ANALYSIS OF BARRIERS CAUSING DELAY IN POST-HURRICANE RECOVERY: EXPERTS' VS. PUBLIC'S PERSPECTIVES

by

BEHZAD ROUHANIZADEH

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DEDICATION

To my friend and wife, Elnaz, for her love, kindness, devotion, and all of the unsuccessful efforts she made to stop me eating! I wish I could find her sooner and could spend more time with her. Thank you for letting me experience the kind of love that people freely die for.

To my parents, Roya and Mahmood, for always loving and supporting me and for their endless sacrifice and faith in me.

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ABSTRACT

ANALYSIS OF BARRIERS CAUSING DELAY IN POST-HURRICANE RECOVERY: EXPERTS' VS. PUBLIC'S PERSPECTIVES

Behzad Rouhanizadeh, Ph.D.

The University of Texas at Arlington, 2020

Supervising Professor: Dr. Sharareh Kermanshachi

Destructive natural disasters such as hurricanes, affect countries around the world. To recover from a hurricane, the managers need to make various decisions; however, what makes the post-hurricane decision making unique is lack of time to make the optimum decision. A comprehensive understanding of barriers to recovery can lead to development of policies that help prevent delays in recovery process and consequently results in resiliency. Although several studies have been performed to identify the recovery barriers, they did not provide a comprehensive review of barriers and their classification. On the other hand, experts and the public commonly have different understandings about the post-hurricane conditions and the corresponding issues. This may elongate the process of post-hurricane recovery and consequently affects many social and economic aspects of the people living in the affected areas. A precise investigation of the experts' and public's understanding of the post-hurricane barriers and their reasons would be useful for timely recovery. In addition, delays in accomplishment of post-hurricane recovery processes has been a major issue for the governors recently, leading to huge economic losses. Different barriers and of different types intervene in causing delays in the recovery after hurricanes.

In addition, the interaction among these barriers can intensify the negative effect of them and further delays. Thus, a significant step toward resolving this problem is determining how these barriers affect the recovery process and interact with each other.

The aims of this study were to (1) identify public's perception on the importance of barriers of timely post-hurricane recovery, (2) identify experts' perception on the importance of barriers of timely post-hurricane recovery, (3) prioritize the barriers of timely post-hurricane recovery based on public's and experts' perception, (4) investigate whether there are relationships among the barriers to timely post-hurricane recovery or not, (5) identify what is the causal relationship among the barriers, and (6) determine to which extent the barriers and their interactions affect the timeliness of recovery process.

An exhaustive review of 1,535 publications from existing literature was performed, and after a thorough search and exclusion process, 452 publications, focusing on hurricane-related issues and authored by scientists, practitioners, etc., were collected and sorted by source of literature, disaster type, year of publication, continent of origin, and data collection method. Sixty-two (62) barriers to effective post-hurricane recovery were identified and sorted into five categories: financial and economic, social, infrastructure and housing reconstruction, environment, and coordination and resources. Then, a survey was developed and distributed to experts and public separately to explore their perspectives of the importance of the identified barriers. Next, the barriers were ranked from both groups point of view, using Relative Importance Index (RII) analysis. Then, ten interviews were conducted with experts in post-hurricane recovery in order to evaluate the results of the survey and analysis.

Implementing structural equation modeling (SEM) technique, the interrelated network of 62 barriers to timely post-hurricane recovery process was modeled and the impacts of barriers on

the time of the recovery after hurricanes was evaluated. The findings showed that according to the experts model the barriers underlying coordination latent variable have more impacts on the time of recovery. However, for the public model the highest priority was given to the barriers underlying the social group. This research assists decision-makers in understanding the critical paths that lead to delays in the post-hurricane recovery process. In addition, they would be able to predict the impacts of interdependent barriers during the recovery process after hurricanes.

The results demonstrated that infrastructure and housing reconstruction category includes highest number of recovery barriers. The top two most-cited barriers in the literature were rate of employment and number of active small businesses. In addition, the results of this study showed that the experts selected undefined roles and responsibilities in the recovery as the most important barrier to timely post-hurricane recovery, while the public selected insufficient built infrastructures. In addition, five of the top-10 ranked barriers of the experts and public were similar; even though these barriers did not have the same ranks according to the two groups. Furthermore, the findings showed that according to the experts model the barriers underlying coordination latent variable have more impacts on the time of recovery other than the other variable groups. However, for the public model the highest priority was given to the barriers underlying the social group. This research assists decision-makers in understanding the critical paths that lead to delays in the post-hurricane recovery process. In addition, they would be able to predict the impacts of interdependent barriers during the recovery process after hurricanes.

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CHAPTER 1. INTRODUCTION

1.1. Background

Over the past twenty years, natural disasters such as hurricanes have occurred more frequently and have devastated many parts of the U.S. The timely recovery of the affected communities has become a major focus of governors and other decision makers as they have worked to help return the people to their cities, homes, and businesses as rapidly as possible. Post-hurricane recovery is defined as the restoration of a damaged area to its pre-hurricane condition (Barbarosoglu and Arda, 2006), and it is adversely impacted by the dynamicity of the barriers that impede the process (Ku and Ma, 2015; Rouhanizadeh & Kermanshachi, 2020a). In most cases where a timely recovery after hurricanes is not achieved, there has been a lack of integrated planning and coordination (Sun and Xu, 2011), but recovery is also delayed for other reasons, such as those than are man-made. The process of recovery is unique to each occurrence and depends upon the location, the characteristics of the affected population, and many other factors that impact the resiliency of a community. Recovery policies, plans made prior to the disruptive events, and the nature or type of disruption(s) are important to all post-hurricane recoveries (Orabi et al., 2010).

Delays in the recovery process can diminish the effectiveness of the recovery and result in higher costs (El-Anwar and Chen, 2013; Rouhanizadeh & Kermanshachi, 2020b). Thus, many researchers have focused on minimizing the duration of the recovery process, as well as effectively allocating and utilizing resources (Barbarosoglu and Arda, 2006). Orabi et al. (2010) conducted a resource allocation study on cost constraints and concluded that delays in making resource allocation decisions lead to a late recovery and increase the corresponding costs. El-Anwar and Chen (2013) conducted research on ways to minimize economic losses and optimize recovery.

Delays in the recovery of damages wreaked by high intensity natural disasters can have short-and-long-term cascading and unrecoverable effects. Causes of delays in the short-term recovery phase have been thoroughly investigated, but the long-term recovery phase has not been studied in much detail (Ku and Ma, 2015). Long-term hurricane recovery begins after the affected area has been cleared of chaos, crowds, and vehicles, and at this stage, the allocation of sufficient resources particularly important to the speed of the recovery. A shortfall of recovery funds results in delays in the developmental investments, (Jordan and Javernick-Wil, 2013) improper allocation of resources, inefficient governmental responses (Lam et al., 2015), and increased vulnerability of the community to future hurricanes (Lyons, 2009).

Recovery plans cover two time periods: pre-hurricane and post-hurricane (Kaklauskas et al., 2015; Rouhanizadeh et al., 2020). Pre-hurricane recovery planning commonly includes the integration of local planning efforts, coordination of community priorities, assignment of roles and responsibilities, and rapid implementation (Schwab et al., 2014). Post-hurricane recovery and reconstruction is a continuation of pre-hurricane planning and is vital to achieving sustainable development (Schwab et al., 2014). Many researchers argue that post-hurricane recovery is a dynamic, multivariable, political, and social process, and is not limited to the reconstruction of the buildings and the living environment (Hwang et al., 2015; Rouhanizadeh & Kermanshachi, 2020c).

Understanding the influencing factors of extreme and disruptive events, as well as their relationships with each other, is crucial to mitigating their consequences, but some researchers have narrowed their focused to either single or multiple indicators (Schwab et al., 2014). Based on the literature, the availability of economic resources, including loans, governmental aids, and donations, is one of the most important determinants of the duration of post-hurricane recovery (Smith and Wenger, 2007). Employment, income, and the number of active businesses that remain after a hurricane are other factors that have been studied (Lam et al., 2015; Kermanshachi & Rouhanizadeh, 2018). Although these factors are commonly interrelated with existing and new policies, the integration of them has been rarely studied. Social recovery includes a number of outcomes, such as quality of life, civic engagement, and societal connections (Tuzun and Özdamar, 2014). To accomplish social recovery, amenities such as shops, schools, recreational facilities, and worship places must be reconstructed (Chang et al., 2010), which is an indication that physical and social recoveries are interconnected aspects of the restoration process. Chang et al. (2010) recognized the temporary loss of learning opportunities and the breakdown of traditional family support as short-term, and long-term impacts of delays in post-hurricane recovery, respectively.

Planning and policymaking for hurricane recovery are developed by both local and federal governments and enhance the quality and timeliness of the recovery (Tuzun and Özdamar, 2014; Kermanshachi et al., 2019). State agencies often authorize the implementation of federal laws and regulations for hurricane management (Chang et al., 2010), while local recovery plans deal with controlling the general local conditions, coordinating the control of resources, measuring the opportunities and obstacles, and managing the public input (Schwab et al., 2014). Delays in the recovery postpone the actualization of hurricane risk reduction programs, which is one of the short-term goals of a hurricane recovery program.

Modelling the interrelations among the barriers is useful for helping both the public and experts better understand the recovery process, the barriers that cause delays, and the combinations of barriers that make the most adverse impact. Little research has been conducted on this subject, however, and most of the researchers have only modeled a few of the issues and barriers, and have not always modeled them specifically for hurricanes. After the 1995 Kobe earthquake, Tatsuki et al. (2003) conducted one of the very first studies on the barriers to the post-earthquake recovery process. The approach implemented in their study was mainly social, and the results showed that social recovery has priority over infrastructure recovery. Assaf (2011) introduced a disaster framework for mitigating the socio-physical risks after the 1959 Malpasset dam failure that led to a big flood in southern France, but even though a very detailed simulation was developed for the framework, the scale of the disaster is not comparable to that of the major hurricanes that have occurred over the past 20 years (e.g., Katrina, Harvey, etc.). Nejat and Ghosh (2016) developed a predictive model for post-hurricane recovery decision-making that was based upon Hurricane Sandy and focused on housing recovery. Mostafizi et al. (2019) presented an agent-based model for evacuation after a tsunami and investigated how the evacuation scenarios are affected by the life safety systems. The outputs of their framework demonstrated that there is a significant non-linear relationship between evacuation behavior and life safety systems. In summary, even though there are more such models to discuss, none of them comprehensively explore the issues or focus on short-and-long-term barriers after a hurricane. Hence the need for comprehensive models for timely post-hurricane recovery still exists.

1.2. Problem Statement and Research Questions

Despite the adoption of some post-hurricane recovery activities during the past several decades, not enough attention has been paid to effective post-hurricane recovery, which has resulted in unnecessary losses of properties, lives, and financial resources (Sun and Xu, 2011; Rouhanizadeh et al., 2019b). A recent tendency among decision makers has been to shift to a systematic post-hurricane recovery effort (El-Anwar and Chen, 2013; Rouhanizadeh et al., 2019a), but although the importance of fast-moving hurricane recovery has been acknowledged, no one has established a comprehensive list of barriers to effective post-hurricane recovery (Orabi et al., 2013; Rouhanizadeh & Kermanshachi, 2019b).

Identifying and analyzing the barriers to effective post-hurricane recovery needs to be the pivotal focus of achieving an integrated approach. Then, the interactive relationships among the barriers and their impacts on timely recovery need to be analyzed and modeled. The impacts of individual barriers have been studied, but no modeling of the interactive effects of these barriers has been conducted. Only a few researchers attempted to model and evaluate the effect of specific barriers, and many of them concentrated on disasters other than hurricanes (Alipour et al., 2015; Rouhanizadeh & Kermanshachi, 2019a). According to the literature, there is a major misunderstanding between the experts and the public that is related to their perspectives of post-hurricane recovery, which leads to considerable issues and could itself be considered as a fundamental barrier. Based on the abovementioned identified problems, the following research questions are raised:

- What are the barriers to timely post-hurricane recovery?
- Which of the barriers to timely post-hurricane recovery are of the highest priority?
- If the interrelations among the different barriers exist, to what extent do they impact timely post-hurricane recovery?
- How different are the experts' and the public's perspectives on the importance of post-hurricane barriers?

1.3. Study Objectives and Contributions

This purpose of this research was to develop comparative models that analyze the effects of barriers to post-hurricane recovery that affect the timeliness of the process. Accordingly, the objectives of the study were formulated as follows: (1) identify and categorize the barriers; (2) prioritize and rank the barriers; (3) investigate both the experts' and public's perspectives to determine whether interrelations among different barriers to timely post-hurricane recovery process exist; (4) develop causal models that capture the perspectives of both the experts and the public of the interrelations among different barriers to timely post-hurricane recovery; (5) find the paths from the barriers to delays in the process of recovery, according to both the experts' and public's perspectives; and (6) demonstrate the extent to which the interrelations of the barriers act. In the aftermath of hurricanes, the findings of this study can help the decision makers identify the barriers that most significantly affect the timeliness of recovery process and overcome them systematically to achieve a successful recovery.

1.4. Dissertation Layout

The current manuscript includes five chapters, each of which presents a section of the study. Chapter 1 presents the background, problem statement, research questions, research objectives and contributions, and dissertation layout. Chapters 2, 3, and 4 each contain three papers that address some of the research questions and objectives of this study. The paper presented in Chapter 2 is related to the identification and categorization of the barriers to post-hurricane recovery. Chapter 3 presents the prioritization and ranking of the identified barriers according to the experts' and public's perspectives. Chapter 4 focuses on the paper through which the interrelations among the barriers are investigated, analyzed, and discussed, according to the experts and the public. The contributions and implications of these papers are shown in Figure 1-1. Finally, in Chapter 5, the conclusions and limitations of this study, as well as the recommendations for future works, are presented.

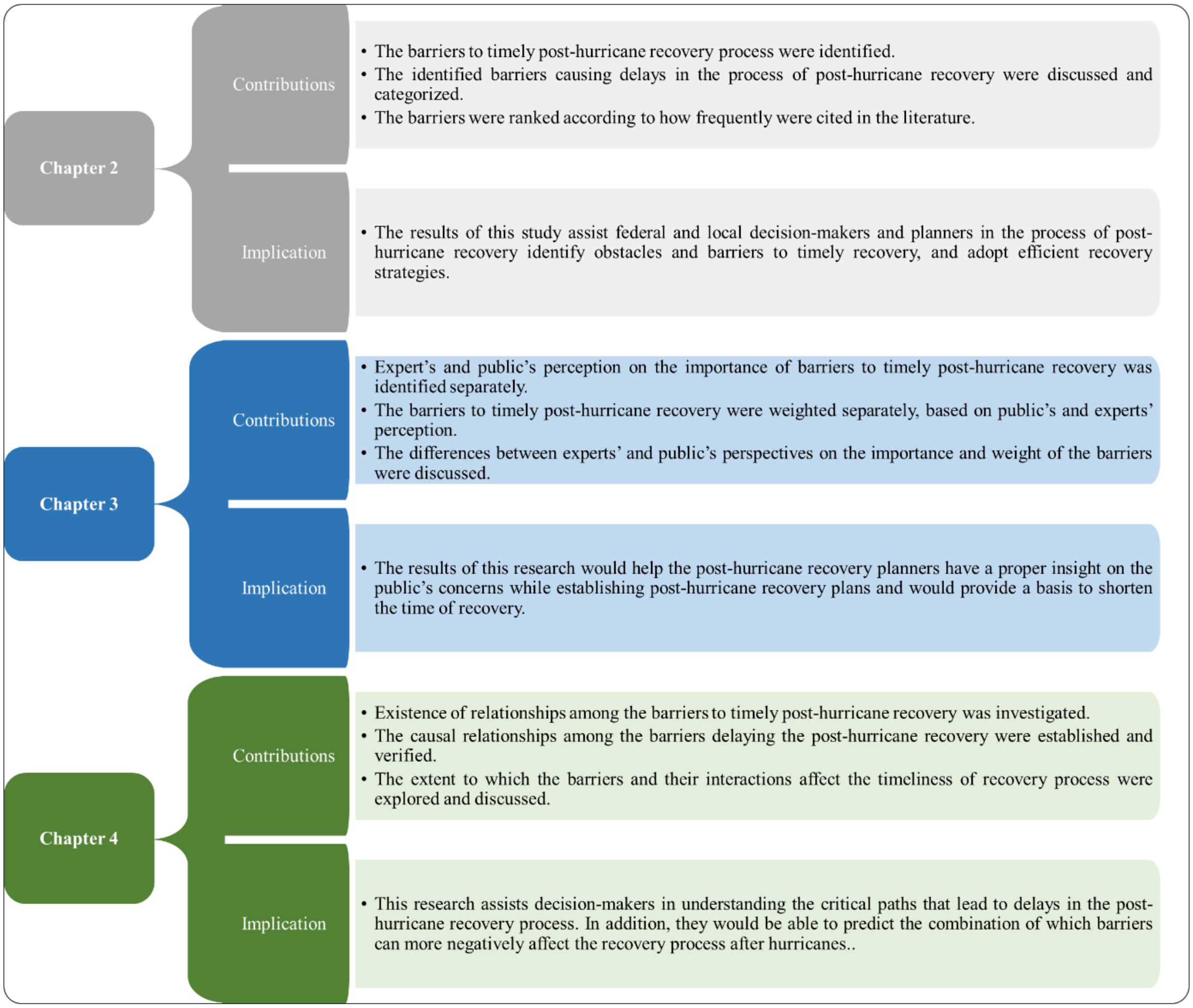

Figure 1-1: Overview of the papers presented in this dissertation in Chapters 2, 3, and 4.

