Analyzing Post-Disaster Recovery Success Factors in Developing Countries Using Interpretive Structural Modeling Approach

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Abstract

There remains a significant gap in emergency management efforts and governance during natural disasters in developing countries, leading to preventable losses of life and damages to properties. Recent efforts to improve disaster responses and achieve long-term post-disaster recovery are threatened by increasing frequency of natural disasters and consistent failures in managing and planning responses. This study aims to: (1) investigate current state of emergency management practices using two case studies i.e., hurricanes in South Florida, United States and earthquakes in Kathmandu, Nepal; and (2) investigate the critical success factors that foster faster post-disaster recovery in developing countries, rank them, and develop an Interpretive Structural Modeling (ISM) framework. To achieve these objectives, the study conducted a systematic literature review (SLR) and questionnaire surveys to stakeholders who reside in disaster-prone communities both in the United States and Nepal. The study results indicated that bolstering critical transportation systems is the most influential factor that impacts other success factors during post-disaster recovery in developing countries. Moreover, the study results also indicated that a significant gap exists in awareness and proactive decision-making skills among many Nepalese residents due to the lack of emergency management training, policies, and leadership in emergency situations. The findings of this study contribute to two bodies of knowledge: firstly, the construction management through embracing systematic ISM framework that bridges the gaps in post-disaster recovery efforts in developing countries; and secondly, disaster risk management by demonstrating the strengths and weaknesses of emergency management practices in disaster-prone communities of developed and developing countries.

1. Introduction And Background

Natural disasters are defining moments for communities worldwide that cause more than physical damages with complex social and economic consequences. With the growing frequency and intensity of natural disasters, more people are being displaced from their homes each year, and this trend seems to continue to increase (Thomas and López 2015). Underprivileged communities in both developed and developing countries are the most vulnerable population during natural disasters since a significant number of people in these communities are immediately affected with prolonged suffering during recovery. For instance, during the Maharashtra earthquake in 1993, poor people suffered the most as they struggled to rebuild their houses while the wealthy households recovered rapidly (Lloyd-Jones 2006). Many of the poor people lived in slums that lacked inspectors to check building codes or build earthquake-resistant structures/shelters, which consequently led to the demise of tens of thousands of people during the earthquake and in the aftermath. According to Federal Emergency Management Agency, FEMA (2020), the emergency management cycle includes four recurring phases: mitigation, preparedness, response, and recovery. Based on this report, all disaster-prone communities are in at least one phase of emergency management at any time. However, past lessons from natural disasters have highlighted that underprivileged communities in developing countries are generally underprepared in all four stages because of the absence of government bodies like FEMA (i.e., guidelines, protocols, safety,

measures, availability of PPE, and necessary training) to reduce the damages and loss of lives (Duffield 2013). Therefore, this study investigated: (1) current state of emergency management practices using two case studies of disaster-prone areas in South Florida, United States and Kathmandu, Nepal; and (2) critical success factors that foster faster post-disaster recovery in developing countries. In the following section, lessons learned from hurricanes in the United States and earthquakes in Nepal are discussed in detail.

A. Current Hurricane Impact Scenarios in the United States

During the last decade, coastline cities in the United States have experienced population growth and have been exposed to costly and damaging natural disasters, including hurricanes (Preston 2012). According to the U.S. Census Bureau's 2016 population, the combined population of coastal counties increased by more than 10 million from 2000 to 2016, indicating that established strategies need to be updated to reduce causalities in future disasters on such growing populations (Neumann et al. 2015). The devastating hurricanes that hit the United States revealed that people and communities lack effective preparedness regarding social connectivity and making proactive decisions to survive during disasters (Dow and Cutter 2002). Although hurricanes are considered predictable and trackable with early warnings, there are increased anxiety levels among the community in preparation for disasters, including allocating critical supplies for survival (Stark and Taylor 2014). Sadri et al. (2017) highlighted that the household, neighborhood, and community-related factors significantly impact the rebuilding process and enhancement of resilience from disasters based on a study of a rural community in Indiana that was hit by a deadly tornado. Similarly, due to the lack of community preparedness and resilience during previous hurricanes such as Floyd, Katrina, Sandy, and Irma, there were chaotic as well as shadow evacuations that resulted in congestion and traffic problems which in turn threatened people's safety during hurricanes (Lindell et al. 2005). Learning to deal with such challenges before, during, and after a hurricane is vital regardless of whether people stay or evacuate, yet the society lacks an innovative community education module that improves the thinking capacity and bolsters effective decision-making during disasters (Shreve and Kelman 2014).

In 2020, 20 hurricanes and 11 tropical storms developed in the Atlantic ocean, making it the most active and threatening hurricane season on record. Yum (2021) highlighted that Hurricane Dorian, a category five hurricane, significantly impacted the Bahamas and generated spatial reactions and mobility across the eastern coast of the United States. Through analysis of Twitter data, the study indicated that peoples' response to the landfall of hurricanes significantly increased during hurricane week compared to those in the pre-hurricane week and post-hurricane week. The authors concluded that spatial reactions varied considerably among different states, especially in Florida, North Carolina, and New York. Moreover, the study highlighted that community resilience in highly vulnerable regions like Florida was different from those of New York due to experience from highly frequent tropical storms and hurricanes. Community resilience is a collective term that describes the resources and capabilities to survive a disaster (Mostafavi et al. 2018). It is highly dependent on household emergency preparedness, which incorporates various topics such as understanding the risks of catastrophe, developing and implementing

an emergency plan, and having the critical emergency supplies for 72 hours, among others (Levac et al. 2012). Although all vulnerable communities are expected to be adequately aware of these topics, Murti et al. (2014) highlighted that only 30-40% of residents in the United States are fully prepared with emergency plans and critical supplies. Communities with a robust social network and shared values have stronger community resilience during adversity (Sadri et al. 2018). ElZomor et al. (2016) conducted a case study in Phoenix to address the challenges of extreme weather conditions by developing a decision support tool, which also bolsters disaster preparedness and community resilience; their results highlighted the importance of preparedness in dealing with the crisis and emphasized emergency planning in a decentralized approach. However, to date, many disaster-prone communities lack innovative pedagogies that utilize decentralized strategies.

B. Lessons Learned from Devastating Earthquake in Nepal

The most recent earthquake shock of 7.8 magnitude earthquake occurred in Nepal on April 25th, 2015, destroying over 750,000 buildings and leaving millions homeless (Hall et al., 2017). Such destruction left a death toll of 8,500 and more than 18,500 persons critically injured, with approximately 6% suffering spinal cord injuries (SCI), 2% had amputations, 4% sustained traumatic brain injuries (TBI), and 70% with fractures (Goda et al. 2015). This event was deemed the worst disaster to strike the region in over 80 years, taking the lives of many and leaving a total economic loss of 10 billion U.S. dollars, equivalent to 50% of Nepal's gross domestic product (Subedi and Poudyal Chhetri 2016). Multiple aftershocks followed this major earthquake for weeks, further exacerbating the damage, with the biggest shock striking on May 12th, 2015. The destruction of road networks left multiple areas isolated, and consequently, many villages were without aid for weeks (Cutter et al. 2008). Additionally, the disaster created hazardous environments for survivors and volunteers, threatening their health and safety. Pradhananga et al. (2021) highlighted that besides the injured from the actual earthquake itself, many volunteers also suffered from health issues caused by traumatic situations and the constant risk of injuries by collapsing structures. The study also indicated that although the Nepal Engineers Association (NEA) instructed volunteers on Rapid Visual Assessments, helping volunteers identify and avoid unstable and damaged structures, many of these were still at constant risk from damages brought on by the random aftershocks.

For prompt restoration and reconstruction of the built environment, effective management of disaster waste is crucial. Many developed countries have established standard guidelines for disaster waste management (DWM) (Brown 2012). Furthermore, usually developed countries utilize advanced waste management technologies that manage disaster waste appropriately and rapidly. For instance, Japan, a developed country in North-East Asia, is one of the most vulnerable nations to natural disasters, including volcanic eruptions, earthquakes, and severe storms (Asari et al. 2013). The effective management of disaster waste utilizes a standard guideline developed by the Japan Society of Material Cycles and Waste Management (JSMCWM), which is efficient in disaster response. Similarly, in the United States, there are state-level guidelines such as Public Assistance Debris Management Guide developed by the Federal Emergency Management Agency (FEMA) and national level guidelines like Planning for Natural Disaster Debris formulated by U.S. Environmental Protection Agency (EPA), which encourage and implement

debris management plans post-disaster (Anneli Berghalm Soder 2018). On the other hand, developing countries rarely have effective DWM plans or standard guidelines, which provide strategies for separating, treating, and recycling disaster waste (Karunasena et al. 2009). The absence of an effective DWM plan and guidelines overwhelms the existing solid waste management facilities as well as negatively impacts humanitarian rescue operations, recovery, and the reconstruction phases (Memon 2016). Hence, this indicates that developing countries are in desperate need of applicable strategies and practical guidance to manage post-disaster debris better.

