Trust, we jointly examined why the village affected by *E. coli* showed limited learning in spite of the presence of community groups. The village was not taking any preventive initiatives to clean and maintain the water tanks in spite of the known risk of waterborne infections. Further investigation identified the political divisions within the village and the inability of groups to take proper hold in the management of village affairs. Based on these discussions, Sodhana Charitable Trust is now encouraging the community groups to take a larger role in the management of village affairs to ensure that learning occurs and that processes are developed to maintain clean drinking water systems.

5.2 Limitations

One of the limitations of this study lies in its geographic setting**.** All the cases were in India, hence the model is likely to be limited to the South Asian context. Further research is needed to examine the generalizability of the model by testing it in other developing countries and investigating the impact of culture, history, geography, and political structure on disaster resilience. Another limitation arises because the model has no specific time unit (e.g. weeks, months, or years) associated with it; future longitudinal studies are needed to examine the rate of recovery.

5.3 Theoretical implications and future research

Resilience depends on the ability of the members of a group, collective, or community to work together to increase their capacity to deal with future events (Gunderson 2010)

through learning (Scholten et al. 2014). One critical aspect of learning is the participation and involvement of the group or community (Aldrich 2012). Our model adds to the research on learning by identifying the importance of both single-domain and alternate-domain learning along with the factors that influence these constructs in the context of disaster resilience.

One possible future research endeavor would be to explore how individual learning and group learning differ in the context of managing projects, both in the traditional corporate sector and that of disaster management; single-domain and alternate-domain learning need to be examined in these two project management contexts at both group and individual levels. In our research group, processes appear to increase their effectiveness when they are operating at a high level; it would be interesting to explore this further and to develop a function that could capture this non-linear effect. Another intriguing area of future research would be to look at the Total Cost to Community (TCC) in depth. TCC is a new concept developed though our research. It would be interesting to investigate how measures from Total Cost of Ownership from a supply chain management perspective can be adapted to the disaster project management context. This line of study might be able to provide an interesting adaptation of cost measures from the supply chain field to project management, helping to create new sub-measures that better capture costs associated with disaster management.

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