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CHAPTER 2. EXPLORATORY ANALYSIS OF BARRIERS TO EFFECTIVE POST-DISASTER RECOVERY

Abstract

Destructive natural disasters affect countries around the world. To recover from a disaster, the managers need to make various decisions; however, what makes the post-disaster decision making unique is lack of time to make the optimum decision. A comprehensive understanding of barriers to recovery can lead to development of policies that help prevent delays in the recovery process and consequently results in resiliency. Although several studies have been performed to identify the recovery barriers, they did not provide a comprehensive review of barriers and their classification. This paper aimed to identify and categorize barriers to effective post-disaster recovery with a focus on hurricanes. An exhaustive review of 1,535 publications from existing literature was performed, and after a thorough search and exclusion process, 452 publications, focusing on hurricane-related issues and authored by scientists, practitioners, etc., were collected and sorted by source of literature, disaster type, year of publication, continent of origin, and data collection method. Sixty-two (62) barriers to effective post-disaster recovery were identified and sorted into five categories: financial and economic, social, infrastructure and housing reconstruction, environment, and coordination and resources. The barriers in each category were ranked, based on how frequently they were referred in the studied literature. The results demonstrated that infrastructure and housing reconstruction category includes highest number of recovery barriers. The top two most-cited barriers in the literature were low rate of employment and low number of active small businesses. The results of this study assist decision-makers identify obstacles to effective recovery, and adopt efficient recovery strategies.

2.1. Introduction

The growing number of natural disasters such as hurricanes, earthquakes, floods, wildfires etc., has jeopardized the lives of thousands of people worldwide (Tuzun and Özdamar, 2014). More specifically, they affect the daily lifestyle of the affected communities by causing damage to homes and businesses; demolishing infrastructures; and creating environmental problems, health issues, etc. Such phenomena displace a huge number of people from their hometowns every year (Barbarosoglu and Arda, 2004), and cause many other short-and-long-term difficulties.

Post-disaster recovery has been defined in a variety of ways. Smith and Wenger (2007) defined the disaster recovery process as "*the differential process of restoring, rebuilding, and reshaping the physical, social, economic, and natural environment through pre-event planning and post-event actions.*" Schwab et al. (2014) defined recovery as "*Recovery includes restoring housing, transportation, and public services; restarting economic activity; and fostering long-term community redevelopment and improvements.*" The UN Office of Disaster Risk Reduction (UNISDR, 2015) defined disaster recovery as "*decisions and actions aimed at restoring or improving livelihoods, health, as well as economic, physical, social, cultural and environmental assets, systems and activities, of a disaster-affected community or society, aligning with the principles of sustainable development, including build back better to avoid or reduce future disaster risk.*" The emphasis of this definition is on both short-term and long-term recovery, with the short term focusing on returning the community to normalcy, and the long term focusing on helping communities become more resilient so that they are less vulnerable and more capable of dealing with future disasters (Hwang et al., 2015). In addition, the process of recovery might overlap with the emergency response time, which may usually last between one to six months. After emergency response period, the long-term recovery process begins which might even last for several years (UNISDR, 2015). When both short-term and long-term recovery are achieved, the recovery process can be considered successful (Shrestha et al., 2018).

Resilience or rebound is a technically defined as a multi-dimensional concept including many dimensions such as social, economic, physical, etc. (Platt, 2017). According to MCEER (2006), the process of recovery after a disaster normally is followed by an s-shaped curve which results in development of the resilience triangle concept. By increasing the robustness of a society and reducing the time of recovery process, the resilience-enhancing approaches aim to reduce the size of the resilience triangle (Platt, 2017). Chang and Shinozuka (2004) recommended considering rapidity and robustness as conspicuous goals of resilience-enhancing approach. Also, Chang (2010) implemented a framework for measuring recovery after the 1995 Kobe earthquake and emphasized on the dependency of resiliency to reducing the time of recovery. According to Disaster Recovery Reform Act of 2018 (Federal Emergency Management Agency (FEMA) 2018) for enhancing resiliency in the recovery process after disaster the damaged facilities must be repaired based on the latest codes and standards. Thus, resiliency which is the outcome of successful recovery must be targeted inclusivity. It should be added that most vulnerabilities due to disasters are social and economic, not physical (Wisner et al., 2003).

Recovery absorbs a huge amount of financial resources (Orabi et al., 2009), and successful recovery of an affected community can be measured by the extent to which the social and public services are effectively redeveloped (Schwab et al., 2014). Recovery is a complicated, challenging, and dynamic process, as many tasks of recovery are inter-dependent (Miles et al., 2012), and have to be undertaken simultaneously (Schwab et al., 2014; Lam et al., 2015). For example, the recovery of a local economy is dependent upon restoration of the infrastructure, housing, and public services (Lyons, 2009). After a disaster, economic recovery is very complex; it requires participation of the private sector and benefits both the private and government sectors (Chang et al., 2010). In a long-term recovery process, the disaster-affected communities need support from different organizations such as NGOs, local and Federal governments, etc. (Islam et al., 2017). Restoration of the infrastructure is also vital to successful post-disaster recovery (Jordan and Javernick-Will, 2013). For example, transportation systems play a fundamental role by facilitating the delivery of the resources and materials. Environmental recovery is not usually a high priority after a natural disaster (Schwab et al., 2014).

Even though some post-disaster recovery activities have been adopted within the past decades, there remains a lack of attention to effective post-disaster recovery, which leads to great losses of properties, lives, and financial resources (Sun and Xu, 2011). Consequently, a recent tendency among decision-makers is to shift to a systematic post-disaster recovery effort (El-Anwar and Chen, 2013). In spite of the increasing significance of a fast-moving post-disaster recovery, there is not yet a comprehensive list of barriers to effective post-disaster recovery (Orabi et al., 2009). To achieve an integrated approach for effective post-disaster recovery, the primary pivotal focus needs to be on identifying and analyzing the barriers (Chang et al., 2010; Kaklauskas et al., 2009). According to different conditions after each type of disaster, the barriers to post-disaster recovery of each type of disaster needs to be investigated independently. In this study, the focus was on the post-disaster recovery barriers with a focus on hurricanes due to the increasing rate of hurricanes within the last two decades (Ku and Ma, 2015). The objectives of this study include (1) identify the barriers to effective post-disaster recovery with a focus on hurricanes, (2) categorize the identified post-disaster recovery barriers, and (3) prioritize and rank the post-disaster recovery barriers according to the frequency of the publications that mentioned each barrier. By adding the identified recovery barriers to the post-disaster recovery barrier, different scenarios can be examined in advance to the implementation phase and the results be compared. The results of this research will provide the required basis for developing the post-disaster process modeling, which will help the decision-makers to implement practical policies to achieve timely, successful, and effective recovery process.

2.2. Research Methodology

This study consisted of five major steps. In the first step, relative literature of different types from 2000 to 2018 was collected and archived. The documents were selected by entering different combinations of keywords, including disaster, recovery, barrier, infrastructure, timeliness, hurricane, etc., into a search engine. In the second step, literature irrelevant to the aim of this study and not meeting the pre-determined criteria was excluded. In step three, the remaining resources were carefully reviewed, and the content was analyzed with regard to source of literature, year of publication, continent of origin, and data collection method. In step four, the barriers to effective post-disaster recovery were identified through a thorough review of the collected database, which was performed by the computer coding and human review consecutively. According to the literature, there were five major areas mainly focusing on the recovery processes (financial and economic, social, infrastructure and construction, environment, and coordination and resources). Therefore, in the fifth step, the identified barriers were categorized into the abovementioned five categories. Within the categorization, each of the categories were studied/evaluated through the procedure to ensure that all the references were sufficient and consistent with the selected categories. The frequency of the publications which focused on each barrier in the selected literature determined its ranking. Figure 2-1 shows the research methodology used to conduct this study. The search strategy and literature inclusion and exclusion procedures are presented in the following.

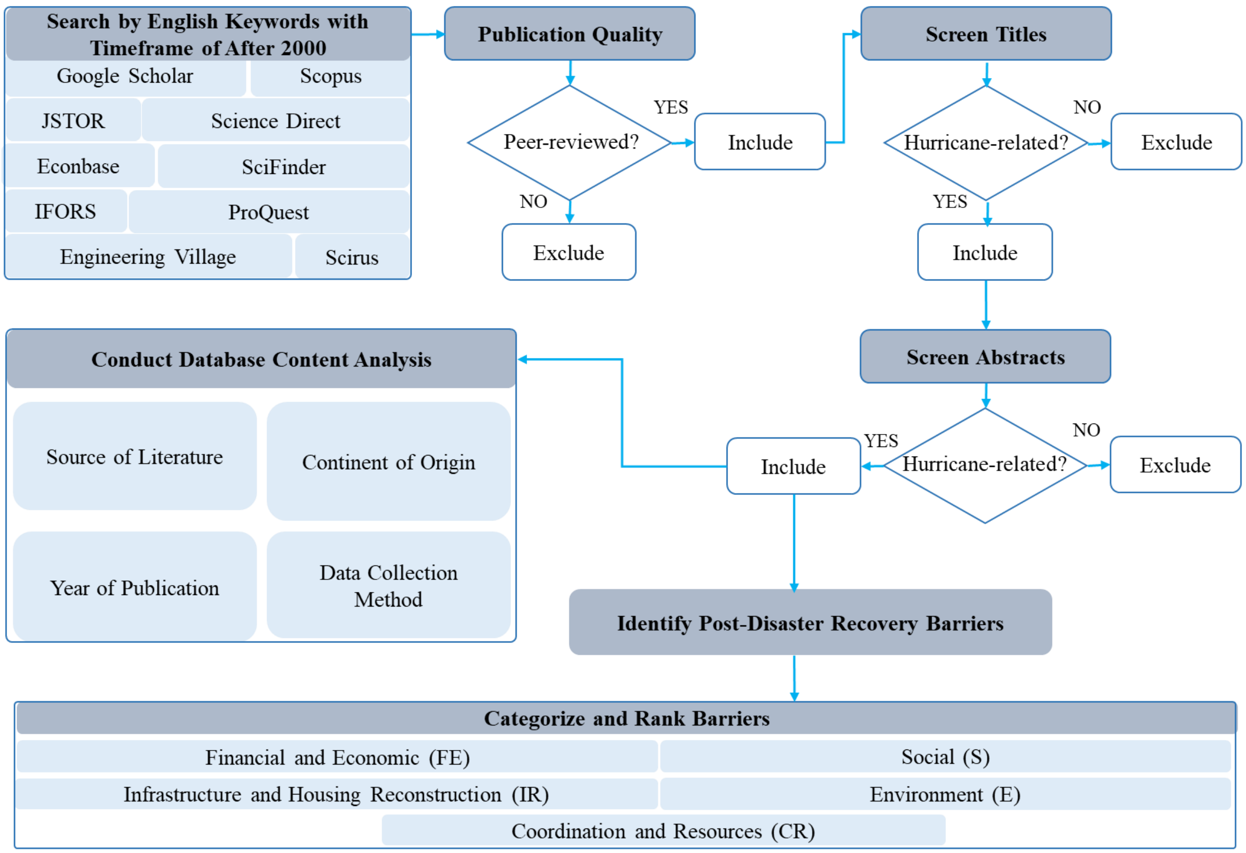


Figure 2-2. Research methodology and the literature search process.

To collect the references from literature, multiple international electronic databases, including Scopus, Google Scholar, JSTOR, ProQuest, IFORS, Science Direct, Engineering Village, Scirus, SciFinder, and Econbase, were searched. Different combinations and extensions of the following major keywords were searched only in English-language publications: post-disaster, hurricane, infrastructure, natural disaster, recovery, barrier, timeliness, extreme event, delay, catastrophic, planning, risk reduction, resiliency, housing, community, indicator, strategy, etc. The search period was limited to 2000 forward because the disaster recovery database preceding this date predominantly focused on emergency planning and preparedness of the communities against nuclear war, rather than natural disasters (Rotimi et al., 2009). Existing literature was collected that referred to various types of natural disasters, mitigation strategies after natural disasters, indicators and barriers of post-disaster recovery, timetable of disaster recovery, case studies of disaster recovery, issues after natural disasters, frameworks for disaster recovery, etc. The authors also focused on documents from famous agencies, publishers, journals, and conference proceedings, including, but not limited to Elsevier, American Society of Civil Engineers (ASCE), FEMA, etc. The initially-found 1,535 documents were reduced to 633 by excluding the publications that were not peer-reviewed and screening the title and abstract/summary of each publication. Through the screening the title and abstract/summary of each publication only the hurricane related documents were included. At the end of this step, 181 papers had been excluded, and the final database consisted of 452 publications. The variety of the selected publications emphasized the complexity and interdisciplinary nature of post-disaster recovery.

2.3. Database Content analysis

2.3.1. Source of Literature

As described, 452 publications of different types were selected for this study. The selected peer-reviewed articles were from 141 journals published all around the world. The number of qualified books, planning documents, reports, conference papers, and theses was respectively 20, 21, 33, 36, and two, and amounted to 25% of all of the publications. As shown in Table 2-1, the top five selected journals were *Disasters, International Journal of Disaster Risk Reduction, Natural Hazards, Natural Hazards Review,* and *Procedia Engineering,* respectively having 19, 16, 16, 15, and 14 articles in the database.

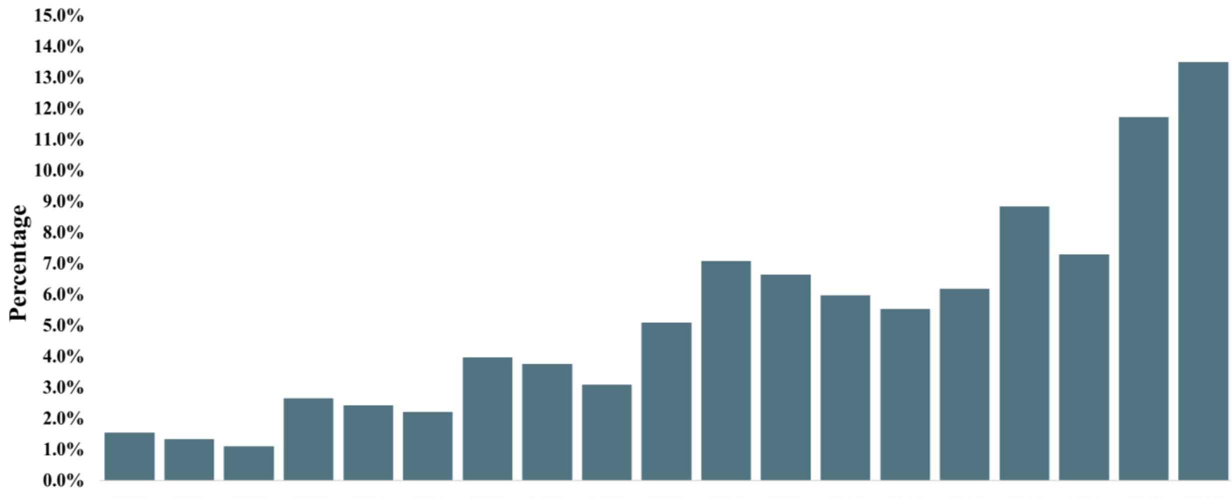
The publishers of these journals are all well-known and often focus on disaster circumstances: Blackwell Publishing Inc., Elsevier Limited, Kluwer Academic Publishers, ASCE, and Elsevier. Table 2-1 shows the percentage of papers from the different journals that authors used for defining barriers to post-disaster recovery. The effects of disaster, as well as the degree and pace of recovery, depend on a variety of factors. Thus, the authors enriched the research database by considering diverse types of publications.