C. Critical Success Factors for Faster Post-Disaster Recovery in Developing Countries

Existing studies have revealed that there has been a significant focus on preparedness and recovery with less emphasis on factors that impact the success of post-disaster recovery in both developed and developing countries. Various critical success factors were identified from literature and after validating the factors from expert ratings eight factors are finalized. The following paragraphs explore different critical success factors that impacts faster post-disaster recovery measures that have been documented in the literature.

Transportation Network: The transportation network plays an essential role in emergency management. It should be maintained to an acceptable service level to prevent disruption of critical infrastructures in the aftermath of natural disasters. Several studies have been conducted to investigate ways of improving transportation resilience. Aydin et al. (2018) developed a tool to determine the necessary changes for the critical functionalities of road segments and effectively evaluated the resilience of the transportation based on a case study of the 2015 Nepal earthquake. Similarly, Nikoo et al. (2018) developed an emergency transportation network design to determine an optimal network that can perform recovery trips with high priority in the aftermath of seismic events. The authors conducted a network analysis to facilitate decision-makers to select an alternative measure and determine critical routes post-disaster. However, both studies evaluated transportation resilience only in terms of networks and redundancy. According to Tachaudomdach et al. (2018), there are ten principles of resilience that need to be used for measuring transportation resilience which include: redundancy, cost-effectiveness, safe-to-fail, robustness, absorbing externally induced changes, change-readiness, leadership and culture, networks, preparedness, rapid recovery, and robustness. Therefore, to further improve emergency management post-disaster, research needs to be conducted to assess the contingency plans for transportation management and resilience of transportation systems.

Community Centered Disaster Education and Training: Disaster education is also an essential community-based pedagogical approach to building resilience conveyed to the community through traditional channels like public notices and federal/governmental websites. Simultaneously, modern technology platforms such as social media, radio, and news are used to communicate instructions (Feng et al. 2018). Authorities deem it vital to provide information about the anticipated risk pre-disasters, highway traffic, ways to prepare for imminent disasters, etc. (Jhon H. Sims 1983). In many recent disasters, the information about one's condition and location, as well as learning about a disaster-

affected individual' has been possible through the use of social media platforms such as Facebook and Twitter (Houston et al. 2015). These informal education platforms are also advantageous in providing rapid instructions, including disaster preparedness information, disaster warning, response, recovery, rebuilding, and mental and behavioral support (Wendling and Radisch 2013). Additionally, social media platforms are being used to document the severity of disasters while learning about their impacts and preparedness measures (Velev and Zlateva 2015).

Communication Resilience: Communication resilience needs to be a crucial part of crisis management and decision-making during natural disasters. Crisis communication plays a critical role in reducing uncertainty, responding to and resolving emergencies effectively, and disseminating specific harm-reducing information to victims of natural disasters (Firdhous and Karuratane 2018). Due to the increasing frequency and complexity of natural disasters, crisis communication has become challenging (Palttala et al. 2012). Strategies need to be developed to improve communication between stakeholder groups in various types and phases of a natural disaster to address this gap. Ahmed et al. (2020) highlighted that communication patterns or topics for the construction industry varied significantly in a Twitter dataset analysis of Hurricane Michael. The authors indicated that construction stakeholders need to systematically make better and timely decisions during future natural disasters to facilitate effective response and recovery in major natural disasters. Additionally, Hyvärinen and Vos (2015) indicated that crisis communication should not be limited to response networks such as authorities, construction stakeholders, and non-governmental organizations and facilitate collaboration with community engagement.

Pre-Disaster Planning and Understanding Disaster Risks: Embracing preparedness measures remain fundamental to reduce physical and psychological stresses when addressing natural disasters. Prior to any disaster, there is a pressing need to ensure that disaster-prone communities are educated about the recommended preparedness measures and guidelines. Disaster management agencies traditionally share preparedness guidelines through formal educational channels (such as academic institutions, articles, and the Federal Emergency Management Agency, etc.); however, such formal modalities in vulnerable communities are challenged by poor inclusive accessibility, lack of receptiveness, and responsiveness from such communities. With the increasing frequency and severity of natural disasters worldwide, disaster education, including preparedness knowledge, is one of the most effective approaches to preparing disaster-prone communities and their people (Preston 2012). For instance, before a hurricane, residents who feel unsafe in their homes tend to evacuate, while those who feel safe tend to stay (Sadri et al. 2014). It is clear that due to a lack of efficiency in disaster education and practices, people are unable to accurately decide on their rational and required resources, especially when making evacuation decisions (Huang et al. 2016). It also explains why some people feel safe while others are unsafe despite living in the same community and sharing similar demographics (Thiede and Brown 2013). Another major problem during a disaster is that required disaster supplies such as water, non-perishable food, gas, special items for babies and the elderly, and toiletries/hygiene items become out of stock due to the sudden increase in demands (Wolshon et al. 2005). Consequently, people with limited supplies generally suffer the most in the aftermath. Similarly, there have been shortcomings in providing supplies and

support to nursing homes due to a lack of pre-disaster planning and disaster preparedness. Such shortcomings were observed in 13 nursing homes during hurricane Katrina when 70 home residents died (Robert et al. 2007). Some communities lack the readiness to make educated decisions prior to a disaster; therefore, educating the community with fundamental disaster knowledge is deemed necessary, especially in disaster-prone communities (Richard Eiser et al. 2012).

Administrative Efficiency: Emergency management is also highly dependent on the engagement and coordination of governments, private and voluntary agencies to respond to the urgency caused by natural disasters. As such, administrative efficiency guided by supportive laws and regulations plays a vital role in influencing positive outcomes in the aftermath of a disaster. Moe and Pathranarakul (2006) highlighted 34 different laws for various organizations in Thailand, but such variation created confusion among organizations during their enforcement and a line of authority during the tsunami disaster in 2004. The authors indicated that administrative efficiency could be enhanced by adopting proactive and reactive approaches that focus on developing supportive laws during pre-disaster planning, i.e., proactive stage, and implementing the plans and regulations during the response or recovery phase, i.e., reactive stage. Furthermore, government departments and agencies must plan, organize, and mobilize resources efficiently when there is an onset of disaster.

Funding and Resources Availability: To this end, obtaining appropriate funding and resources for reconstruction is a primary issue for many underprivileged communities worldwide. The post-disaster site conditions are very chaotic. There is a severe scarcity of resources and funding due to simultaneous reconstruction projects being initiated by numerous local, private, governmental, and international organizations (Chang et al. 2011). Reconstruction should maximize the use of locally sourced materials, mainly recycling the debris of the disaster to ensure that what is built is better than what it replaces. Although several studies have identified the utilization of local materials as a potential solution, many underprivileged communities are unable to utilize the resources due to dependence on local government and lack of technical knowledge (Winchester 2000). Pre-event planning for resource availability for efficient response post-disaster doesn't necessarily indicate finding significant housing reconstruction resources (Chang et al. 2010). Therefore, more robust construction strategies need to be explored to limit the cost of resource provision and increase accessibility to available resources, meeting a variety of local conditions.

Safety Equipment Availability: Some of the international organizations such as United Nations Office for Disaster Risk Reduction and Red Cross Society, among others have been playing significant role in training and engaging volunteers during post-disaster recovery. However, due to absence of government bodies like Federal Emergency Management Agency (FEMA) in North America, there remains a lack of resources such as disaster recovery guidelines and availability of personal protective equipment to ensure community workers’ health and safety post-disaster. Pradhananga et al. (2021) highlighted that there are still health and safety challenges in developing countries during post-disaster recovery. It was observed that disaster workforces and community volunteers lack knowledge about disaster

preparedness in the aftermath of the Nepal earthquake indicating that disaster education is indispensable mainly for disaster-prone communities.

Temporary Disaster Waste Storage Site: Improper management and disposal of disaster waste is a critical issue in developing countries due to the lack of innovative strategies and the feasibility of implementing them (Poudel et al. 2019). Consequently, the disposal of different types of disaster waste, which often contains hazardous waste, is conducted in any available open space in disaster-affected areas without consideration of its impact on the environment, as well as survivors' health and wellbeing (Pradhananga et al. 2021). For instance, developing countries affected by disasters face a massive challenge in DWM due to lack of permanent landfill sites and lack of availability of temporary waste storage sites, thereby, leading to the disposal of disaster waste near rivers or in recreational parks (Ranjitkar and Upadhyay 2015). Hazardous disaster waste must undergo treatment before disposal in any landfill, and it is critical to treat these wastes when disposed near rivers. The treatment of solid disaster waste is significant as decomposition and putrefaction may occur, causing land and water pollution when the waste products percolate down into the underground water resources (Hall et al. 2017). Additionally, when these wastes are not collected and are allowed to accumulate, they may create unsanitary conditions leading to epidemic outbreaks (Wendelbo et al. 2016). Many diseases like cholera, plague, dysentery, diarrhea, jaundice, or gastrointestinal diseases may spread and cause further loss of human lives (Karunasena et al. 2009).