Table 2-1. Frequency of publications based on the sources.

#	Source	Frequency	Percentage
1	Disasters	19	4.2%
2	International Journal of Disaster Risk Reduction	16	3.5%
3	Natural Hazards	16	3.5%
4	Natural Hazards Review	15	3.3%
5	Procedia Engineering	14	3.1%
6	Disaster Prevention and Management	11	2.4%
7	Journal of Infrastructure Systems	10	2.2%
8	World Development	9	2.0%
9	Journal of the American Planning Association	9	2.0%
10	Journal of Homeland Security and Emergency Management	7	1.5%
11	International Social Work	6	1.3%
12	Journal of Management in Engineering	6	1.3%
13	International Journal of Strategic Property Management	5	1.1%
14	Procedia Economics and Finance	5	1.1%
15	Risk Analysis	5	1.1%
16	Public Administration Review	5	1.1%
17	Transportation Research Record	5	1.1%
18	Journal of Construction Engineering and Management	4	0.9%
19	Applied Geography	4	0.9%
20	Journal of House and the Built Environment	4	0.9%
21	International Journal of Disaster Risk Science	4	0.9%
22	Other	161	35.6%
Peer-Reviewed Article		340	75.2%
Book		20	4.4%
Planning Documents		21	4.6%
Report		33	7.3%
Conference Paper		36	8.0%
Thesis		2	0.4%
Total		452	100.0%

2.3.2. Year of Publication

Researchers, practitioners, and engineers have been studying disasters and their corresponding issues, mitigating strategies, and recovery procedures for over a century (Rapeli 2017). As explained in the publication inclusion and exclusion section, the final database in this study consisted of documents from 2000-2018. Figure 2-2 shows the distribution year of the reviewed literature in this research. Approximately 70% of the publications were from 2010 to 2018, and a steady increasing trend in the number of studies after 2006 is obvious.



Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Percent	1.55%	1.33%	1.11%	2.65%	2.43%	2.21%	3.98%	3.76%	3.10%	5.09%	7.08%	6.64%	5.97%	5.53%	6.19%	8.85%	7.30%	11.73%	13.50%

Figure 2-3. Distribution of selected publications according to the year of publication.

From Figure 2-2, it is evident that studies related to disasters and their corresponding issues have been flourishing recently. The advances in urbanization during the last decades have caused the emergence of large and mega-cities, as well as complex infrastructures, which frequently increase the vulnerability of communities to the negative effects of natural disasters. This, along with the increasing number of weather-related disasters due to climate change, could be the fundamental causes for the number of studies on disasters increasing recently.

2.3.3. Continent of Origin

Around 77% of the studied publications that discussed hurricane mentioned the origination of the disaster they studied. Figure 2-3 shows the distribution of the selected publications, based on the originating continent: 38% addressed hurricanes that occurred in North America, and 28% addressed hurricanes that occurred in Asia. Only 17% of the publications focused on hurricanes and recovery issues in South America, Africa, and Oceania, but the number of hurricanes in these regions is increasing, which portends more hurricane-related research focus on these continents in the future.

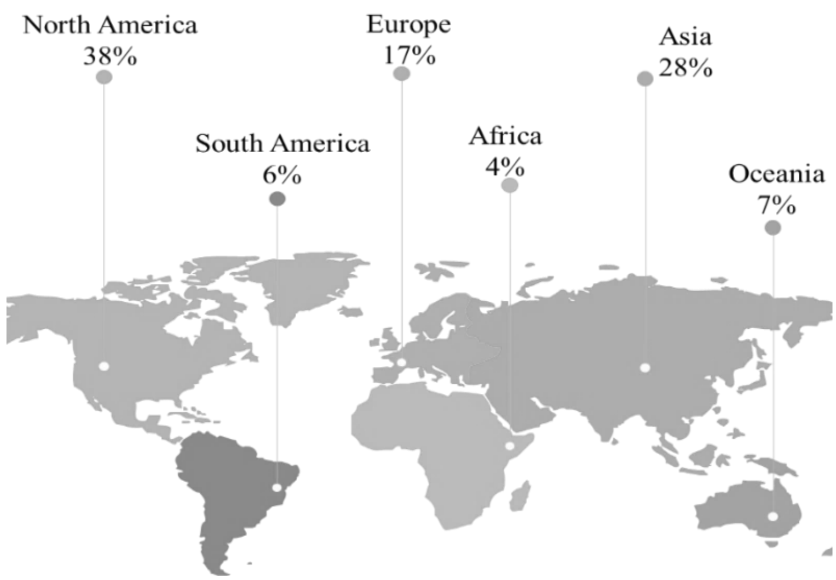


Figure 2-4. Distribution of disaster publications according to the continent of origin.

2.3.4. Data Collection Method

The common data collection techniques include literature reviews; interviews; questionnaires and surveys; observations; focus groups, such as the Delphi method; case studies, etc. The studied publications were grouped, based on the data collection method as shown in Figure 2-4. Thirty percent (30%) of the researchers collected the data by reviewing the documents and records, while only four percent of them gathered data through field observations. The Delphi survey was performed in only eight percent of the selected literature, which is most likely due to the difficulty of finding a sufficient number of professionals to conduct it, and 18% of the publications provided information from case studies conducted all around the world. A review of the case studies provided the opportunity to compare the consequences of natural disasters in various locations, as well as the local challenges the affected communities need to deal with throughout the recovery process.

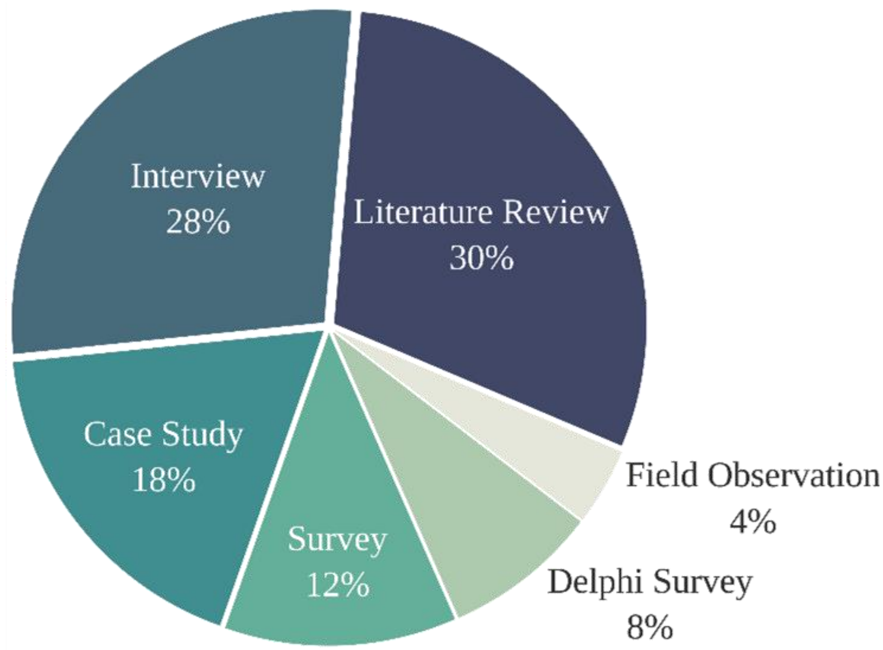


Figure 2-5. Distribution of disaster publications according to the data collection method.

2.4. Identification and Categorization of Post-Disaster Recovery Barriers

The full texts of the collected publications were reviewed and analyzed to identify the barriers to effective post-disaster recovery. The barriers were classified into categories, and were ranked in each category according to how frequently they were mentioned in the studied literature (e.g. rank one denotes the most frequently mentioned post-disaster recovery barrier in the studied literature). Each of the categories, barriers, frequency of mentioning in the literature, and ranks are presented below.

2.4.1. Financial and Economic

After disasters, the communities need to recover as fast as possible in order to maintain the existing society and bring the economy back; however, they also need to be accurate in optimizing the provided opportunities by the disaster for improvement and resiliency (Kim and Olshansky, 2015). The financial and economic category consisted of fourteen barriers, which can be considered as economic metrics for performing an effective recovery. As shown in Table 2-2, the rate of employment after a disaster was the most-cited barrier belonging to the financial and economic category. In post-disaster circumstances, people need jobs for rebuilding their lives. Thus, unemployment can put major obstacles in the path toward recovery, and acts as an important barrier to the timeliness of recovery (Alipour et al., 2015).

Table 2-2. List of financial and economic barriers with frequency and rank.

ID	Financial and Economic Barrier	Frequency	Rank
FE1	Rate of employment	94	1
FE2	Number of active small businesses	90	2
FE3	Local government revenue	89	3
FE4	Not having insurance or insufficient insurance coverage	86	4
FE5	Lost household income	69	5
FE6	Uneven access to governmental financial resources	54	6
FE7	Level of housing value in affected area	53	7
FE8	Income disparity and diversification of livelihoods	48	8
FE9	Late allocation of funding resources	44	9
FE10	Level of post-disaster blight	31	10
FE11	Lack of legislation for controlling post-disaster blight	28	11
FE12	Delay in disbursement of emergency funds	21	12
FE13	Lack of transport-related businesses	18	13
FE14	Tough legislative criteria for low-income groups	16	14

A high rate of unemployment also results in higher crime rates in communities, absorbs part of the human and financial resources needed for enhancing social security (Audefroy, 2010), and results in fewer active small businesses in disaster-affected areas, and less availability of resources (Verderber, 2008; Andrew et al., 2013; Félix et al., 2014). The number of businesses in pre-disaster and post-disaster situations should be similar to provide resources for restoring the local community and for resiliency (Barenstein, 2006). For example, after Katrina, there has not been much desire in the Louisiana to achieve resiliency against extreme disasters; but, by efforts made by the local and Federal government and organizations such as FEMA the community was back to the resiliency track after a while (Pew Charitable Trusts, 2018).

Local government revenue and insufficient insurance were the next two most referred-to barriers, while the lost household income received the fifth top place with a significant reduction in number of references. Governmental financial advocacy is one of the most important factors in enabling communities to recover following a disaster - both for restoring the social services and systems, and for supporting the affected population's return to normalcy. The local and federal governments can provide the financial resources (Bilau et al., 2015); however, the local government's preparation plays a key role because the governors directly deal with the post-disaster issues and can accelerate the recovery process if they are financially prepared (Bilau et al., 2016). This is especially vital for residents without sufficient insurance coverage (Mechler, 2016). The lost household income prevents families from quickly returning to life as it was before the disaster, and results in lower standards of living, decreasing household amenities, and psychological problems (Murphy, 2007; Carrasco et al., 2016).

Governmental funding must be able to be accessed evenly by the affected community to achieve an effective recovery process, thus uneven access to governmental financial resources was identified as the sixth most frequently referred-to barrier in the studied literature. The seventh, eighth, and ninth barriers in the list of financial and economic barriers are housing values, income disparity, and late funding allocation respectively. High housing values and late allocation of the financial resources lead to delays in the process of recovery due to the rise of financial demands after disasters (Lou and Zhang, 2011; Sun and Xu, 2011). Disparity of income in an area indicates that the area is comprised of different social classes. The impacts of a disaster are different for each social class, making the process of recovery more complex (McGee, 2011; Minato and Morimoto, 2012; MacAskill and Guthrie, 2014; Department of Homeland Security, 2015).

The last five barriers of this category are related to post-disaster blight and blight legislation-related issues, delays in funding, lack of transport-related businesses, and tough legislations for low-income people after disasters. Blight is a common economic phenomenon that follows the occurrence of disasters (Zotti et al., 2013; Auzzira et al., 2014; Bostick et al., 2017) due to economic downturns, destroyed businesses, etc. Therefore, blight makes communities more vulnerable, and disrupts the process of recovery (Kousky, 2016). The late disbursement of emergency funds delays emergency recovery to the extent that it is incomplete when the short-term and long-term recovery is scheduled to commence, which postpones the whole recovery process to a later time (Wisner et al., 2004; Zahran et al., 2011; Zotti et al., 2013). Transport-related businesses, such as taxi services, trucking, shopping services, air cargo businesses, etc., are fundamental to the acceleration of the recovery process (El-Anwar et al., 2010). Since the transportation systems provide significant services, their proper functionality during post-disaster recovery plays a vital role in avoiding delays (Orabi et al., 2010). The disruption of transportation systems also leads to significant negative effects on the social, economic, and financial aspects of the affected areas. Moreover, since most probably the low-income communities do not have insurance and are not capable of meeting all the requirements to receive supports, less difficult legislations should be considered for them (Bostick et al., 2017).

2.4.2. Social

According to the social science literature, resiliency is defined as "*the complex web of social interactions, characteristics and capacities that enable a community to live with the hazards they face"* (Porter and Davoudi, 2012). Therefore, the communities are required to be prepared for mitigating the impacts of disasters and build resilience in order to reducing the negative effects of disaster and recover as rapidly as possible (Saja et al., 2019). The social category includes 10 post-disaster recovery barriers, among which diversity of culture and languages in the affected area was the most widely cited. As shown in Table 2-3, during the Hurricane Andrew recovery process, black families supported their relatives to a greater degree than the Anglo families did (Sanders et al., 2003).

Table 2-3. List of social barriers with frequency and rank.

ID	Social Barrier	Frequency	Rank
S1	Diversity of culture and languages in affected area	73	1
S2	Lack of disaster recovery public training	68	2
S3	Lack of voluntary public participation	67	3
S4	Large number of disabled & elderlies	63	4
S5	Education level of residents	57	5
S6	Population density	52	6
S7	Distrust among stakeholders	43	7
S8	Lack of traditional family and/or friend support	42	9
S9	Not being experienced in disastrous situations	41	9
S10	Unstable mental condition of affected people	39	10

The variations of languages in the affected areas also cause communication problems between the people and the supporting organizations (Nakhaei et al., 2016), which delay the process of recovery, and racial and ethnic communities are less interested in participating in public training programs (Zottarelli, 2008). The lack of disaster recovery public training, the second most cited social barrier, is related to pre-disaster actions, and results in the people affected by the disaster being in a situation of which they have no knowledge (Jordan and Javernick-Will, 2013). The third post-disaster recovery process facilitates the process by removing the bureaucratic norms

(Lowry, 2009; Aldrich, 2012). Even though some of the citizens may not have any technical expertise, having a plan that involves them throughout the recovery will be advantageous to recovery time management.

The extreme events and disasters are higher risks for elderly and disabled people than for most individuals (Ganapati, 2012; Beiler et al., 2016). Having a large number of disabled and elderly individuals is the fourth most referred-to social barrier, and makes it essential for the support teams to consider specific considerations, accommodations, and facilities for their relocation and services (Arouri et al., 2015), which requires more time than the same actions do for other people (Kronenberg et al., 2010; Bradshaw, 2012). The next most frequently addressed social barrier in the studied literature is the barrier of low education. Field investigations have shown that educated individuals are more likely to survive extreme events, and cope better during the long-term recovery period. Educated individuals are less eager to continue living in camps than less educated individuals are, and are more willing to make an effort to restore their homes and lives (Karlaftis and Peeta, 2009). They are also better able to follow regulations, which helps them accelerate the process of recovery (Chen and Miller-Hooks, 2012). High population density also affects the effectiveness and timeliness of post-disaster recovery. For example, more resources from funding, materials, and services are required for heavier populated communities, which leads to a greater recovery time (Li et al., 2011). It takes longer to relocate all of the people in a heavy-populated area before recovery is initiated (Lou and Zhang, 2011).

The next four referred-to social barriers in the studied literature were lack of traditional family and/or friend support, unstable mental condition, inexperience in disaster situations, and distrust among stakeholders. Receiving financial and mental support from a familiar person is a very important factor in accelerating the process of returning an affected person’s life to normalcy

(Li et al., 2011; Wang et al., 2012). Furthermore, in some disasters, the level of mental impact is very high and requires a greater recovery time (Wang et al., 2012). Being experienced in disastrous situations has proven to be helpful in reducing the recovery delays to achieve a more efficient recovery (Li et al., 2011) and helping communities avoid performing activities by trial and error. Furthermore, establishment of lessons learned from previous disasters in the area and updating the recovery planning before the next disaster have constructive effects on the recovery process (El-Anwar and Chen, 2014). The performance of the recovery is positively related to civil cooperation and trust among the social groups (Schwab et al., 2004). Distrust can separate people from social groups and organizations, thereby making the disaster recovery procedure difficult (El-Anwar and Chen, 2014; Arouri et al., 2015), while social trust can aid in the recovery (Heaney et al., 2000; Padgett and Tapia, 2013).

2.4.3. Infrastructure and Housing Reconstruction

Infrastructure is the name given to a series of systems and networks, such as water distribution systems, electric power, telecommunication systems, and transportation networks, that have a basic organizational role in the operation of a society (Heaney et al., 2000). Improper functioning of various infrastructures and buildings can affect all of the activities in an area (Lou and Zhang, 2011). While the post-disaster recovery provides the opportunity for building resilient infrastructures and housing, it usually involves a number of barriers (Ahmed, 2017). If the reconstruction of the infrastructures is slow, the resiliency that existed before the occurrence of the disaster could be achieved at most, and no considerable improvement could occur. However, with quick reconstruction, the recovery from the disaster would be accelerated, and the resiliency level of would consequently rise to a higher level (Moris and Diaz, 2020).

As shown in Table 2-4, this category consisted of eighteen barriers, among which land-use determination for rebuilding was cited the most often in the considered literature.

Table 2-4. List of infrastructure and housing reconstruction barriers with frequency and rank.

ID	Infrastructure and Construction Barrier	Frequency	Rank
IC1	Land-use determination for rebuilding	88	1
IC2	Damage to residential housing	83	2
IC3	Damage to commercial and industrial buildings	79	3
IC4	Damage to major transportation systems	78	4
IC5	Damage to major infrastructure systems	75	5
IC6	Improper physical development patterns and rules	70	6
IC7	Ignorance of traditional resources for reconstruction	67	7
IC8	Obstacles in the legislative for reconstruction approval	65	8
IC9	Unavailability of medical services after the disaster	63	9
IC10	Damage to medical services, like hospitals	59	10
IC11	Inappropriate infrastructure maintenance policies	58	11
IC12	Incompetence of contractors	55	12
IC13	Illegal construction during reconstruction	34	13
IC14	Insufficient built infrastructures	33	14
IC15	Insufficient construction method, quality, and practices	32	15
IC16	Unclear recovery and reconstruction regulations	27	16
IC17	Outdated construction standards and codes	17	17
IC18	Insufficient investment in natural buffers	16	18

Many natural disasters force decision-makers to change the land use to prevent rebuilding in disaster-prone regions (Orabi et al., 2009). Since buildings and infrastructures affected by a disaster are not usually located in the same areas, large-scale changes of land use rarely occur, even within the post-disaster period (Roosli and Collins, 2016). Conflicts on reconstruction in hazard-prone regions are more likely to arise between governors and homeowners, leading to a slowing down of the reconstruction process (Jordan and Javernick-Will, 2013). When damage to residential housing occurs, which is the second most cited infrastructure and housing reconstruction barrier, it is difficult to reconstruct or repair them quickly (El-Anwar et al., 2010). Timely reconstruction, with minimal delays, of important buildings in the affected areas is of major importance to the restoration of the affected community (Padgett and Tapia, 2013). Therefore, damage to commercial and industrial buildings, major transportation systems, and major infrastructure systems, were the third, fourth, and fifth most referred-to barriers of this category, and play key roles in delaying the process of recovery (El-Anwar and Chen, 2014). For example, late restoration of water distribution or electrical power in the affected area can cause delays in the reconstruction of all types of buildings (Jordan and Javernick-Will, 2013; Arouri et al., 2015). Natural disasters regularly invoke serious damages to transportation networks, which disrupts the public commute within the affected area (Padgett and Tapia, 2013). Since the reconstruction process relies upon the existence of functioning transportation systems, late restoration of the damages of such systems leads to delays in the post-disaster recovery process (El-Anwar et al., 2010).

The next most cited barriers of this category are respectively referred to as improper physical development patterns and rules, and ignorance of traditional resources for reconstruction. Improper urbanization patterns are relative to pre-disaster actions that affect the post-disaster reconstruction process and lead to chaotic situations, complexities, and conflicts among the stakeholders during reconstruction (Jordan and Javernick-Will, 2013; Schwab et al., 2014). Furthermore, using traditional techniques, materials, etc., helps achieve timely reconstruction when there is a lack of resources and services (Heaney et al., 2000).

Even when all of the needed resources are available for initiation of the reconstruction, obstacles in the legislation for reconstruction approval, the ninth barrier of this category, can lead to post-disaster reconstruction delays (Orabi et al., 2010; El-Anwar et al., 2010). Unavailability of medical services after the disaster, followed by damage to medical services are the next two most-repeated barriers of this category in the studied literature. Medical services and buildings are required immediately after a disaster to return the community to health (El-Anwar et al., 2010). Inappropriate infrastructure maintenance policies was the thirteenth barrier of the infrastructure and housing reconstruction category. The timely establishment of maintenance policies for infrastructures leads to a decrease in the vulnerability of such systems and increases their reliability (Roosli and Collins, 2016). Incompetence of contractors was the fourteenth most frequently cited barrier of this category in the studied literature (Padgett and Tapia, 2013). The demand for well-established contractors increases during the reconstruction process, and finding contractors who are capable of properly handling the reconstruction activities becomes difficult, and affects the labor productivity and results in reworks, conflicts, and further delays (Minato and Morimoto, 2012). Illegal construction during reconstruction was the next top-ranked barrier. Illegal construction worsens the already chaotic circumstances after a disaster, and results in the buildings not being safety compliant because they were not built according to standards (Jordan and Javernick-Will, 2013). Following a disaster, the need for infrastructures increases (Padgett and Tapia, 2013); therefore, insufficiently built infrastructures, which is the fifteenth most cited barrier, will slow down the reconstruction process (Arouri et al., 2015). The last four barriers of this category are related to: the insufficiency of construction methods, unclear reconstruction regulations, outdated standards, and insufficient investment in natural buffers (Roosli and Collins, 2016).

2.4.4. Environment

Numerous benefits are derived from the ecosystems and the environment, so they play an important role in the well-being of human beings (Uy and Shaw, 2013). The disaster risk reduction and resiliency to the disasters could be achieved by well-management of ecosystems and the environment. As shown in Table 2-5, six barriers were classified in the environment category: slow/late debris and erosion removal after a disaster, damage to environmental areas, high levels of water contamination, environmental harm, and air and noise pollution. These barriers can be used as the metrics of the natural environment recovery, but were cited much less frequently than the barriers of the other categories. They were primarily referred to in the context of specific natural disasters (El-Anwar et al., 2010). After a hurricane, though, erosion and environmental contaminations increase (Li et al., 2011).

Table 2-5. List of environment barriers with frequency and rank.

ID	Environment Barrier	Frequency	Rank
E1	Slow/Late debris and erosion removal after a disaster	43	1
E2	Damage to environmental areas	28	2
E3	Level of water contamination	27	3
E4	Level of environmental harm	26	4
E5	Level of air pollution	11	5
E6	Level of noise pollution	5	6

Slow debris removal leads to late recovery from disasters, slowing down the transportation systems (Pramudita and Taniguchi, 2014). Some researchers stated that timely removal of debris is very important for both mental and psychological health (Finch et al., 2010). Every natural disaster creates debris, and based on the amount generated, it takes weeks, or even months, to fully remove it so that recovery can begin (Roosli and Collins, 2016). Since the amount can vary, the responsibility for removing the debris from public and private properties should be assigned clearly in the recovery planning (Orabi et al., 2010). The magnitude and distribution of damage to environmental areas and the ecosystems (e.g. the vegetation) after a disaster can severely extend the long-term recovery process (Chen and Sun, 2010; Wang et al., 2019). Bothe the detection of the damages of this type and the recovery itself takes long time and requires spending huge amount of funds (Wang et al., 2019). Before performing recovery, environmental hazards, water contaminations, air pollutions, and noise pollutions should be controlled, which might cause delays in the process if not cleared systematically, since the workers will not able to work in the area due to noise and/or air pollution (Weerakoon et al., 2015).

2.4.5. Coordination and Resources

The implementation of different methods, such as technologies, to improve the coordination and resources allocation within the post-disaster recovery can effectively reduce the time of recovery (Yulianto et al., 2020). The coordination and resources category includes fifteen barriers, among which lack of comprehensive resource database was cited most often in the literature, as shown in Table 2-6. Access to a comprehensive database of all resources helps to optimize the allocation of resources and avoid delays (Jordan and Javernick-Will, 2013). For instance, if a list of vulnerable and historic buildings is prepared by the local government, the required resources can be allocated to them as quickly as possible following a disaster (Pramudita and Taniguchi, 2014). Number of available active contractors after a disaster was the second most referred-to barrier in the studied literature, and was very close in number to the first ranked barrier.

Table 2-6. List of coordination and resources barriers with frequency and rank.

ID	Coordination and Resources Barrier	Frequency	Rank
CR1	Lack of comprehensive resource database	88	1
CR2	Number of available active contractors	86	2
CR3	Slow/Improper decision-making for recovery actions	74	3
CR4	Unsmooth relocation before reconstruction	72	4
CR5	Lack of appropriate policies for people's relocation	60	5
CR6	Undefined roles and responsibilities in the recovery	58	6
CR7	Misalignment between Federal policies and local planning	48	7
CR8	Inappropriate material allocation and disbursement	39	8
CR9	Community engagement during recovery policy development	38	9
CR10	Weak cooperation among NGOs and governmental entities	37	10
CR11	Occurrence of multiple disasters in a short period	18	11
CR12	Unclear moratoria or temporary construction restrictions	16	12
CR13	Local capacity of producing materials	15	13
CR14	Political Pressure	11	14
CR15	Engagement of technical expertise for recovery planning	10	15

The number of available contractors often are less than the demand in the affected areas, which causes delays in the recovery process (Schwab et al., 2014). Slow recovery is often a result of slow/improper decision-making for recovery actions, the third most referred-to barrier in this category. The next two most cited barriers of this category are respectively referred to as unsmooth relocation and lack of appropriate policies for peoples' relocation. Unsmooth relocation leads to the affected residents being unable to access transportation systems and other infrastructures, and consequently increases chaos and the time of reconstruction (Li et al., 2011; Roosli and Collins, 2016). Furthermore, relocation of the people should be performed with the help of a roadmap, to avoid conflicts and corresponding delays (Pramudita and Taniguchi, 2014).

Undefined roles and responsibilities in the recovery is the next most frequently mentioned barrier in the literature. Clarity of the roles decreases the reworks and conflicts, optimizes the performance, and leads toward timely post-disaster recovery (El-Anwar and Chen, 2014). Alignment between federal policies and local planning procedures helps to avoid the above-mentioned issues and consequent delays (Schwab et al., 2014). Inappropriate material allocation and disbursement, community engagement during recovery policy development, and weak cooperation among NGOs and governmental entities are the sixth, seventh, and eighth most cited barriers, which have been referred to almost the same number of times. The sixth barrier leads to too many materials in some locations and not enough in others, which causes delays while extra time and money is spent to locate the materials (El-Anwar and Chen, 2014).

Community engagement during recovery policy development is important because communities that are involved in the policy-making process are familiar with the regulations and challenges of disasters, and may share their knowledge with those less informed. Thus, their engagement in the planning process positively influences the timeliness of the recovery process (Ku and Ma, 2015). The eighth barrier causes delays in the process of post-disaster recovery due to repetition of activities and even opposite actions by different groups. The last five coordination and resources barriers were mentioned less often in the literature. These barriers noted the occurrence of multiple disasters in a short period of time, unclear moratoria or temporary construction restrictions, incapability of local governments to produce materials, political pressure, and less implementation of technical expertise for recovery planning development.

2.5. Conclusion

This paper strived to identify the barriers to an effective and timely post-disaster recovery process. From the database, 62 barriers to effective and timely post-disaster recovery were identified and classified in five categories: financial and economic, social, infrastructure and housing reconstruction, environment, and coordination and resources. Rate of employment after a disaster was the most-cited barrier in the financial and economic category. Unemployment can create obstacles in the recovery process and often results in higher crime rates in the affected communities, wasting the human and financial resources needed for enhancing social security. Diversity of culture and languages in the affected area was the most-cited barrier in the social category. Variations in the languages of people in affected areas lead to communication difficulties between the people and the supporting organizations. The most referred barrier of the infrastructure and housing reconstruction category was land-use determination for rebuilding, due to conflicts between governors and homeowners on recovery in hazard-prone regions. Slow/late debris and erosion removal after the disaster was the top-ranked barrier in the environment category. After a disaster, it requires weeks, or even months, to fully remove the debris and start the recovery work, which delays the recovery process. The most referred barrier of the coordination and resources category was the lack of a comprehensive resource database. Access to a comprehensive database of all resources helps to optimize the allocation of resources and avoid delays.

The infrastructure and housing reconstruction category consisted of 18 barriers, highest number of barriers among all the identified recovery barrier categories. The results mainly show that the barriers of environment category, which are very important in the long-term recovery process, were not much studied by the researchers. So, due to their importance, for the future work it is suggested that more focus be dedicated on these barriers. Furthermore, the dynamic relations among different recovery barriers and categories need to be examined which help with optimization of post-disaster recovery tasks. The results of this research will assist policymakers acquire the knowledge necessary for modeling effective post-disaster recovery processes, and develop practical policies that can achieve successful recovery activities.

2.6. References

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CHAPTER 3. COMPARATIVE ANALYSIS OF PUBLIC'S AND EXPERTS' PERSPECTIVES ON BARRIERS CAUSING DELAYS IN POST-HURRICANE RECOVERY PROCESS

Abstract

Post-hurricane recovery barriers are differently interpreted by the recovery experts and the public. This gap can lead to increase of the recovery process; thus, understanding how differently the experts and public prioritize the barriers toward timely recovery after hurricanes would lead to avoiding the corresponding delays. The aim of this study was to (1) determine expert's and public's perspectives on social, economic, infrastructure & construction, environment, and coordination & resources barriers to timely post-hurricane recovery and, (2) prioritize the barriers of timely post-hurricane recovery based on public's and experts' perspectives. To achieve these objectives, sixty-two (62) barriers to timely post-hurricane recovery were identified and categorized into five categories: financial and economic, social, infrastructure and construction, environment, and coordinate and resources. Then, a survey was developed and distributed to experts and public separately to explore their perspectives of the importance of the identified barriers. One-hundred and nighty five (195) of the public and 44 experts responded to the survey. Relative Importance Index (RII) analysis was used to rank the identified barriers to timely post-disaster recovery. Ten interviews were then conducted to validate the obtained results. It was found that the experts determined the undefined roles and responsibilities in the recovery (B53) as the most important barrier to timely post-hurricane recovery, while the public believed insufficient built infrastructures (B40) was the top barrier to timely post-disaster recovery. In addition, Top-three barriers that were most differently understood by the two groups were respectively damage to major transportation systems (B28), improper physical development patterns and rules (B31), and

damage to commercial and industrial buildings (B27). This demonstrates that there is a gap of mutual understanding between the experts and the public on the physical barriers rather than other barriers. The results of this research would help reduce the gap between the experts' and public's perspectives on post-hurricane recovery barriers and assist the experts understand public's perspectives and adopt strategies that better serve public needs after recovery.