2. Methodology

During natural disasters, public engagement in risk mitigation is highly dependent on proper guidance and a decision-making framework that would foster enhanced emergency management practices. Thus, the study aims to investigate current state of emergency management practices using two case studies: (a) hurricanes in South Florida, United States; and (b) earthquakes in Kathmandu, Nepal. The study utilizes the following three-step research methodology to attain the proposed goals: (1) conduct a systematic literature review (SLR) to identify the critical success factors for faster post-disaster recovery in developed and developing countries; (2) conduct a questionnaire survey to collect data from professionals in earthquake-prone areas of Nepal and use ISM technique to develop a critical framework for ensuring faster post-disaster recovery; and (3) conduct questionnaire survey in a frequent hurricane-prone area in South Florida, to identify the awareness of emergency management strategies among the residents. Hence, this study has two main guiding questions: (1) What are the critical success factors that foster faster post-disaster recovery in different natural disasters and their corresponding ranking in the Interpretive Structural Modeling framework; and (2) How aware are residents of varying emergency management strategies in disaster-prone communities?

A. Systematic Literature Review for Identification of Factors

The authors identified and assembled the critical success factors that impact the successful implementation of emergency management measures in developing countries through a qualitative

method such as a systematic literature review (SLR). SLR is a widely used method to identify, evaluate and interpret all available research relevant to a particular objective (Casino et al. 2019; Subedi and Pradhananga 2021). The SLR method involves a structured review of literature through defining keywords, searching relevant literature, and identification of research gaps that, when addressed, strengthens the field of interest (Kamble et al. 2018). The SLR method includes three different levels of processing: identification, screening, and survey design. During the identification phase, the authors utilized google scholar to search the relevant literature using the keywords as shown in Figure 1. Then, after downloading a maximum number of research articles, any duplicate articles were eliminated. Furthermore, only those research articles were manually reviewed that fit the screening parameters, as shown in Figure 1. Finally, survey questions were developed based on the identified critical success factors to identify the contextual relationship between the factors impacting the successful implementation of emergency management measures.

B. Data Collection in Nepal

The questionnaire survey was conducted for three months using Qualtrics, Provo, Utah, an online tool for developing and collecting survey responses. Surveys in Nepal were distributed using Facebook, a social media platform, in which private and governmental organizations operate their official forums and where approximately 1200 professionals are active in research activities. Based on the obtained data, those professionals worked in major organizations (such as Nepal's Engineering Association (NEA), Department of Urban Development and Building Construction (DUDBC), National Society for Earthquake Technology (NSET), Nepal Reconstruction Authority (NRA), and Solid Waste Management Technical support Centre (SWMTSC)). They also had hands-on experience in emergency management activities in the Nepal earthquake. The survey questions included multiple choice and Likert scale questions. The multiple-choice questions in the survey included socio-demographic information such as expertise in the construction industry, years of experience, acquired trainings, and education. On the other hand, to determine the contextual relationship between the factors impacting the successful implementation of emergency management measures, the authors utilized a Likert scale from 1 (i.e., low impact) to 5 (i.e., high impact). Overall, 117 Nepalese professionals responded to the survey.

C. Data Collection in the United States

In the United States, 126 participants responded to the survey at the beginning of the spring 2020 semester. Based on the survey data, all the United States participants are students who enrolled in the Hazard Mitigation course at Minority-Serving Institution. These participants also have been living in South Florida for several years and have experienced at least one hurricane, thus demonstrating that the results obtained are relevant and aligned with the study's goals. Thus, multiple-choice questions in the survey recorded students' awareness about emergency management and the strategies they prioritized during the threat of Hurricane Dorian. Additionally, the survey also collected socio-demographic information such as gender, race, ethnicity, type of home people resided, academic background, and their annual income, among others. Hurricane Dorian was an extremely powerful category 5 Atlantic Hurricane

tied for the strongest landfall in the Atlantic basin in September 2019. Although Hurricane Dorian didn't make landfall in South Florida, the threat of Hurricane made significant impacts on the livelihood of South Floridian residents, and the survey recorded relevant data about emergency management.

D. Survey Sample Justification

For the determination of representative sample size for both surveys, equations (1) and (2) were used (Israel 1992). The confidence interval is assumed to be 95% for this study; thus, the area under the curve (z) is obtained as 1.96. Similarly, sample error (e) of ±10% was selected for the study, and the value of p was chosen as 0.5. Therefore, based on the table for sample size calculation, the value for the adjusted representative sample size was found to be 100.

$$\eta_0 = \frac{z^2 * p * (1-P)}{e^2} \quad (1)$$

Finite population correction

$$\eta = \frac{(\eta_0 * \text{Population})}{\eta_0 + \text{Population} - 1} \quad (2)$$

Where, η_0 = initial number of required observations; z = area under the normal curve based on level of confidence; p= response variability; e= sample error; η = adjusted true sample size

E. Interpretive Structural Modeling (ISM) Analysis

The interpretive structural modeling (ISM) technique is an interactive learning process in which a group of different directly and indirectly related items is structured into a comprehensive model. This technique is interpretive in nature since the decision about interdependencies among the variables is based on the judgment of experts in the specific field. The ISM technique has been used successfully in different fields such as green supply chain management, six sigma, productivity improvement, among others (Yadav and Barve 2015). The primary goal of using ISM in this study is to analyze the intricate issues in post-disaster recovery of developing countries by utilizing systematic and logical thinking supported by experts' judgments as shown in Figure 2. Moreover, ISM analysis is the best fit analysis for this research because it requires a smaller number of experts in comparison to other methods such as structural equation modeling (SEM) and the Delphi technique. Therefore, the study conducted ISM analysis partially based on procedures in Tseng et al. (2011), Yadav and Barve (2015), Trivedi et al. (2015), and Cai and Wei (2020).

The interpretive structural modeling (ISM) technique is used in this study to identify the contextual relationship between the factors impacting the successful implementation of emergency management measures. These factors are utilized to develop a structural self-interaction matrix and a reachability matrix. Based on these matrices, reachability and antecedent sets are prepared, and an intersection set with a common variable between them is identified. Then, subsets that consist of only a common variable between reachability set and intersection set are separated in different levels through a process called partitioning until a single variable is obtained at the end. Afterward, the MICMAC analysis will be

used to develop a conical matrix to find the driving power and dependency of the identified factors. Finally, an ISM model is developed based on the partition levels and MICMAC analysis.

3. Results And Analysis

This section analyzes the obtained survey data related to: (1) identification of current state of emergency management practices in a developed country i.e., U. S. and a developing country i.e., Nepal; and (2) validation and ranking of critical success factors for faster post-disaster recovery using ISM analysis.

A. Case Study of Emergency Management Practice in the United States

Natural disasters have become an important restricting factor for economic and social development in both developed and developing countries. Since disaster events do not limit to national borders, it is important to have a mutual understanding of emergency management systems in different countries such that joint disaster response can be more effective during emergencies. The survey conducted in South Florida collected socio-demographic information, housing information, and location information, including annual income, marital status, educational background, house members, home type, homeownership, among others. In this study, eight respondents had an annual income of $10,000 or less, seven had $10,000- $20,000, 12 had $20,001-$30,000, 20 had $30,001-$50,000, 18 had $50,001-$80,000, 17 had over $80,000 and 31 preferred not to answer as shown in Figure 3. The obtained results indicate that a low proportion of individuals have low income, most of the individuals have moderate-income, and some have high income based on per capita income categories of South Florida (Lin et al. 2019). Moreover, as shown in Figure 4, the marital status of the respondents was also recorded, and a significant number of respondents, 93, were single while only ten were married, one divorced, one widowed, four living in cohabitation, and two preferred not to answer. Lastly, among the recorded responses, 28 have completed high school, 62 Undergraduates, 20 graduate, and two others.

Out of 126 participants, 109 reported prioritizing disaster preparedness and mitigation measures. Moreover, 67 participants indicated relying on Federal Emergency Management Administration (FEMA) guidelines and notices for emergency management. While 18 participants used Red Cross Society and 41 were unaware of any sources. Based on the literature review of standard guidelines used in different developed countries such as FEMA in the United States, Emergency Management Australia (EMA), and Public Safety Canada, among others, the authors identified 13 major emergency management measures. Figure 4 shows box plots representing the identified emergency management measures where the respondents' ratings are represented by a five-point scale with one indicating not important and five indicating very important. The obtained results show that the understanding of natural disaster risk, knowing your area, and post-disaster health and safety have the highest Likert scale rating of 5. Whereas property risk assessment has a Likert scale rating of 4.5, and the rest of the topics have a rating of 4. Although there are some outliers, the higher ratings in the box plots indicate that many people prioritize emergency management measures in hurricane-prone areas to reduce the impact of potential hurricanes in the region.

B. Case Study of Emergency Management Practice in Nepal

Developing countries are more vulnerable to natural disasters due to notable lower capacity to preparedness (e.g., lack of resources to reinforce buildings and infrastructures, absence of health and safety education/training, lack of early warning system) and response (e.g., inability to manage disaster waste effectively, delays in reconstruction, social inequity in recovery activities). Moreover, many developing countries worldwide lack a standard guideline that provides comprehensive information about emergency management measures (Sharma et al. 2018). Consequently, many local volunteers in developing countries who participate in the reconstruction phases are unaware of safety practices and resilient construction processes. The survey results from Nepal indicated that many participants have 1-5 years of experience in the construction industry, with most of them being younger (i.e., 18-29 years old), as shown in Figure 5. In the aftermath of a disaster, 49% of respondents engaged in reconstruction activities, 7% in disaster waste management and 44% in rapid visual assessment, respectively.

Emergency management practices in Nepal have several weaknesses and a few strengths that directly impacted people's health and well-being and the environment. The major strength of recovery practices in Nepal is community participation in managing disaster waste and reconnaissance of partially damaged buildings. However, the major weaknesses such as lack of training and education on emergency management and occupational health and safety concerns significantly impact community resilience in disaster-prone communities (Pradhananga et al. 2021). Additionally, due to delay in formation of National Reconstruction Authority (NRA) and its activities, there was delay in reconstruction activities obligating many underprivileged communities to live in temporary shelters (Lohani et al. 2017). To understand and validate the critical success factors that fosters faster post-disaster recovery, professionals who had hands-on experience of emergency management rated the identified factors in an online survey on a scale of 1 (i.e., No impact) to 5 (i.e., high impact). Moreover, the validation of critical success factors from expert judgement indicated that all the factors have a median rating of 4 and these factors play a critical role to accelerate reconstruction activities and recovery process.

Based on survey results from Nepal, 78% of the professionals in Nepal had not received any training on emergency management, demonstrating that many professionals were unprepared for the seismic event of 2015, as shown in figure 6. Education and training in a disaster-prone community is a collective way to encourage the development of community resilience, improve their preparedness and ability to respond to natural disasters. Hence, it is evident from the survey results that many professionals in developing countries still require trainings and fundamental emergency management education, which would eventually build more resilient communities. Located along the active Main Himalayan Thrust arc, where the subducting Indian plate and the overriding Eurasian plate interact, Nepal, a developing country in South Asia, is prone to massive earthquakes periodically (Goda et al. 2015). This region accommodates nearly half of the tectonic convergence between the two plates, i.e., about 20 mm/year (Ader et al. 2012). Although significant earthquakes tend to hit this developing country every 400 to 600 years, medium-sized earthquakes occur with a periodicity of 70-80 years (Avouac et al. 2015). During the recent major earthquake, new investigations from Nature Geoscience and Science state that it did not release all the

stress. However, some of this stress shifted to western Nepal, where the last earthquake occurred in 1505 A. D. (Avouac et al. 2015). This indicates that Nepal is still notably vulnerable to a significant earthquake in the near future. Therefore, this is a timely research given that it provides an important emergency management contribution, which identifies gaps and weaknesses in emergency management practices particularly in developing countries and thus develops a systematic framework for stable and long-term post-disaster recovery in developing countries.

C. Interpretive Structural Modelling Framework for Faster Post-Disaster Recovery in Developing Countries

This section presents an ordered, directional framework for factors that fosters faster post-disaster recovery in developing countries through the development of Interpretive Structural Modelling (ISM). *To form this ISM model, the survey in Nepal was conducted to validate the contextual relationship between the critical success factors*. The ISM model has been developed as shown in the steps below:

1. Establishing the contextual relationship between the identified factors:

During Phase 1, the authors utilized a systematic literature review (SLR) to identify the critical success factors from various existing research articles. Based on SLR, the authors identified several factors: Developing supportive laws and regulations for administrative efficiency (Rosenthal and Kouzmin 1997; Moe and Pathranarakul 2006; Sarker et al. 2020), Improving communication resilience (Jordan et al. 2011; Palttala et al. 2012; Firdhous and Karuratane 2018; Liu 2020), Bolstering critical transportation systems, networks, and routes (Zhang et al. 2017; Liao et al. 2018; Aydin et al. 2018; Nikoo et al. 2018), Community-centered disaster training and education (Jhon H. Sims 1983; Mishra and Suar 2012; Feng et al. 2018), Ensuring adequate funding and resources availability (Smith 2011; Seville et al. 2011; Chang et al. 2011; He 2019), Ensuring adequate availability of temporary disaster waste storage sites (Cheng and Thompson 2016; Brown and Milke 2016; Tabata et al. 2017; Amato et al. 2019), Ensuring adequate Personal Protective Equipment/Safety equipment availability (Perce 2007; Uddin et al. 2019; Pradhananga et al. 2021), and Developing pre-disaster plans and understanding natural disaster risks (Wolshon et al. 2005; Preston 2012; Huang et al. 2016). In Phase 2, an online Qualtrics questionnaire was used to validate these factors, by surveying more than 100 local disaster professionals.

2. Development of Structural Self-Interaction Matrix:

After identifying the contextual relationship between the factors, a structural self-interaction matrix is developed based on expert ratings, as shown in Table 1, indicating a pair-wise relationship between the factors. For this matrix, the following references are utilized to describe the direction of the relationship between the variables (i and j):

V = Variable i will lead to variable j

A = Variable j will lead to variable i

X = Variable i and j will lead to each other

O = Variable i and j are unrelated

3. Development of Reachability Matrix:

A reachability matrix is developed using the structural self-interaction matrix, as shown in Table 3, which facilitates checking for transitivity. The variables V, A, X, O are then replaced with the binary values 1 and 0, using the rules in Table 2.

4. Partitioning the Reachability Matrix:

Once the reachability matrix is developed, reachability and antecedent sets are formed for each identified factor. The reachability set entails all the factors driven by the variable represented by horizontal rows. While the antecedent set is represented by vertical columns and consists of all the factors that drive the variable. Then, common elements between the two sets are identified to form an intersection set. If all the elements in the reachability set is common in the antecedent set, the factor becomes the top-level factor in this interpretive structural modeling hierarchy. Such top-level factors are disassociated from other factors, and the partitioning process is repeated until all the levels are obtained. All the iterations involved to place the factors into different levels of partitioning were conducted and the final results are as shown Table 4.

5. MICMAC (Matrice d'Impacts Croisés Multiplication apliquée á un Classement - Cross impact matrix multiplication applied to classification) Analysis:

The driving power and dependency of the factors are identified in the conical matrix, as shown in Table 5, and analyzed using a MICMAC analysis, which is then plotted in Figure 7. This analysis states that if an element X affects element Y, which in turn directly influences element Z, then any change affecting X may have repercussions on Z. Based on the obtained driving power and dependency, the factors are divided into four categories.

I. Autonomous Factors: Those factors that have weak driving power and low dependency fall into the autonomous category. In this MICMAC analysis, there are no autonomous factors.

II. Dependent Factors: This category includes those factors, which have a high dependency and weak driving power. In this study, T.W.S. and S.E. are dependent factors.

III. Linkage Factors: Those factors, which have strong driving power and high dependency, fall in this category. In this study, A.E., and P.D.P. are linkage factors.

IV. Driver Factors: This category includes those, which have strong driving power and low dependency. In this study, T.E., C, T.N. and F.A. are driver factors.

6. Development of ISM Model:

For the development of an interpretative structure model, the top-level factors are placed at the bottom of the flowchart, with the second-highest factor above, and so on until the last factor is placed at the top of the flowchart, as shown in Figure 8. Therefore, there are six different levels in the framework that are arranged based on the level of partitioning in step 4. Based on the ISM analysis, the primary factor is bolstering critical transportation systems, networks, and routes (TN), followed by improving communication resilience (C).