3.1. Introduction

The number and severity of devastating natural disasters have been extremely on the rise during the last decades all over the world (Field et al., 2012; Zhang and Managi, 2020). Consequently, the corresponding total losses and damages due to catastrophic events have increased proportionally (Zhang and Chang, 2020). Through the last decades, U.S. has frequently experienced severe hurricanes (Sajjad et al., 2020). According to the published report by National Hurricane Center (NHC) in 2020, forty-five (45) hurricanes occurred in the U.S. between 2000 and 2009, while seventy-two (72) hurricanes happened after 2010. Furthermore, nine of the top ten costliest hurricanes in the history of U.S. occurred after the year 2000 (NHC, 2020). Therefore, achieving timely post-hurricane recovery is of high importance.

After a hurricane, the decision-makers (including the governors and the experts in the area of post-hurricane recovery) need to make decisions to bring back the affected community to pre-event condition (Smith, 2012; Nejat and Ghosh, 2016). Normally, both the local and federal governors develop and prepare recovery planning prior to occurrence of natural disasters (Mitchell et al., 2012). To achieve timely recovery, it is necessary to effectively implement a pre-developed recovery plan in which the public's perspectives on barriers to post-disaster recovery are considered and integrated (Nelson, et al., 2007; Bernier et al., 2019).

Although on barriers of timely post-hurricane recovery, and (2) prioritize the barriers of timely multiple studies have been conducted on the post-hurricane planning, a few studies have been conducted to investigate the gap between the public's perspectives on post-hurricane recovery barriers that lead to delays, and that of the experts. Therefore, this study articulated the following research objectives: (1) determine experts' and public's perspectives post-hurricane recovery based on public's and experts' perspectives. The outputs of this research enhance the experts' and public's insight on the barriers to timely recovery after hurricanes. In addition, the findings of this study assist decision-makers develop plans integrating public's perspectives on barriers to timely post-disaster recovery.

3.2. Literature Review

3.2.1. Natural Disasters, Hurricane, and Recovery

The increasing number of natural disasters within the last decades caused many damages, loss of lives, economic and social issues, etc. all around the world (Field et al., 2012; Gori et al., 2020; Schaffer-Smith et al., 2020). Among different types of natural disasters, hurricanes are significantly devastating and frequent in the U.S. (Weinkle et al., 2018; Sajjad et al., 2020). For instance, Hurricane Katrina which happened in 2005, has been the most destructive natural disaster in the history of U.S. (Freeman and Ashley, 2017). In addition, within the last ten years, several extreme hurricanes happened in the U.S. such as Maria, Harvey, Irma, Florence, Michael, Sandy, etc. each causing serious number of fatalities and destructions in several states (Sajjad et al., 2020). Thus, significant attention for bringing back the hurricane-affected communities has been dedicated by recovery decision-makers and experts (Nejat and Chosh, 2016).

3.2.2. Post-Hurricane Recovery

The recovery is defined as the process of rebuilding and/or repairing the damaged buildings, facilities, and infrastructure; reestablishing the businesses; and bringing the affected community to normal functioning (Federal Emergency Management Agency (FEMA), 2011; Schwab et al., 2014). Following a hurricane, the recovery process starts to bring back the society to the normalcy (Cimellaro et al., 2016). However, according to the complexity of recovery process, this process usually lasts longer than expected (Lambert and Patterson, 2002; Sanusi et al., 2020). The delay in the process of recovery influences the routine lifestyle of the region and lead to inevitable social and economic consequences (Choi et al., 2019). Thus, a main concern for the hurricane-affected areas is always recovering in a timely manner (FEMA, 2011). Several studies have been conducted to analyze post-hurricane recovery process. For instance, Nejat and Ghosh (2016) developed a statistical predictive model based on Hurricane Sandy for making appropriate post-hurricane recovery decisions. Their analysis showed the high significance of financial indicators on the effectiveness of the recovery process; regarding time and cost.

3.2.3. Experts' and Public's Understanding on Post-Hurricane Barriers

In many different hurricanes such as Hurricane Katrina, the perspectives of the people and their reactions differ with the ones of the experts. For the decision-makers and policy-makers, a very essential decision-making issue after hurricanes has been achieving timely recovery of the hurricane-affected communities (Schwab et al., 2014). Therefore, having an appropriate understanding of the multiple barriers of on-time post-hurricane recovery would enable the decision-makers to reach timeliness in the process of recovery (FEMA, 2011). In addition, the affected communities need to have an appropriate understanding of the situation and the barriers of timely recovery after a hurricane to sufficiently cooperate and act to the directions given by the recovery policies and planning (Palttala et al., (2012). Sharing information among the public and obtaining information from them could improve the recovery process by decreasing the time and cost of recovery (Beierle and Cayford, 2002; Tuler and Webler, 2020). For example, the experts who make plans for post-hurricane recovery in an area need to render the priorities to the public and also need to know the concerns of the public about the recovery issues (Choi et al., 2019). This could also build trust between the decision-makers and the affected communities, which would accelerate the process of recovery (FEMA, 2011).

A few researches have investigated the various understandings of the experts and the public on post-hurricane issues and barriers. Nelson et al. (2007) explored the challenges through recovery process after Hurricane Katrina. Their investigation showed that even though the residents' participation in the recovery process was helpful; their different priorities of the recovery actions compared to the ones of the professionals caused issues in the recovery process. Sullivan et al. (2009) assessed the public's risk perception on issues after a hurricane and identified the potential list of their needs and expectations in a post-hurricane circumstance. Palttala et al. (2012) investigated the practical communication gaps in post-hurricane management process and identified that poor mutual understanding between the decision-makers and the public exists, which leads to unsuccessful implementation of recovery practices.

3.2.4. Identification and Categorization of Barriers of Timely Post-Hurricane Recovery

During the time, a number of researches have been conducted to determine the impeding factors and barriers that avoid on-time completion of post-hurricane recovery process. In general, these barriers can be classified into different categories. By conducting a comprehensive review of the existing literature, 62 barriers to timely post-hurricane recovery were identified and classified into five categories including financial and economic, social, infrastructure and construction, environment, and coordination and resources. In Table 3-1, the identified barriers and their sources are shown.

Fourteen (14) barriers, with IDs of B1-B14, were classified in financial and economic category. According to Table 3-1, the barriers of this category refer to post-hurricane issues such as lack of job (Audefroy, 2010), lost income (Carrasco et al., 2016), low number of active businesses (Barenstein, 2006), uneven and late access to funding (MacAskill and Guthrie, 2014), etc. In post-hurricane circumstances, people need source of funds to rebuild their lives (Félix et al., 2014). Hence, being unemployed can cause major issues in the recovery path (Alipour et al., 2015). Furthermore, lack of governmental financial support is another barrier which acts as an important obstacle for the communities recovering following a hurricane (Bostick et al., 2017).

The social category includes 10 barriers, with IDs of B15-B24. As shown in Table 3-1, the barriers of this category refer to post-hurricane social issues such as social diversities (Chen and Miller-Hooks, 2012; Nakhaei et al., 2016), lack of public training and participation (Aldrich, 2012; Jordan and Javernick-Will, 2013), high population (Li et al., 2011), lack of familial support (Heaney et al., 2000), etc. The variation of race, language, culture, and education in the affected areas lead to many communication issues and even distrust between the public and the governors (Nakhaei et al., 2016).

As shown in Table 3-1, infrastructure and reconstruction category included 20 barriers, with IDs of B25-B44. The barriers of this category cover post-hurricane issues such as damage to the buildings and infrastructures (El-Anwar et al., 2010; Padgett and Tapia. 2013), public relocation issues (Roosli and Collins, 2016), lack of policies, codes, and regulations (Pramudita and Taniguchi, 2014), illegal constructions (Lou and Zhang, 2011), etc. When damage to infrastructures, medical buildings, and other important buildings occurs, it will become difficult to reconstruct them quickly (El-Anwar et al., 2010). Moreover, improper operation of infrastructures after a hurricane can negatively impact the timeliness of recovery activities (Lou and Zhang, 2011). In addition, arise of conflicts between stakeholders in a post-hurricane situation is another barrier of this category, which leads to slowing down the recovery process (Jordan and Javernick-Will, 2013).

Table 3-1. List of identified barriers to timely post-hurricane recovery and the sources.

ID	Category & Barrier	Source
	Financial and Economic	
B1	Rate of employment	Alipour et al., 2015; Audefroy, 2010
B2	Number of active small businesses	Verderber, 2008; Andrew et al., 2013; Félix et al., 2014; Barenstein, 2006
B3	Local government revenue	Bilau et al., 2015; Bilau and Witt. 2016
B4	Not having insurance or insufficient insurance coverage	Mechler, 2016
B5	Lost household income	Murphy, 2007; Carrasco et al., 2016
B6	Uneven access to governmental financial resources	Wisner et al., 2003; Lou and Zhang, 2011
B7	Level of housing value in affected area	Verderber, 2008; Lou and Zhang, 2011
B8	Income disparity and diversification of livelihoods	McGee, 2011; Minato and Morimoto, 20121
B9	Late allocation of funding resources	MacAskill and Guthrie, 2014
B10	Level of post-disaster blight	Zotti et al., 2013; Auzzira et al., 2014; Bostick et al., 2017
B11	Lack of legislation for controlling post-disaster blight	Kousky, 2016
B12	Delay in disbursement of emergency funds	Zotti et al., 2013; Wisner et al., 2004; Zahran et al., 2011
B13	Lack of transport-related businesses	El-Anwar et al., 2010; Orabi et al., 2010
B14	Tough legislative criteria for low-income groups	Bostick et al., 2017
	Social	
B15	Diversity of culture and languages in affected area	Sanders et al., 2003; Nakhaei et al., 2016
B16	Lack of disaster recovery public training	Zottarelli, 2008; Jordan and Javernick-Will, 2013
B17	Lack of voluntary public participation	Lowry, 2009; Aldrich, 2012
B18	Large number of disabled & elderlies	Ganapati, 2012; Beiler et al., 2016
B19	Education level of residents	Karlaftis and Peeta, 2009; Chen and Miller-Hooks, 2012
B20	Population density	Lou and Zhang, 2011; Li et al., 2011
B21	Distrust among stakeholders	Schwab et al., 2014; El-Anwar and Chen, 2014
B22	Lack of traditional family and/or friend support	Heaney et al., 2000

B23	Not being experienced in disastrous situations	Li et al., 2011; El-Anwar and Chen, 2014
B24	Unstable mental condition of affected people	Li et al., 2011; Wang et al., 2012
	Infrastructure and Construction	
B25	Land-use determination for rebuilding	Orabi et al., 2009; Roosli and Collins, 2016
B26	Damage to residential housing	Jordan and Javernick-Will, 2013
B27	Damage to commercial and industrial buildings	El-Anwar et al., 2010
B28	Damage to major transportation systems	Padgett and Tapia, 2013
B29	Damage to major infrastructure systems	El-Anwar et al., 2010
B30	Unsmooth relocation before reconstruction	Li et al., 2011; Roosli and Collins, 2016
B31	Improper physical development patterns and rules	Schwab et al., 2014; Jordan and Javernick-Will, 2013
B32	Ignorance of traditional resources for reconstruction	Heaney et al., 2000
B33	Obstacles in the legislative for reconstruction approval	El-Anwar et al., 2010; Orabi et al., 2010
B34	Unavailability of medical services after the disaster	El-Anwar et al., 2010
B35	Lack of appropriate policies for people's relocation	Pramudita and Taniguchi, 2014
B36	Damage to medical services, like hospitals	El-Anwar et al., 2010
B37	Inappropriate infrastructure maintenance policies	Roosli and Collins, 2016
B38	Incompetence of contractors	Minato and Morimoto, 2012; Heaney et al., 2000
B39	Illegal construction during recovery	Lou and Zhang, 2011
B40	Insufficient built infrastructures	Padgett and Tapia. 2013
B41	Insufficient construction method, quality, and practices	Arouri et al., 2015
B42	Unclear reconstruction and recovery regulations	Roosli and Collins, 2016
B43	Outdated construction standards and codes	Padgett and Tapia. 2013
B44	Insufficient investment in natural buffers	El-Anwar and Chen, 2014
	Environment	
B45	Slow/Late debris and erosion removal after a disaster	Orabi et al., 2010; Finch et al., 2010
B46	Level of water contamination	Weerakoon et al., 2015
B47	Level of environmental harm	Roosli and Collins, 2016; Finch et al., 2010
B48	Level of air pollution	Weerakoon et al., 2015
B49	Level of noise pollution	Orabi et al., 2010; Roosli and Collins, 2016
	Coordination and Resources	
B50	Lack of comprehensive resource database	Jordan and Javernick-Will, 2013; Pramudita and Taniguchi, 2014
B51	Number of available active contractors	Schwab et al., 2014
B52	Slow/Improper decision-making for recovery actions	El-Anwar and Chen, 2014
B53	Undefined roles and responsibilities in the recovery	El-Anwar and Chen, 2014
B54	Misalignment between Federal policies and local planning	Schwab et al., 2014
B55	Inappropriate material allocation and disbursement	El-Anwar and Chen, 2014
B56	Community engagement during recovery policy development	Ku and Ma, 2015

B57	Weak cooperation among NGOs and governmental entities	Arouri et al., 2015
B58	Occurrence of multiple disasters in a short period	Kronenberg et al., 2010
B59	Unclear moratoria or temporary construction restrictions	Bradshaw, 2012
B60	Local capacity of producing materials	Heaney et al., 2000
B61	Political Pressure	Padgett and Tapia. 2013
B62	Engagement of technical expertise for recovery planning	McGee, 2011

Five barriers with IDs of B45-B49 were classified in the environment category: slow/late debris and erosion removal (Orabi et al., 2010), high levels of water contamination (Weerakoon et al., 2015), environmental harm (Roosli and Collins, 2016), air pollution (Weerakoon et al., 2015). and noise pollution (Orabi et al., 2010). Slow debris removal leads to late recovery from hurricanes (e.g. by slowing down the transportation systems) (Finch et al., 2010). According to several researches, timely removal of air and noise pollutions after a hurricane are very important for both mental and psychological health (Finch et al., 2010; Orabi et al., 2010; Weerakoon et al., 2015). The coordination and resources category included 13 barriers, with IDs of B50-B62. The barriers of this category include issues such as lack of resources (Pramudita and Taniguchi, 2014; Schwab et al., 2014), weak cooperation (Arouri et al., 2015; Ku and Ma, 2015), slow decision-making (El-Anwar and Chen, 2014), etc. Preparing a comprehensive database of all the resources would help optimizing the allocation of resources and avoiding delays (Jordan and Javernick-Will, 2013). For instance, when the list of important buildings is prepared before the hurricane happening, the needed resources can be allocated as fast as possible (Pramudita and Taniguchi, 2014). Furthermore, insufficient number of active contractors after a hurricane can affect the timeliness of the recovery process (Schwab et al., 2014).

In summary, the experts' and public's understanding of the post-hurricane situation differs due to several reasons (Tuler and Webler, 2020). People, based on their perception of the post-hurricane situation and barriers, sometimes react inappropriately, which leads to issues in the process of recovery and consequently may cause delays in the process (Sullivan et al., 2009). In this regard, improving the mutual understanding of the issues and barriers delaying the post-hurricane recovery between the public and experts is required. There is a lack of comprehensive understanding of the gap between the public's and experts' perception on post-hurricane barriers. Therefore, this study aims to identify and prioritize the post-hurricane barriers to timely recovery process according to the public and the experts' perspectives.

3.3. Research Method

The process of the study included nine steps. In the first step, a thorough literature review was conducted. More than 450 peer-reviewed articles, conference papers, and other relative documents were collected. In step 2, sixty-two (62) potential barriers to timely post-hurricane recovery were identified and categorized into five categories: financial and economic, social, infrastructure and construction, environment, and coordination and resources. In the third step, according to the identified barriers, a survey was developed to determine the importance of the barriers and distributed to two groups separately: public individuals who had been involved in at least one major hurricane, and experts who were active in the management of post-hurricane recovery activities. In the fourth step, the significance level of the barriers was identified according to both surveyed group's perspectives, using the Kruskal-Wallis test. In steps 5 and 6, the barriers were ranked according to public and experts responses to the survey using RII method. In step 7, the results of the conducted analyses within steps 4 to 6 were compared and discussed. In step 8, interviews were conducted with ten recovery experts and finally, in step 9, the results of the surveys were evaluated and discussed based on the conducted interviews. Fig. 1 shows the research methodology utilized in this study. Figure 3-1 shows the research methodology utilized in this study.