4. Discussion

The successful implementation of efficient emergency management measures in disaster-prone communities is highly dependent on social, human, political, and economic capital. The greater the capabilities of communities to develop, acquire, or exchange these resources, the more likely communities are to be resilient during and post natural disaster events. However, many developing countries face several social, political, and economic challenges that increases vulnerability in disaster-prone communities and makes it arduous to bridge gaps in emergency management practices in natural disasters (Miller and Rivera 2011). For instance, after the Nepal earthquake, the necessity of National Reconstruction Authority (NRA) was realized after three months of earthquake in 2015. But due to legal hurdles, it was officially established only after eight months (Lohani et al. 2017). Furthermore, there were delays in its reconstruction activities due to which many underprivileged communities were obligated to live in temporary shelters for more than three years (Pradhananga et al. 2020). Therefore, this study identified eight critical success factors that foster faster post-disaster recovery in a disaster-prone community and developed an ISM framework that improves the capabilities of communities to accumulate the resources effectively and recover faster. Based on the ISM framework, it is evident that the most vital factor is bolstering critical transportation systems, networks, and routes. This is particularly accurate given that during the 2015 Nepal earthquake, landslides damaged the existing transportation networks and left multiple jurisdictions isolated, thereby impeding not only the mobilization of resources needed for reconstruction, but also the transfer of disaster waste (Memon 2016). Consequently, the absence of adequate transportation networks that can relocate and reuse disaster waste, negatively impacted both the environment by increasing pollution as well as the peoples' well-being through increasing health risks. Additionally, the damaged transportation networks can cease access to volunteers and international aid as well as limit the evacuation of people from disaster-prone communities.

Once a community ensures resilient infrastructure system like transportation, the next critical step is to establish an effective communication network between stakeholders, improve administrative efficiency and properly manage funding. With efficiency in administration and access to resources, people can be properly trained about critical response, recovery, mitigation, and preparedness strategies such that people are less vulnerable in future disasters. Another important factor that impacts emergency management is establishing proper pre-disaster plans to prepare community workers and volunteers for future disaster scenarios. Pradhananga et al. (2021) highlighted that many volunteers during disaster waste management suffered from at least one severe health problems. Therefore, there is also a pressing

need to improve post-disaster health and safety efforts by supplying necessary safety equipment and providing health and safety education/training in different disaster-prone communities. Moreover, proper pre-disaster plans would also help residents to reduce the potential waste generation which ultimately helps to reduce the required number of temporary waste storage sites.

Unlike developed countries, the government structures in developing countries usually overlook their fiduciary responsibility to protect communities in disaster-prone communities through equitable means (Mohanty 2011). The research results confirms that a significant number of underprivileged communities within developing countries are vulnerable to natural disasters due to inadequate decision-making ability, lack of education, insufficient resources, and monopoly of authorities and stakeholders. Additionally, many of these communities' practice informal settlements where houses are built incrementally in proximity over the years. Such homes are built with unsustainable materials and do not comply with official safety standards. On the other hand, the survey in South Florida indicated that many residents in developed countries prioritize the emergency management measures such as understanding the risk associated with natural disasters, learning about the vulnerability of their areas, and learning about post-disaster health and safety, among others. Additionally, the availability of institutional text guidelines (e.g., FEMA guidelines) enables people to follow through with the emergency management measures. Many local news and churches also disseminate such information and provide necessary preparedness guidance. Moreover, the Federal Emergency Management Agency (FEMA) operates various courses and training for pre-disaster preparedness through its different resources like the Center for Domestic Preparedness (CDP), Emergency Management Institute (EMI), and National Training and Education Division (NTED) to have an emergency response community capable of responding to all-hazard events (Wilson and Oyola-Yemaiel 2001). For instance, one of the courses referred to as "Hazus for Hurricane" in EMI offers: 1) an overview of the hurricane-related inventory components; 2) defining a hurricane hazard; and 3) adjusting parameters for identification of economic and social impact from hurricanes which eventually supports emergency management (Federal Emergency Management Agency (FEMA) 2017). Hence, this study indicated that the general public in the United States is aware of different emergency management measures in addition to those efforts from FEMA, Red Cross Society, and other NGOs have proved to reduce the number of casualties during natural disasters. In contrast, developing countries are generally underprepared in all four stages of emergency management because of the absence of government bodies like FEMA (i.e., guidelines, protocols, safety, measures, availability of PPE, and necessary training) to reduce the damages and loss of lives. Therefore, the ISM framework developed in this study provides baseline guidance for faster post-disaster recovery in developing countries that can facilitate emergency management agencies, volunteers, and community workers to make proactive decisions in all phases of emergency management. The findings of this study indicate that it is critical to bring a paradigm shift in post-disaster recovery practices to overcome economic and environmental as well as health and wellbeing challenges during reconstruction in developing countries. The ISM framework developed based on case study of Nepal illustrates a methodology, as well as findings, that may be helpful to other developing countries in the same region, or with similar circumstances, to Nepal as these countries seek to adopt sustainable and faster post-disaster recovery practices.

5. Limitations And Future Work

Although the study analyzed the contextual relationship between eight critical success factors that foster faster post-disaster recovery in developing countries, there were some limitations in this research. The assessment of the potential relationships of the identified factors in the survey questionnaire may be subjective due to personal opinions and self-judgments. However, the authors believe that anchorage of the questions in the survey to relevant findings of research available in various literature supports valid judgments. Future studies could focus on developing streamlined guidance for each phase of emergency management with emphasis on enhancing the capacity of critical success factors in developing countries.

6. Conclusion

There is an emerging need for innovative strategies that eliminate inequity and lack of resources during emergency management for underprivileged communities in developing countries. The research study tackles this drawback through developing an ISM framework and identifying flaws in post-disaster recovery practices in a developing country. The framework highlights the eight identified factors, which have been divided into six distinctive levels where each factor has different dependencies and driving power in the ISM framework. The proposed framework will be useful to emergency management agencies for tailoring effective post-disaster recovery practices and fostering proactive decision-making abilities within underprivileged communities in response to natural disasters and hazards. Moreover, it would also foster improvement in the capabilities of communities to accumulate the resources effectively and improve resilience during preparation for future disasters. The study also collected the emergency management priorities from coastal residents in a hurricane prone city within the United States. The results confirmed that such coastal population are aware of preparedness measures. In contrast, 78% of professionals in developing countries indicated not being aware of basic disaster preparedness education and lacking emergency management trainings. Such vast difference in awareness exists due to the absence of policies and government bodies that develop and implement emergency management measures according to the country's needs. The methodologies, and implications of this study can be transferred in establishing effective intervention policies and strategies to mitigate risks of natural and man-made disasters. The findings of this study are practical not only to practitioners but also to academics since it advances our understanding of different factors that addresses the gaps in emergency management practices in developing countries and fosters social sustainability during post-disaster recovery.

Declarations

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Availability of data and material: Some or all data or models, that support the findings of this study are available from the corresponding author upon reasonable request.

Codes Availability: Some or all codes, that support the findings of this study are available from the corresponding author upon reasonable request.

Ethics Approval: The research conducted survey of human subjects after receiving approval from Institutional Review Board (IRB) from Florida International University Office of Research Integrity.

Consent to Participate: This study conducted survey of human subjects after receiving consent to participate from the participants

Consent for Publication: The research leading to these results have received consent for publication from the participants

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Tables

Table 1 Structural Self-Interaction Matrix

i, j	PDP	SE	TWS	FA	TN	T.E.	C	AE
AE	X	A	V	X	X	X	A	V
C	X	V	V	V	A	X	V	
T.E.	V	V	V	A	O	V		
TN	V	V	X	X	V			
F.A.	V	V	V	V				
TWS	X	O	V					
SE	A	V						
PDP	V							

Table 2 Rules for Reachability Matrix

	(i,j)	(j,i)
V	1	0
A	0	1
X	1	1
O	0	0

Table 3 Reachability Matrix

	PDP	SE	TWS	FA	TN	T.E.	C	AE
AE	1	0	1	1	1	1	0	1
C	1	1	1	1	0	1	1	1
T.E.	1	1	1	0	0	1	1	1
TN	1	1	1	1	1	0	1	1
F.A.	1	1	1	1	1	1	0	1
TWS	1	0	1	0	1	0	0	0
S.E.	0	1	0	0	0	0	0	1
PDP	1	1	1	0	0	0	1	1

Table 4 Final Results of Partitioning of Reachability Matrix after Six Iterations

	Reachability set	Antecedent set	Intersection set	Level
TWS(6)	1,3,5	1,2,3,4,5,6,8	1,3,5	I
SE(7)	2,8	2,3,4,5,7,8	2,8	I
PDP(8)	1,2,3,8	1,2,3,4,5,8	1,2,3,8	II
TE(3)	1,2,3	1,2,3,4,5	1,2,3	III
AE(1)	1,4,5	1,2,4,5	1,4,5	IV
FA(5)	1,2,4,5	1,2,4,5	1,2,4,5	IV
C(2)	2,4	2,4	2,4	V
TN(4)	4	4	4	VI

Table 5 Development of Conical matrix

	PDP	SE	TWS	FA	TN	T.E.	C	A.E.	**Driving Power**
A.E.	1	0	1	1	1	1	0	1	**6**
C	1	1	1	1	0	1	1	1	**7**
T.E.	1	1	1	0	0	1	1	1	**6**
TN	1	1	1	1	1	0	1	1	**7**
F.A.	1	1	1	1	1	1	0	1	**7**
TWS	1	0	1	0	1	0	0	0	**3**
S.E.	0	1	0	0	0	0	0	1	**2**
PDP	1	1	1	0	0	0	1	1	**5**
Dependency	**7**	**6**	**7**	**4**	**4**	**4**	**4**	**7**	

Figures

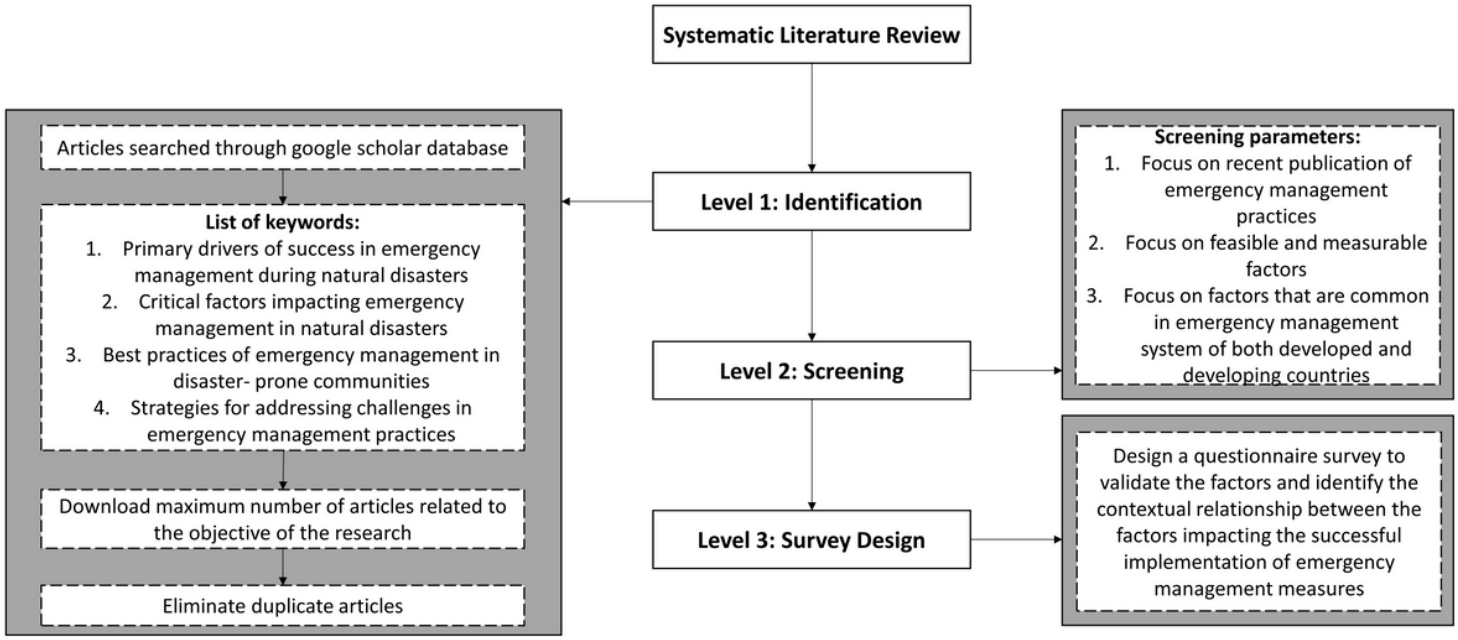

Figure 1

Systematic literature review framework for identification of critical success factors