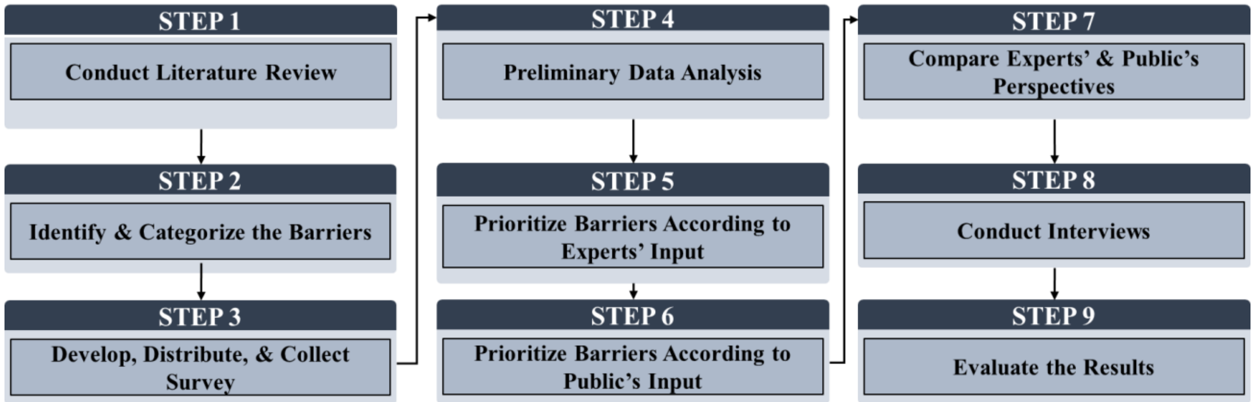


Figure 3-1. Research methodology.

3.3.1. Kruskal-Wallis Method

The Kruskal-Wallis test is a nonparametric procedure used for testing the null hypothesis that n independent samples are identical (Kvam and Vidakovic, 2007). This technique can be used for analysis of Likert-scale data in which the distribution of the residuals do not follow a normal distribution. The test statistic, H, is attained using eq. 1.

$$H = (N-1)\frac{\sum_{i=1}^{g} n_i(\bar{r}_i-\bar{r})^2}{\sum_{i=1}^{g}\sum_{j=1}^{n_i}(r_{ij}-\bar{r})^2} \quad (1)$$

Where,

n_i is the number of observations in group

r_{ij} is the rank,

N is the total number of observations in all groups

$\bar{r}_i$ is the average rank of all observations in group i, and

$\bar{r}$ is the average of all r_{ij}.

3.3.2. Relative Importance Index (RII) Analysis

To determine the ranking of different factors from the viewpoint of different groups, the RII can be used (Muhwezi and Otim, 2014). RII is the mean for a factor which gives it weight in the perceptions of respondents. The RII is attained using eq. 2.

$$\mathrm{RII} = \frac{\sum \mathrm{W}}{(\mathrm{A} \times \mathrm{N})} \qquad (2)$$

Where,

W is weightage given to each factor by the respondents,

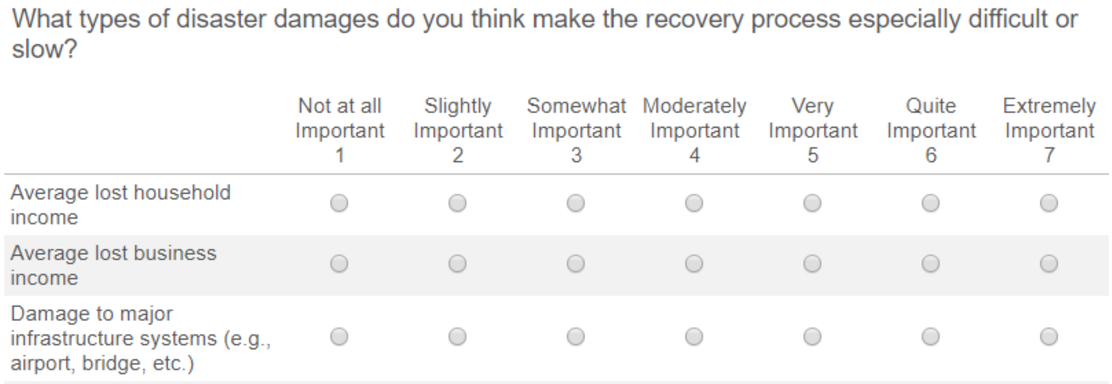
A is the highest weight, and

N is the total number of respondents.

3.4. Data Collection

3.4.1. Survey Development and Distribution

Based on the identified barriers from the literature, a survey was developed to collect the perspectives of the experts and public on the importance of barriers to post-hurricane recovery timeliness. The survey included three sections including respondents’ demographic information, the information of the hurricane(s) they were involved in (such as severity, location, etc.), and the main questions on the importance of each barrier to timely post-hurricane recovery. In the third section, 62 Likert-scale questions were designed and the participants were asked to determine each barriers’ importance on timeliness of post-hurricane process by scoring them from one to seven (one: not at all important, and seven: extremely important). Before sending out the survey, it was pilot-tested by 10 individuals to assure its clarity and accuracy. Figure 3-2 presents a sample question of the survey.



What types of disaster damages do you think make the recovery process especially difficult or slow?

	Not at all Important 1	Slightly Important 2	Somewhat Important 3	Moderately Important 4	Very Important 5	Quite Important 6	Extremely Important 7
Average lost household income							
Average lost business income							
Damage to major infrastructure systems (e.g., airport, bridge, etc.)							

Figure 3-2. Sample question of the survey.

Experts in the post-hurricane recovery and the public having at least one post-hurricane experience were separately asked to take this survey. More than three-hundred (300) experts active in the area of post-hurricane recovery from different organizations and institutes in the U.S., including state emergency management centers, the FEMA, the National Oceanic and Atmospheric Administration (NOAA), etc. were invited by email and phone to complete the survey, out of which 44 responded. All of the expert participants in this survey had at least a college or university degree and approximately 82% of them had a bachelor's or higher level of education. The demographic information of the experts participating in the survey is demonstrated in Table 3-2.

Table 3-2. Demographic information of the expert participants in the survey.

Education Level	**Count**
Associate Degree (2-year College)	8
Bachelor's Degree	18
Master's Degree	9
Doctoral Degree	5
Professional Degree (JD, MD)	4
Total	44

To collect the public's perspectives, the survey was distributed through online social media, including Twitter, Facebook, and Instagram, and also, as hard copies to individuals. Input from 195 university/college students, engineers, project managers, etc. was collected. The demographic information of the public participants is shown in Table 3-3. As shown, more than 80% of the participants had at least a college or university degree and more than 60% of them had a bachelor's degree or higher.

The results of the collected data from both group of respondents (experts and public) is presented and discussed in this section of the paper. First, the preliminary analysis of the raw data is presented. Then, the result of significance level test is provided. Next, the barriers and their categories are weighted, ranked, and compared according to both group's perspectives.

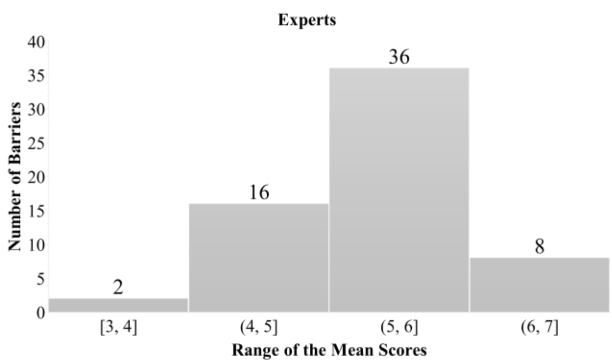
Table 3-3. Demographic information of the public participants in the survey.

Education Level	**Percent (%)**
High School Diploma	18.97
Some College, No Degree	7.18
Two-year College	12.31
Bachelor's Degree	37.44
Master's Degree	23.59
Doctoral Degree	0.51
Total	100

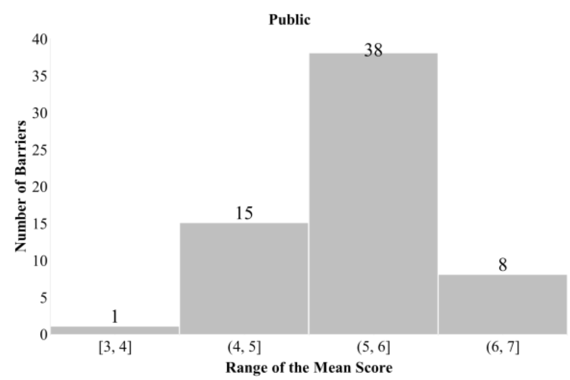
3.5. Results and Discussion

3.5.1. Preliminary Data Analysis

Figure 3-3 shows the scores of the barriers descriptively. As shown in Figure 3-3a, the barrier scores given by the experts range from three to seven. Thirty-six (36) of the barriers (out of 62) received a mean score between five (very important) to six (quite important). In addition, only two of the barriers were scored between three (slightly important) to four (somewhat important). On the other hand, Figure 3-3b shows the range of the barrier scores given by the public. Similar to the experts' responses, the barrier scores given by the public range from three to seven and 38 of the barriers received a mean score between five (very important) to six (quite important). Also, only one of the barriers was scored between three (slightly important) to four (somewhat important). In summary, although the emerging trend of the barriers' scores is very similar according to the public and experts, this does not mean that their perspectives of the barriers is the same. In sum, the mean score of the barriers given by the two groups vary significantly when comparing them visually one by one. For example, the difference of the scores in damage to residential housing (B26), Damage to commercial and industrial buildings (B27), and damage to transportation systems (B28) are very large. In addition, in 38 of the barriers, the experts gave a higher score than the public; while, 14 of the scores were equal.



a. Number of barriers' in different ranges of mean scores given by the experts



b. Number of barriers' in different ranges of mean scores given by the public

Figure 3-3. Descriptive comparison of the public's and experts' input to the survey.

3.5.2. Significance Level Test

The significance level of the collected survey results was evaluated. Because the collected data was in the form of the Likert-scale, the Kruskal-Wallis test was selected as the appropriate test for performing this evaluation. The Null and Alternative hypotheses of this test were as follows:

- *Null hypothesis:* the median of post-hurricane recovery barrier scores given by the public and experts are the same
- *Alternative hypothesis:* the median of post-hurricane recovery barrier scores given by the public and experts are significantly different

For a 95% confidence level, if the P-value≤0.05 the null hypothesis is rejected, which means the mean score of the importance of the barrier on time of recovery is significantly different between the experts and public. As shown in Table 3-4, with 95% confidence level, 42 of the barriers were significant. Nine of the barriers from financial and economic category, seven from social, 13 from infrastructure and construction category, two from environment category, and 10 from coordination and resources category were significant. Even though the significance of 20 barriers was not achieved with significance level of 5%, all of the 62 barriers were included for prioritization in the next steps due to their practical importance and for reserving the study more comprehensive.

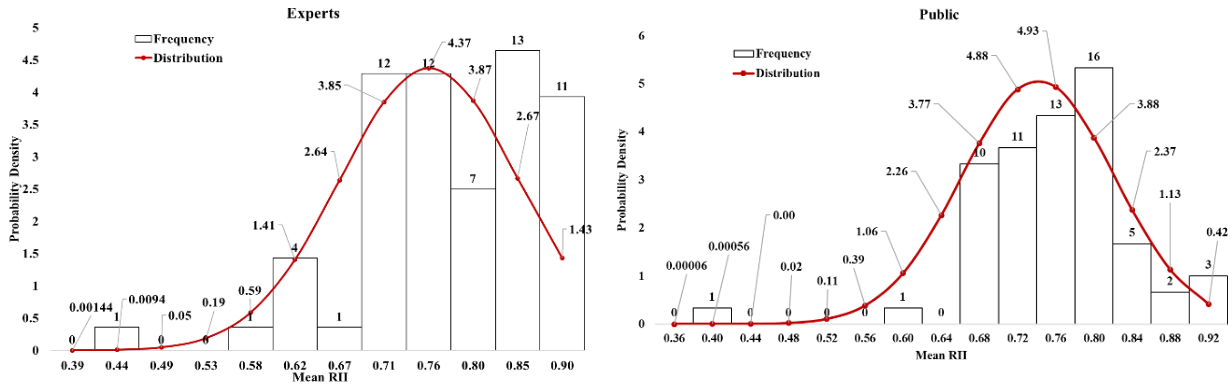
Table 3-4. Significance level test results.

ID	Category & Barrier	P-Value
	Financial and Economic	
B1	Rate of employment	0.0231*
B2	Number of active small businesses	0.01002*
B3	Local government revenue	0.0340*
B4	Not having insurance or insufficient insurance coverage	0.6001
B5	Lost household income	0.7002
B6	Uneven access to governmental financial resources	0.0100*
B7	Level of housing value in affected area	0.0000*
B8	Income disparity and diversification of livelihoods	0.3900
B9	Late allocation of funding resources	0.0000*
B10	Level of post-disaster blight	0.0000*
B11	Lack of legislation for controlling post-disaster blight	0.1312
B12	Delay in disbursement of emergency funds	0.0000*
B13	Lack of transport-related businesses	0.0020*
B14	Tough legislative criteria for low-income groups	0.2010
	Social	
B15	Diversity of culture and languages in affected area	0.0000*
B16	Lack of disaster recovery public training	0.0000*
B17	Lack of voluntary public participation	0.0001*
B18	Large number of disabled & elderlies	0.0000*
B19	Education level of residents	0.0000*
B20	Population density	0.1547
B21	Distrust among stakeholders	0.6867
B22	Lack of traditional family and/or friend support	0.1000
B23	Not being experienced in disastrous situations	0.0000*
B24	Unstable mental condition of affected people	0.0002*
	Infrastructure and Construction	
B25	Land-use determination for rebuilding	0.8010

B26	Damage to residential housing	0.0000*
B27	Damage to commercial and industrial buildings	0.0127*
B28	Damage to major transportation systems	0.0001*
B29	Damage to major infrastructure systems	0.1412
B30	Unsmooth relocation before reconstruction	0.0000*
B31	Improper physical development patterns and rules	0.0020*
B32	Ignorance of traditional resources for reconstruction	0.1010
B33	Obstacles in the legislative for reconstruction approval	0.0003*
B34	Unavailability of medical services after the disaster	0.0000*
B35	Lack of appropriate policies for people's relocation	0.0001*
B36	Damage to medical services, like hospitals	0.0002*
B37	Inappropriate infrastructure maintenance policies	0.0000*
B38	Incompetence of contractors	0.1543
B39	Illegal construction during recovery	0.5856
B40	Insufficient built infrastructures	0.0000*
B41	Insufficient construction method, quality, and practices	0.0006*
B42	Unclear reconstruction and recovery regulations	0.0002*
B43	Outdated construction standards and codes	0.7017
B44	Insufficient investment in natural buffers	0.0003*
	Environment	
B45	Slow/Late debris and erosion removal after a disaster	0.0128*
B46	Level of water contamination	0.0000*
B47	Level of environmental harm	0.1002
B48	Level of air pollution	0.1000
B49	Level of noise pollution	0.2020
	Coordination and Resources	
B50	Lack of comprehensive resource database	0.0210*
B51	Number of available active contractors	0.0003*
B52	Slow/Improper decision-making for recovery actions	0.0000*
B53	Undefined roles and responsibilities in the recovery	0.0001*
B54	Misalignment between Federal policies and local planning	0.0000*
B55	Inappropriate material allocation and disbursement	0.0000*
B56	Community engagement during recovery policy development	0.1447
B57	Weak cooperation among NGOs and governmental entities	0.4860
B58	Occurrence of multiple disasters in a short period	0.0000*
B59	Unclear moratoria or temporary construction restrictions	0.0001*
B60	Local capacity of producing materials	0.0002*
B61	Political Pressure	0.1010
B62	Engagement of technical expertise for recovery planning	0.0002*

3.5.3. Ranking of the Barriers

The contribution of the barriers to post-hurricane recovery process was examined and their ranking in terms of their importance as perceived by the respondents was performed by use of RII analysis. Initially, the normal probability graph and distribution histogram of the computed RII for both the experts' and public's responses were compared, as shown in Figure 3-4a and Figure 3-4b. Comparing Figure 3-4a with Figure 3-4b, the mean estimated RII based on experts' responses has a wider distribution than the public and; the mean RII of the barriers due to the experts and the public were respectively 0.76 and 0.74. Furthermore, comparing the maximum number of barriers with the same RII based on the public's and experts' responses showed that sixteen (16) barriers had a mean RII of 0.8 according to the public; while thirteen (13) of the barriers had a RII of 0.85 regarding the experts.



a. RII based on experts' responses b. RII based on public's responses

Figure 3-4. Mean frequency distribution and density of normal distribution of the estimated RII

Table 3-5 shows difference between mean RII of experts and the public for each barrier. The differences range between -0.14 to 0.20. In twenty-two (22) barriers the mean RII of the public was bigger and in thirty-five (35) barriers the mean RII of the experts was greater. Mean RII of 5 barriers was exactly the same between two groups (RII difference=0) including distrust among stakeholders (B21), ignorance of traditional resources for reconstruction (B32), inappropriate infrastructure maintenance policies (B37), lack of comprehensive resource database (B50), and unclear moratoria or temporary construction restrictions (B59). The maximum positive difference (0.20) relates to severe damage to major transportation systems (B28). The experts considered this barrier more important than the public. This might be due to the experts being aware of complexities of transportation systems recovery and reconstruction after a hurricane and the very fundamental impact of late recovery of these systems on the timeliness of the whole recovery process. On the other hand, the maximum negative difference (-0.14) relates to severe damage to commercial and industrial buildings (B27). The public considered this barrier more important than experts. This is justifiable since the public is often worry about the financial situation after a hurricane, thus identified a barrier that affects the financial condition in a post-hurricane situation as the most important one.