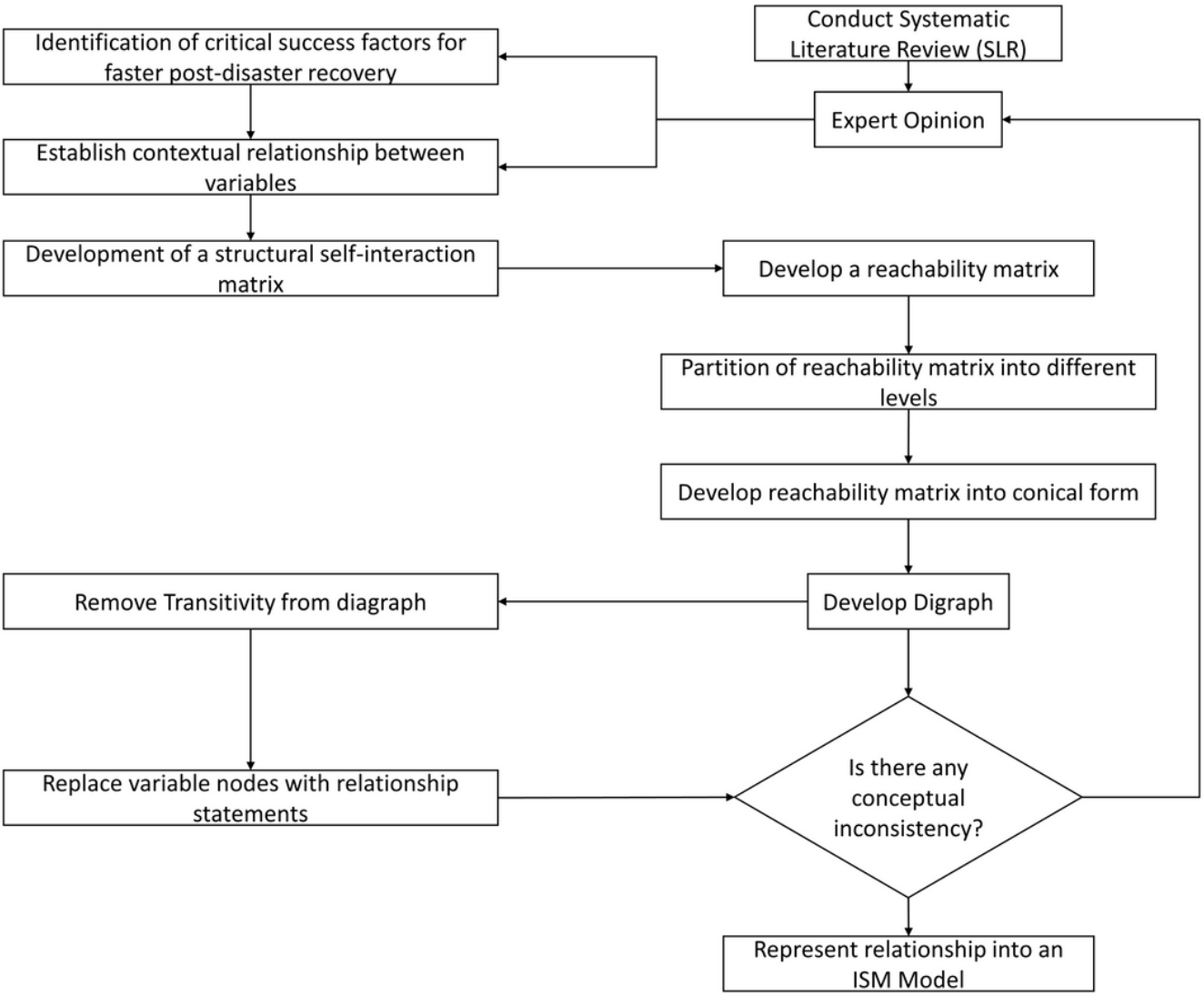

Figure 2

Flow diagram of Interpretive structural modeling technique

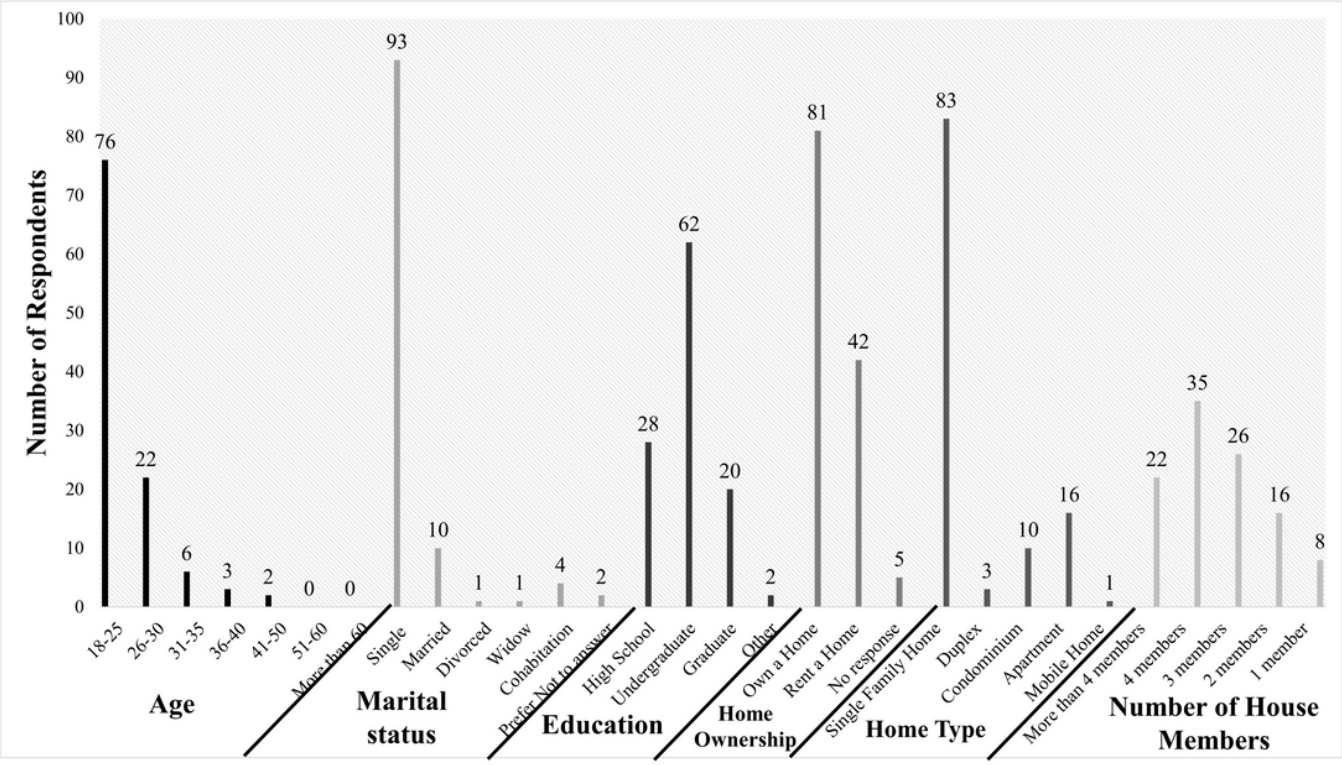

Figure 3

Socio-Demographic background of survey participants in South Florida, n=126

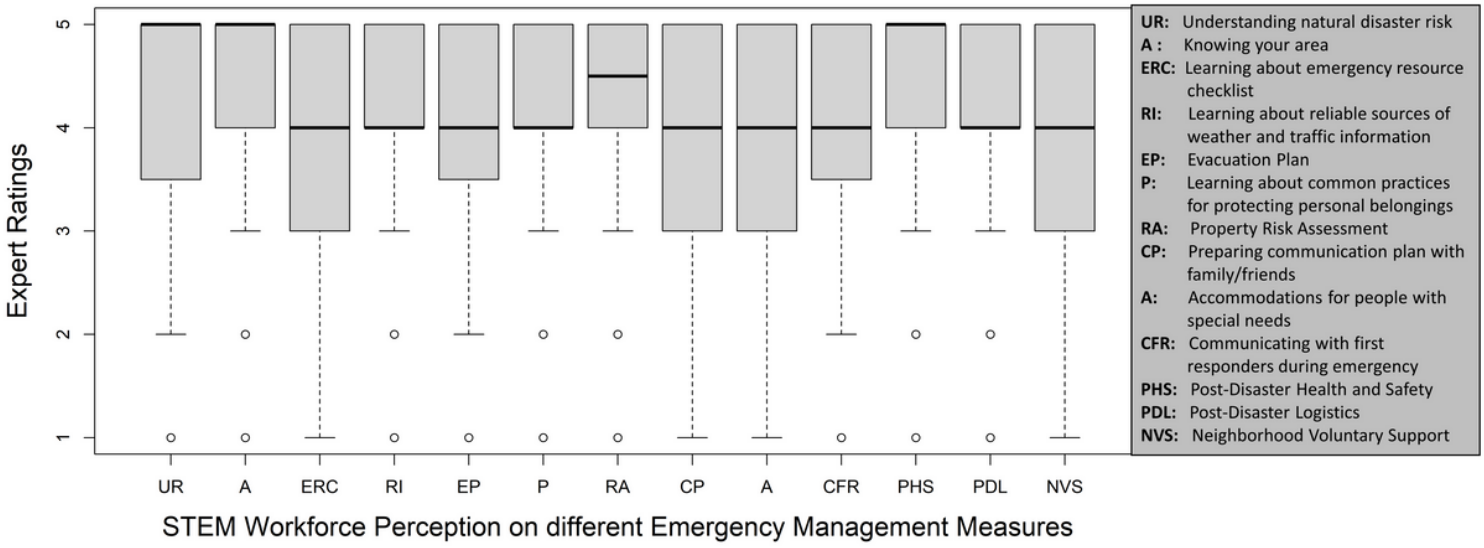

Figure 4

Box plots showing awareness and priorities of South Floridians about emergency management measures

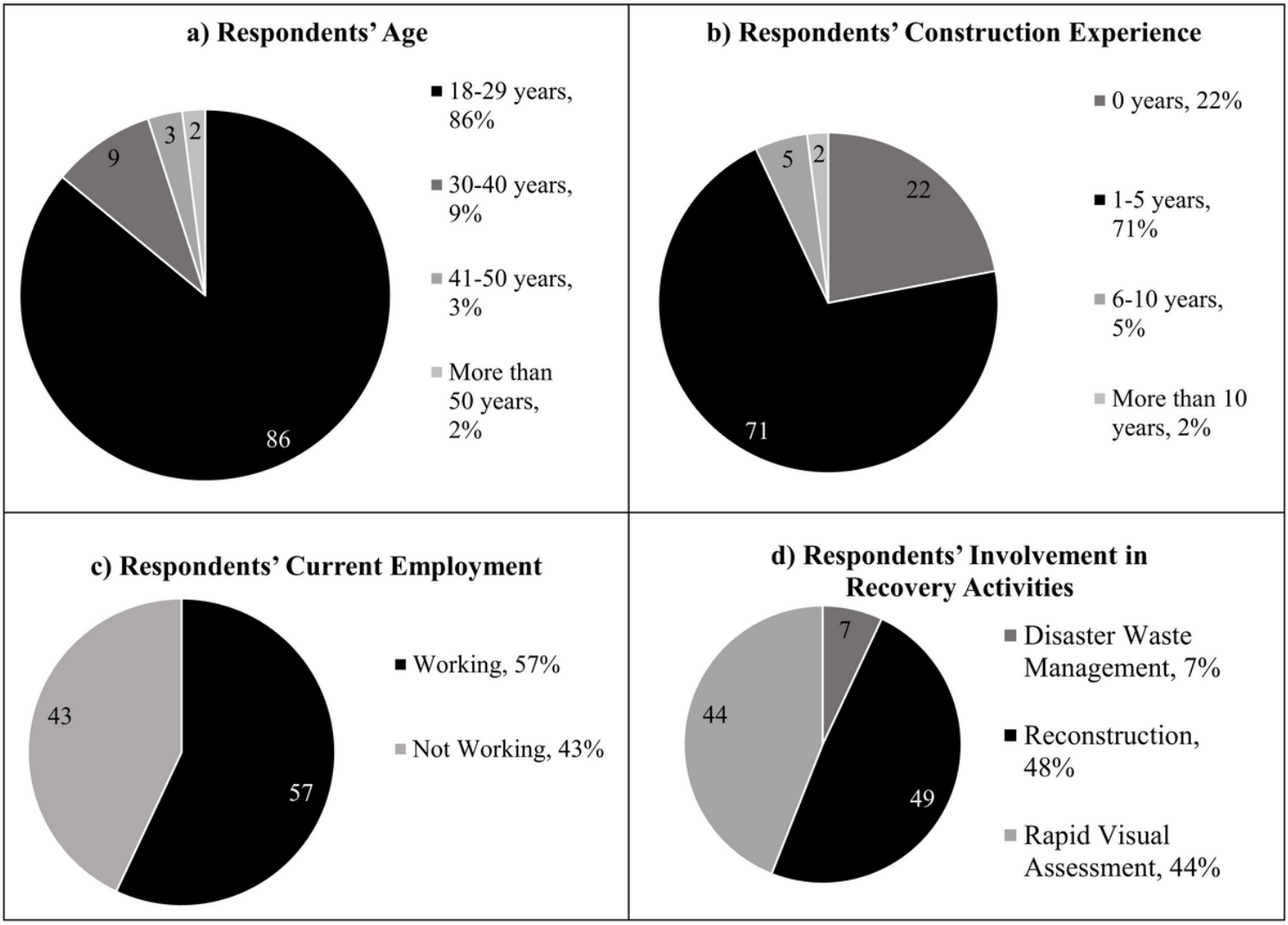

Figure 5

Socio-Demographic Background of the respondents in Nepal, n=117

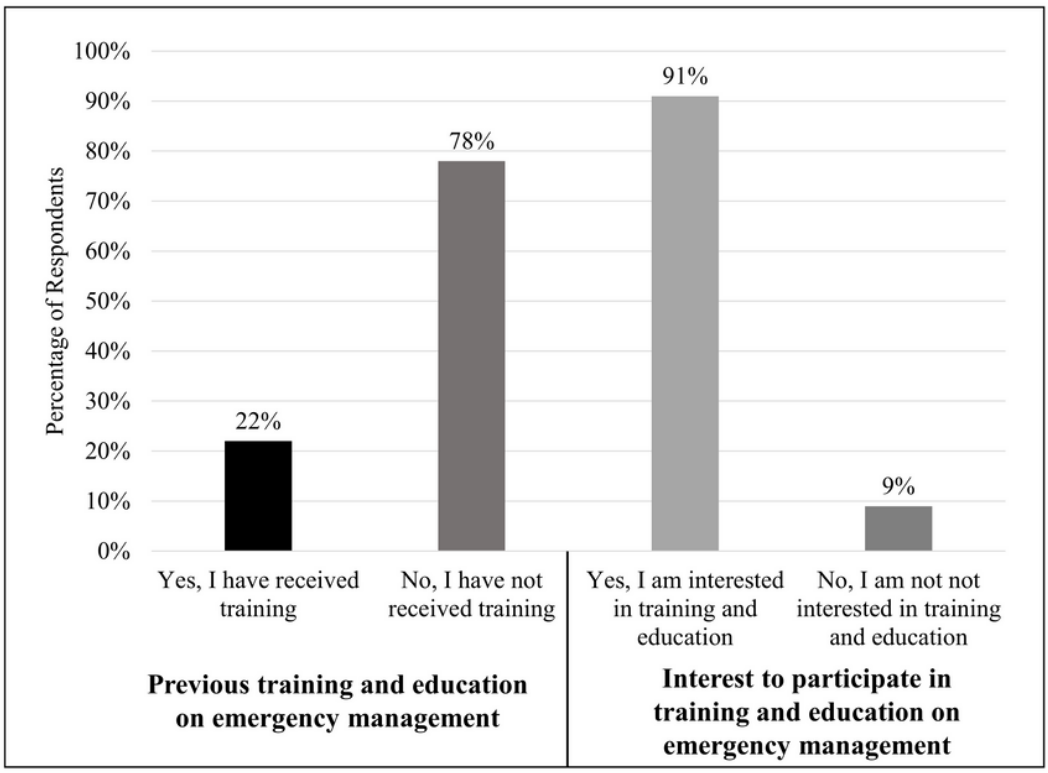

Figure 6

Respondents' previous experience and interest related to emergency management training and education

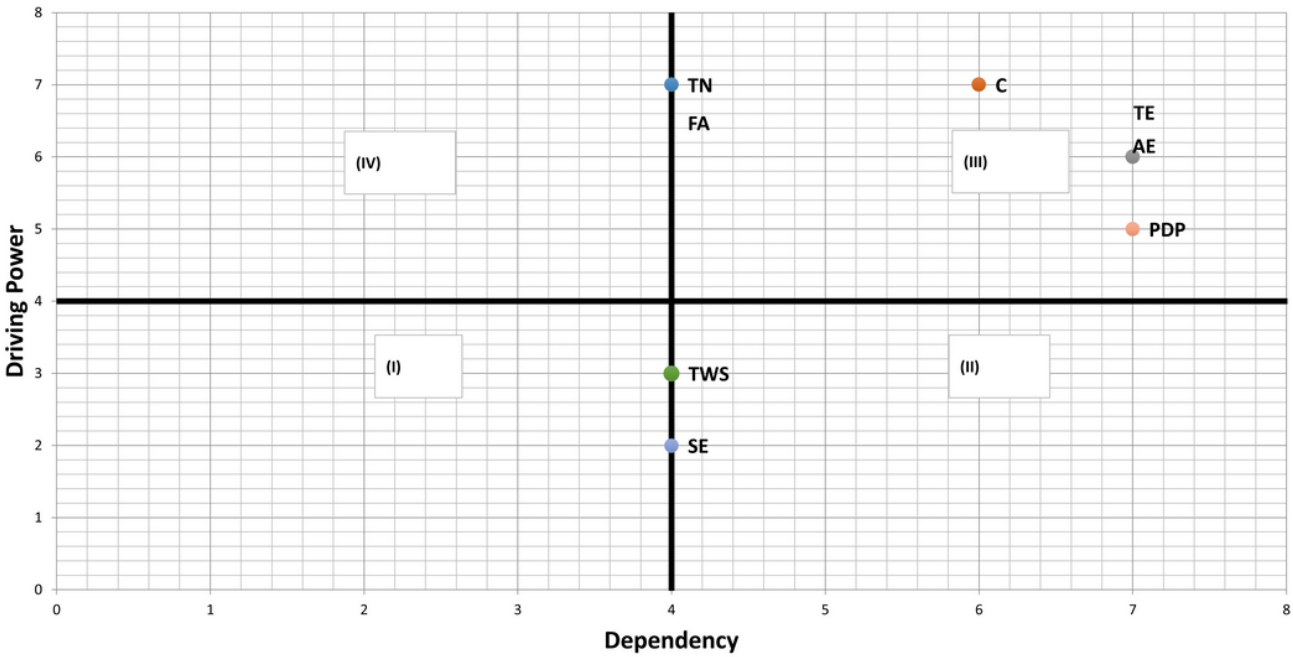

Figure 7

Graphical representation of conical matrix in MICMAC analysis

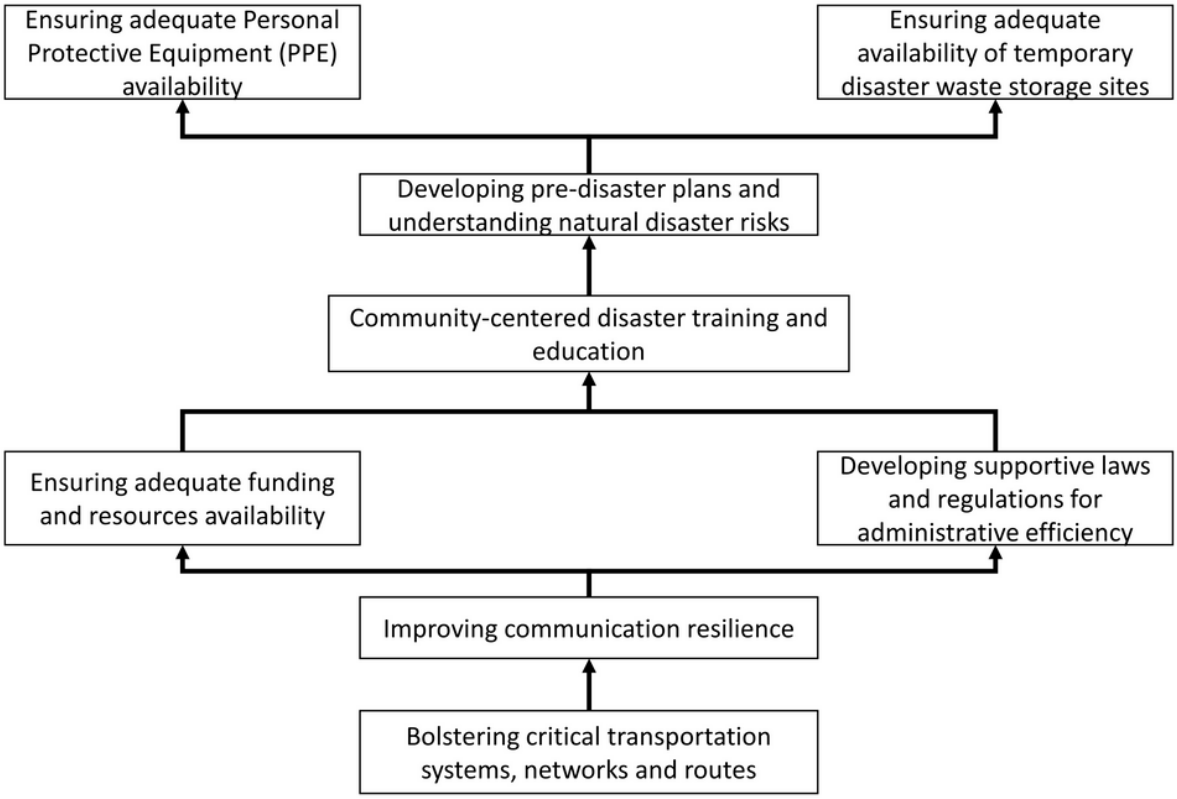

Figure 8

Interpretive Structural Modelling Framework