Table 3-5. Experts' and Public's RII & RII Difference

ID	Barrier	Ex.* RII	Pu.** RII	(Ex.* RII)-(Pu.** RII)
B1	Rate of employment	0.70	0.69	0.01
B2	Number of active small businesses	0.75	0.69	0.06
B3	Local government revenue	0.72	0.80	-0.08
B4	Not having insurance/insufficient insurance coverage	0.87	0.88	-0.01
B5	Lost household income	0.75	0.76	-0.01
B6	Uneven access to governmental financial resources	0.82	0.77	0.05
B7	Level of housing value in affected area	0.60	0.66	-0.06
B8	Income disparity and diversification of livelihoods	0.71	0.67	0.04
B9	Late allocation of funding resources	0.88	0.89	-0.01
B10	Level of post-disaster blight	0.69	0.72	-0.03
B11	Lack of legislation for controlling post-disaster blight	0.70	0.73	-0.03
B12	Delay in disbursement of emergency funds	0.86	0.87	-0.01
B13	Lack of transport-related businesses	0.77	0.90	-0.13
B14	Tough legislative criteria for low-income groups	0.79	0.77	0.02
B15	Diversity of culture and languages in affected area	0.61	0.59	0.02
B16	Lack of disaster recovery public training	0.74	0.76	-0.02
B17	Lack of voluntary public participation	0.81	0.77	0.04
B18	Large number of disabled & elderlies	0.68	0.8	-0.12
B19	Education level of residents	0.59	0.65	-0.06
B20	Population density	0.69	0.79	-0.10
B21	Distrust among stakeholders	0.74	0.74	0.00

B22	Lack of traditional family and/or friend support	0.82	0.79	0.03
B23	Not being experienced in disastrous situations	0.77	0.72	0.05
B24	Unstable mental condition of affected people	0.75	0.77	-0.02
B25	Land-use determination for rebuilding	0.77	0.75	0.02
B26	Damage to residential housing	0.85	0.75	0.10
B27	Damage to commercial and industrial buildings	0.57	0.71	-0.14
B28	Damage to major transportation systems	0.86	0.66	0.20
B29	Damage to major infrastructure systems	0.86	0.79	0.07
B30	Unsmooth relocation before reconstruction	0.81	0.69	0.12
B31	Improper physical development patterns and rules	0.88	0.70	0.18
B32	Ignorance of traditional resources for reconstruction	0.73	0.73	0.00
B33	Legislative obstacles for reconstruction approval	0.66	0.64	0.02
B34	Unavailability of medical services after the disaster	0.86	0.83	0.03
B35	Lack of appropriate policies for people's relocation	0.76	0.78	-0.02
B36	Damage to medical services, like hospitals	0.83	0.84	-0.01
B37	Inappropriate infrastructure maintenance policies	0.68	0.68	0.00
B38	Incompetence of contractors	0.74	0.75	-0.01
B39	Illegal construction during recovery	0.70	0.67	0.03
B40	Insufficient built infrastructures	0.87	0.91	-0.04
B41	Insufficient construction quality and practices	0.71	0.73	-0.02
B42	Unclear reconstruction and recovery regulations	0.81	0.76	0.05
B43	Outdated construction standards and codes	0.60	0.68	-0.08
B44	Insufficient investment in natural buffers	0.80	0.76	0.04
B45	Slow/Late debris and erosion removal after a hurricane	0.86	0.77	0.09
B46	Level of water contamination	0.71	0.67	0.04
B47	Level of environmental harm	0.70	0.68	0.02
B48	Level of air pollution	0.68	0.66	0.02
B49	Level of noise pollution	0.44	0.41	0.03
B50	Lack of comprehensive resource database	0.78	0.78	0.00
B51	Number of available active contractors	0.77	0.71	0.06
B52	Slow/Improper decision-making for recovery actions	0.88	0.81	0.07
B53	Undefined roles and responsibilities in the recovery	0.89	0.78	0.11

B54	Misalignment between Federal and local policies	0.83	0.76	0.07
B55	Inappropriate material allocation and disbursement	0.74	0.75	-0.01
B56	Community engagement in policy development	0.84	0.72	0.12
B57	Weak cooperation among NGOs and governmental entities	0.84	0.76	0.08
B58	Occurrence of multiple disasters in a short period	0.82	0.80	0.02
B59	Unclear moratoria or temporary construction restrictions	0.74	0.74	0.00
B60	Local capacity of producing materials	0.85	0.75	0.10
B61	Political Pressure	0.75	0.71	0.04
B62	Engagement of technical expertise in planning	0.84	0.80	0.04

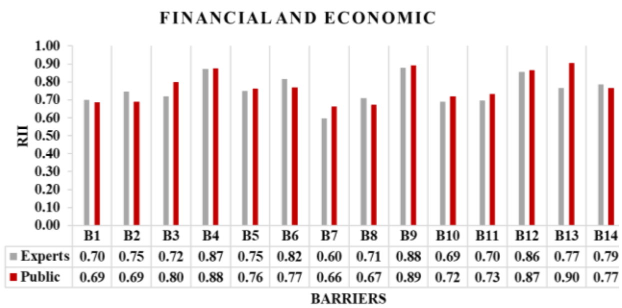
**Ex.: Experts*
***Pu.: Public*

Figure 3-5 compares the RII of barriers in each category according to experts and public. As shown in Figure 3-5a, the RII of the barriers in this category vary between 0.6-0.88 (mean RII=0.76) according to the experts, and between 0.66-0.9 (mean RII=0.77) according to the public. Late allocation of funding resources (B9) was the most important barrier of financial and economic category according to the experts with RII of 0.88. The importance of this barrier could be understood considering that, late disbursement of funds can affect the timeliness of recovery by delaying reconstruction of damaged infrastructures and transportation systems. The public determined insufficient transport-related businesses (B13) as the most important barrier of this category with RII of 0.90. The vital role of transportation systems, services, and specialized workforce in progressing the recovery process could not be denied. Therefore, when the number of transport-related businesses in an hurricane-affected area is not enough, the recovery process would be delayed.

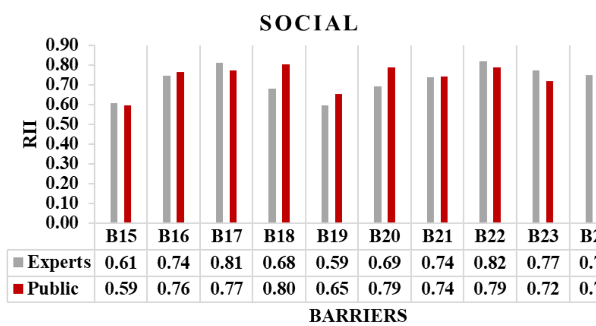
As shown in Figure 3-5b, the RII of the barriers in social category vary between 0.59-0.82 (mean RII=0.72) according to the experts, and between 0.59-0.80 (mean RII=0.74) according to the public. Lack of traditional family and/or friend support (B22) was the most important barrier of this category according to the experts with RII of 0.82. After hurricanes, affected people will be under mental pressure and also need financial support to return their lives to normal condition. In such a circumstance, the individuals with whom the affected people have a friendship and/or familial relationship would be the immediate choices for help and support. Thus, existence of such relationships will lead to timeliness of recovery process. The public determined large number of disabled & elderlies (B18) as the most important barrier of this category with RII of 0.80. People with disabilities and the elderlies need particular attention after hurricanes, which notably can slow-down the recovery process.

As shown in Figure 3-5c, the RII of the barriers in coordination and resources category vary between 0.57-0.88 (mean RII=0.77) according to the experts, and between 0.64-0.91 (mean RII=0.74) according to the public. Improper physical development patterns and rules (B31) was the most important barrier of this category according to the experts with RII of 0.88. When the expansion of an urban area is not properly developed, the recovery activities will be prone to delay due to lack of required space for simultaneous activities. The public determined insufficient built infrastructures (B40) as the most important barrier of this category with RII of 0.91. Evidently, lack of built infrastructures such as transportation infrastructures lead to slowing-down the process of recovery since the presence of these infrastructures are needed for transporting the resources, etc.

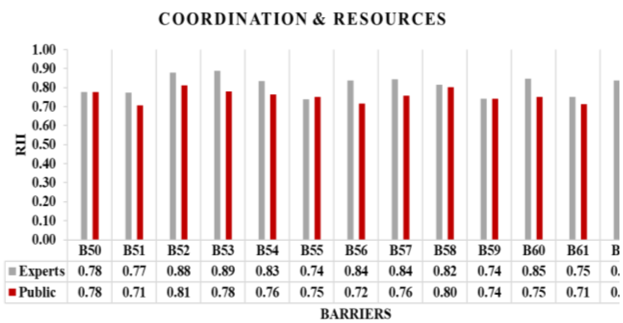
As shown in Figure 3-5d, the RII of the barriers in environment category vary between 0.44-0.86 (mean RII=0.68) according to the experts, and between 0.41-0.77 (mean RII=0.64) according to the public. Slow/Late debris and erosion removal after a hurricane (B45) was the most important barrier of this category according to both the experts and public, with RII of 0.86 and 0.77 respectively. One of the first activities for recovery after hurricanes is removing the erosions and debris in order to facilitate access to all the affected locations. Therefore, slow or late removal of debris would delay the recovery process.



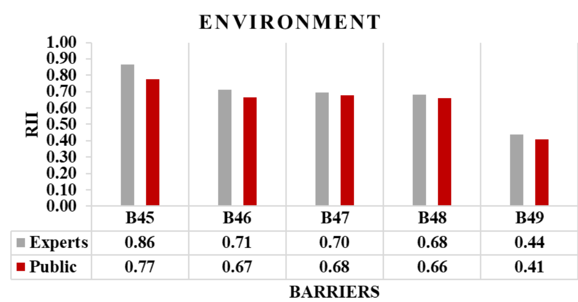
a. Financial & economic barriers



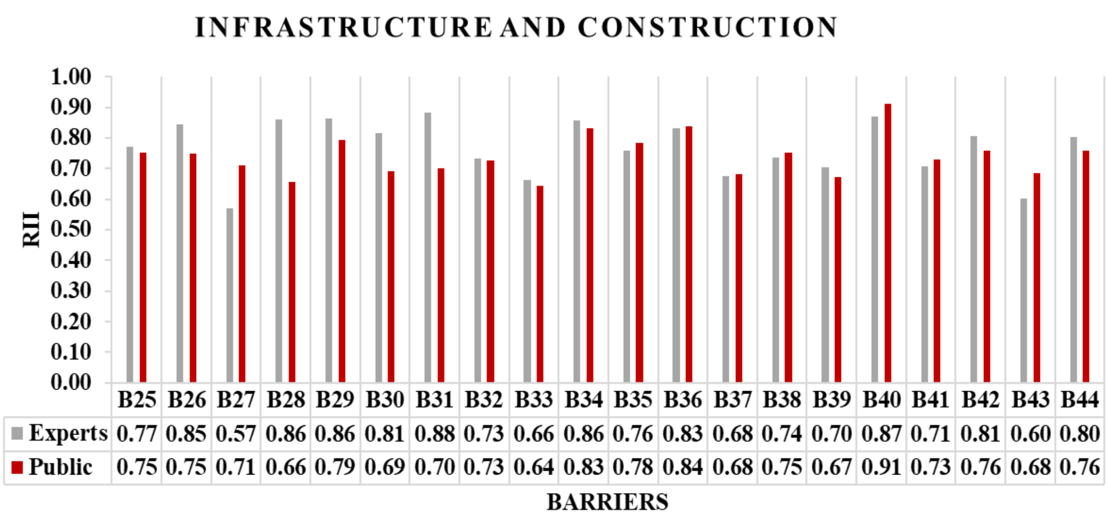
b. Social barriers



c. Coordination and resources barriers



d. Environment barriers



e. Infrastructure & construction barriers

Figure 3-5. RII difference of barriers by category.

As shown in Figure 3-5e, the RII of barriers in infrastructure and construction category vary between 0.74-0.89 (mean RII=0.81) according to the experts, and between 0.71-0.81 (mean RII=0.76) according to the public. Undefined roles and responsibilities in the recovery (B53) was the most important barrier of this category according to the experts with RII of 0.88. Since post-hurricane condition is critically chaotic and complex, inconsistencies among different parts of recovery groups happens, which lead to delays. Thus, predefining the responsibilities and roles could be helpful to avoid delays and accelerating the recovery process. The public determined slow/improper decision-making for recovery actions (B52) as the most important barrier of this category with RII of 0.81. Decision-making plays a key role in the process of recovery after hurricanes; thus, belated decisions and improper decisions would lead to delay in the recovery process.

The accumulative rank and category rank of all the 62 barriers, based on estimated RII for both the experts and public groups are summarized in Table 3-6. As shown, undefined roles and responsibilities in the recovery (B53), improper physical development patterns and rules (B31), slow/improper decision-making for recovery actions (B52), late allocation of funding resources (B9), and not having insurance or insufficient insurance coverage (B4) were the Top-five most important barriers to timely post-hurricane recovery process according to the experts. These barriers respectively relate to categories of infrastructure & construction, coordination and resources, infrastructure & construction, financial and economic, and financial and economic. Four of the top-five barriers determined by the experts are from the infrastructure & construction and financial & economic categories, two from each, which means that the barriers of these categories are more important according to the experts. Evidently, this could be justified since infrastructures and financial resources are the very immediate requirements of recovery process.

According to the public, the Top-five barriers to timely post-hurricane recovery were insufficient built infrastructures (B40), insufficient transport-related businesses (B13), late allocation of funding resources (B9), not having insurance or insufficient insurance coverage (B4), and delay in disbursement of emergency funds (B12). The first barrier of this category (B40) relates to coordination and resources category while the rest of the top-five barriers relate to financial and economic category. This shows that the public have deep concerns about the financial issues after a hurricane. In sum, according to the top-five barriers determined by each group, the experts have concerns about the financial issues as well as infrastructure and construction issues which can affect the timeliness of the recovery process significantly. However, the public are mainly concerned about the financial issues after hurricanes and had less attention to the infrastructure and even the social issues.

Table 3-6. Accumulative and category rank of barriers based on RII.

ID	Barrier	Accumulative Rank		Category Rank	
		Ex.*	**Pu.****	**Ex.***	**Pu.****
	Financial and Economic				
B1	Rate of employment	48	49	11	12
B2	Number of active small businesses	36	48	8	11
B3	Local government revenue	43	11	9	5
B4	Not having insurance or insufficient insurance coverage	5	4	2	3
B5	Lost household income	33	25	7	8
B6	Uneven access to governmental financial resources	20	22	4	6
B7	Level of housing value in affected area	59	56	14	14
B8	Income disparity and diversification of livelihoods	44	53	10	13
B9	Late allocation of funding resources	4	3	1	2
B10	Level of post-disaster blight	52	40	13	10
B11	Lack of legislation for controlling post-disaster blight	49	37	12	9
B12	Delay in disbursement of emergency funds	10	5	3	4
B13	Lack of transport-related businesses	31	2	6	1
B14	Tough legislative criteria for low-income groups	26	23	5	7
	Social				
B15	Diversity of culture and languages in affected area	57	61	9	10
B16	Lack of disaster recovery public training	37	26	5	6
B17	Lack of voluntary public participation	23	21	2	5
B18	Large number of disabled & elderlies	53	9	8	1
B19	Education level of residents	60	59	10	9

B20	Population density	51	14	7	2
B21	Distrust among stakeholders	39	36	6	7
B22	Lack of traditional family and/or friend support	19	15	1	3
B23	Not being experienced in disastrous situations	29	41	3	8
B24	Unstable mental condition of affected people	35	19	4	4
	Infrastructure and Construction				
B25	Land-use determination for rebuilding	30	30	11	8
B26	Damage to residential housing	13	34	6	10
B27	Damage to commercial and industrial buildings	61	44	20	13
B28	Damage to major transportation systems	9	58	4	19
B29	Damage to major infrastructure systems	7	13	3	4
B30	Unsmooth relocation before reconstruction	22	47	8	15
B31	Improper physical development patterns and rules	2	46	1	14
B32	Ignorance of traditional resources for reconstruction	42	39	14	12
B33	Obstacles in the legislative for reconstruction approval	56	60	18	20
B34	Unavailability of medical services after the disaster	11	7	5	3
B35	Lack of appropriate policies for people's relocation	32	16	12	5
B36	Damage to medical services, like hospitals	18	6	7	2
B37	Inappropriate infrastructure maintenance policies	55	51	17	17
B38	Incompetence of contractors	40	33	13	9
B39	Illegal construction during recovery	47	54	16	18
B40	Insufficient built infrastructures	6	1	2	1
B41	Insufficient construction method, quality, and practices	46	38	15	11
B42	Unclear reconstruction and recovery regulations	24	29	9	7
B43	Outdated construction standards and codes	58	50	19	16
B44	Insufficient investment in natural buffers	25	27	10	6
	Environment				
B45	Slow/Late debris and erosion removal after a disaster	8	20	1	1
B46	Level of water contamination	45	55	2	3
B47	Level of environmental harm	50	52	3	2
B48	Level of air pollution	54	57	4	4
B49	Level of noise pollution	62	62	5	5
	Coordination and Resources				
B50	Lack of comprehensive resource database	27	18	9	5
B51	Number of available active contractors	28	45	10	13
B52	Slow/Improper decision-making for recovery actions	3	8	2	1
B53	Undefined roles and responsibilities in the recovery	1	17	1	4
B54	Misalignment between Federal policies and local planning	17	24	7	6
B55	Inappropriate material allocation and disbursement	41	31	13	8
B56	Community engagement during recovery policy development	15	42	5	11
B57	Weak cooperation among NGOs and governmental entities	14	28	4	7
B58	Occurrence of multiple disasters in a short period	21	10	8	2
B59	Unclear moratoria or temporary construction restrictions	38	35	12	10
B60	Local capacity of producing materials	12	32	3	9
B61	Political Pressure	34	43	11	12
B62	Engagement of technical expertise for recovery planning	16	12	6	3

**Ex.: Experts*
***Pu.: Public*

3.5.4. Relative Importance of the Categories

The mean RII of each category was calculated using eq. 3 in order to determine the relative importance level of the categories. Figure 3-6 shows the results of category mean RII estimation. For each category, the discussion is presented below.

$$\text{Category Weight} = \frac{\text{Sum of the RIIs of all barriers of the category}}{\text{Total number of barriers of the category}} \qquad \text{(eq. 3)}$$

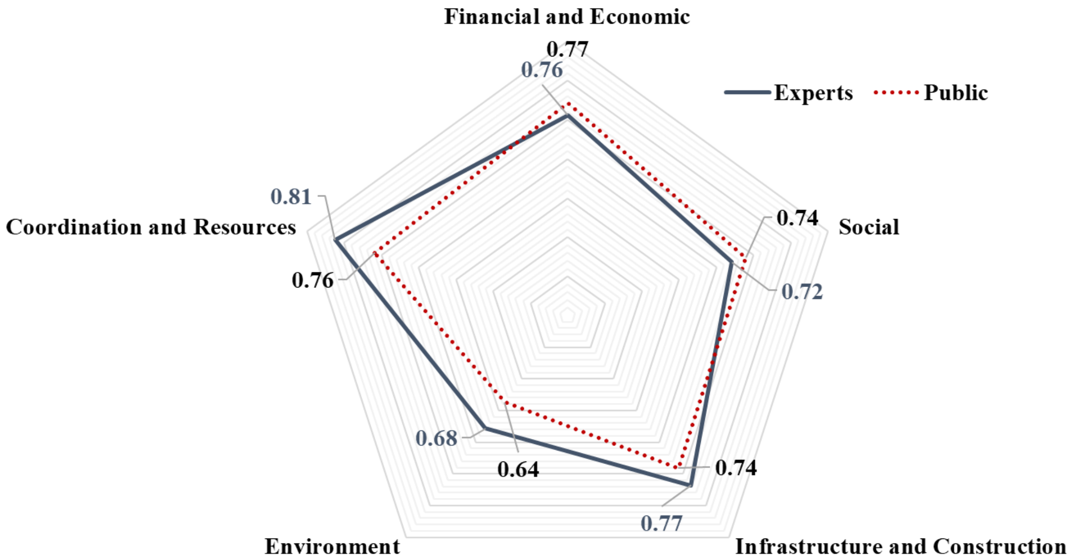


Figure 3-6. Comparison of mean RII of the categories.

- Coordination and Resources: the coordination and resources category was the most important category according to the experts. In addition, the RII of this category was larger comparing the experts and public; experts' mean RII= 0.81 and public's mean RII=0.76. According to the public, this category was the second most important category. Even though both groups determined this category as an important one, the experts believed that coordination and resources barriers are the most important among all the categories. because incoordination and improper resource allocation can lead to several consecutive issues (e.g., rework, excessive fund allocation, etc.) that each slows-down the recovery process.

- Infrastructure and Construction: the infrastructure and construction category was the second most important category according to the experts. On the other hand, according to the public, this category was the third most important category. Furthermore, comparing the public and experts, the RII of the experts was greater than the public; experts' mean RII= 0.77, public's mean RII=0.74. The experts determined the barriers of this category more important than the public since they directly deal with the negative effects of damaged infrastructures on the time of recovery. However, the public would have more important personal challenges after hurricanes such as supporting the family members, etc.

- Financial and Economic: the financial and economic category was the third most important category according to the experts. Moreover, comparing the two groups, this category was more important according to the public; experts' mean RII= 0.76, public's mean RII=0.77. According to the public, this category was the first most important category. Even though the RII of two groups is very close, but since the primary requirement to recover from the consequences of a hurricane is the financial resources, it is understandable that the public determined this category as the most important.

- Social: the social category was the fourth most important category according to both the experts and public. This category was more important according to the public; experts' mean RII= 0.72, public's mean RII=0.74. Even though it was expected that at least the public determine the social category barriers as important ones, but since they found the basis of the issues in economic barriers, this category was not absorb their attention critically.

- Environment: the environment category was the least important category according to both the experts and the public. In addition, this category was more important for the experts; experts' mean RII= 0.68, public's mean RII=0.64. Discernibly, not the public nor the experts have significant concerns on the barriers of this category. However, both groups determined the debris removal as an important barriers, but the rest of the barriers had low RIIs according to both groups.

3.6. Results Evaluation

Ten interviews with experts in post-hurricane recovery were conducted to discuss and evaluate the importance of the barriers determined according to the public's and experts' responses to the survey. The Top-10 most important barriers by the two groups were provided to the experts for the interview. Nine of the interviewees stated that the list of barriers according to the experts was more reliable and rational. One of the interviewees indicated that the fact that most of the Top-ranked barriers (4) by the experts were from the infrastructure and construction category shows the importance of this category's barriers delaying the recovery process. Based on his experience, he indicated that 2 years after Hurricane Irma, the infrastructures were not entirely rebuilt and the projects were behind the schedule; thus, this caused delays in the whole recovery process. Another interviewee stated that the infrastructure should be the first to recover to avoid later waste of time in the process of recovery, even with a large budget. Table 3-7 shows the Top-10 important barriers by the experts and the public.

None of the environment barriers were among the Top-ranked barriers of the public and one of these barriers were in the top-ranked list of the experts barriers. All the interviewees believed that the public do not have environmental concerns as much as the experts. On the other hand, the financial and economic factors were the most frequent barriers due to the public (4).

Eight of the interviewees agreed that the financial factors have been the most important factors according to the public, based on their experiences.

Seven interviewees thought that there is a lack of barriers related to the role of the governments in both group's perception. In addition, all the interviewees believed that scarcity of workers and contractors is a very important barrier that has been missed by both groups. One of the interviewees indicated that occurrence of multiple hurricanes in a short period of time could be in the top-ranked barriers as well. He declared that one year before Hurricane Katrina, Hurricane Ivan hit and lots of people evacuated but had a terrible experience with the situation. So when Katrina was coming, a lot of people did not trust the predictions and the recommendations of the experts and the decision-makers.

Table 3-7. Ten most important barriers causing delays by the experts and the public.

ID	Barrier	Rank	RII	Category
	Experts			
B53	Undefined roles and responsibilities in the recovery	1	0.89	Coordination & Resources
B31	Improper physical development patterns and rules	2	0.88	Infrastructure & Construction
B52	Slow/Improper decision-making for recovery actions	3	0.88	Coordination & Resources
B9	Late allocation of funding resources	4	0.88	Financial & Economic
B4	Not having insurance or insufficient insurance coverage	5	0.87	Financial & Economic
B40	Insufficient built infrastructures	6	0.87	Infrastructure & Construction
B29	Damage to major infrastructure systems	7	0.86	Infrastructure & Construction
B45	Slow/Late debris and erosion removal after a disaster	8	0.86	Environment
B28	Damage to major transportation systems	9	0.86	Infrastructure & Construction
B12	Delay in disbursement of emergency funds	10	0.86	Financial & Economic
	Public			
B40	Insufficient built infrastructures	1	0.91	Infrastructure & Construction

B13	Lack of transport-related businesses	2	0.90	Financial & Economic
B9	Late allocation of funding resources	3	0.89	Financial & Economic
B4	Not having insurance or insufficient insurance coverage	4	0.88	Financial & Economic
B12	Delay in disbursement of emergency funds	5	0.87	Financial & Economic
B36	Damage to medical services, like hospitals	6	0.84	Infrastructure & Construction
B34	Unavailability of medical services after the disaster	7	0.83	Infrastructure & Construction
B52	Slow/Improper decision-making for recovery actions	8	0.81	Coordination & Resources
B18	Large number of disabled & elderlies	9	0.80	Social
B58	Occurrence of multiple disasters in a short period	10	0.80	Coordination & Resources

3.7. Conclusions

This study strived to advance insight into the different point of views of the experts and public regarding the barriers to post-hurricane recovery activities. According to the experts, undefined roles and responsibilities in the recovery (B53), improper physical development patterns and rules (B31), and slow/improper decision-making for recovery actions (B52) were the Top-3 most important barriers causing delays in the process of post-hurricane recovery. When the responsibilities is not well-defined in the aftermath of a hurricane, the likelihood of delays increases since the actions (e.g., resource allocation) are not optimize and multiple actions with the same purpose might be performed at the same time. In addition, proper physical development patterns play a key role in quick access and timely resource allocation in the recovery process after hurricanes. Furthermore, being slow while making the recovery decisions as well as improperly decision-making would lead to slowing-down the process of recovery.

On the other hand, the public's Top-3 barriers included insufficient built infrastructures (B40), insufficient transport-related businesses (B13), and late allocation of funding resources (B9).

The higher the number of built infrastructures in hurricane-affected areas, the faster the community returns to the normal functioning. Since transportation plays an important role in smooth and timely recovery, sufficient number of transport-related businesses are needed after a hurricane happening. Moreover, the funding resources need to be allocated and distributed as quickly as possible to provide the required facilities for accelerating the process of recovery.

Comparing experts' and public's perspectives by category of the barriers, the coordination and resources category was the most important category according to the experts, while, financial and economic category was the most important category according to the public. This could be understood since the experts have more significant concerns for proper management of the recovery process and optimized resource allocation and the primary concern of the public would be providing funding resources for their needs after a hurricane.

While five of the Top-ten barriers of the two groups (experts and public) were similar with different rankings, the Top-three barriers that were most differently understood by the two groups were respectively damage to major transportation systems (B28), improper physical development patterns and rules (B31), and damage to commercial and industrial buildings (B27). Two of these barriers are related to damages to different major buildings and transportation systems, however the other one is relative to physical development patterns. This shows that there is a gap of mutual understanding between the experts and the public on the physical barriers rather than other barriers.

The output of this study helps the decision-makers have a better understanding of the public's perspectives while establishing post-hurricane recovery planning and strategies which lead to accelerating the recovery process.

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CHAPTER 4. EVALUATION OF CAUSAL RELATIONSHIPS AMONG BARRIERS TO TIMELY POST-HURRICANE RECOVERY: A COMPARATIVE STUDY OF THE EXPERTS AND PUBLIC PERSPECTIVES

Abstract

Delays in accomplishment of post-hurricane recovery processes has been a major issue for the governors recently. Different barriers of different types lead to delays in the recovery after hurricanes. In addition, the interaction among these barriers can intensify their negative effects, which can cause further delays. Thus, a significant step toward resolving this problem is determining how these barriers affect the recovery process and how interact with each other. The major aims of this study were to investigate (1) whether there are relationships among the barriers to timely post-hurricane recovery or not, (2) what are the causal relationships among the barriers, and (3) to which extent the barriers and their interactions affect the timeliness of recovery process. Furthermore, since the misunderstanding between the experts and public on the impacts of barriers and the recovery process exists, the analyses were made according to both group's perspectives, in parallel, and the results were compared. Utilizing data from 195 public participants and 44 experts and implementing structural equation modeling (SEM) technique, the interrelated network of 62 barriers to timely post-disaster recovery process was modeled and the impacts of barriers on the time of the recovery after hurricanes was evaluated. The findings showed that the barriers underlying coordination latent variable have more impacts on the time of recovery other than the other variable groups, according to the experts model. However, for the public model the highest priority was given to the barriers underlying the social group. This research assists decision-makers in understanding the critical paths that lead to delays in the post-hurricane recovery process. In

addition, they would be able to predict the combination of which barriers can more negatively affect the recovery process after hurricanes.

4.1. Introduction

The complex conditions after hurricanes lead to arising complexities and consequent delays in the process of post-hurricane recovery (Beiler et al., 2016). From one point of view, the delays can be inferred as a result of increasing number of barriers and the interactions among them that slow-down and/or stop different activities during the post-hurricane recovery process (Gori et al., 2020). Accordingly, integrated and systematic management of the impacts of barriers to timely post-hurricane recovery is significantly required (Orabi et al., 2010).

Investigation of the results of the individual barriers to post-hurricane recovery process has been a topic of several researches within the last decades. However, modeling the interactive effects of these barriers was not conducted. Only a few researches attempt to model and evaluate the effect of some specific barriers, out of which many focused on disasters other than hurricanes such as earthquakes, etc. (Alipour et al., 2015). Furthermore, according to the existing literature, there is a big misunderstanding between the perspective of the experts in the area of post-hurricane recovery and the public, which leads to considerable issues and could be considered as a fundamental barriers by itself. Therefore, the effort in the current research is dedicated to develop comparative models that analyze the dynamic effects of post-hurricane recovery barriers that affect the timeliness of the process. For this purpose, the objectives of this study were formulated as the following: (1) investigate existence of interrelations among different barriers to timely post-hurricane recovery process, according to both the experts' and public's perspectives, (2) develop reliable causal models capturing the interrelations among different barriers to timely post-hurricane recovery, according to both the experts' and public's perspectives, (3) find the effective paths from the barriers to delays in the process of post-hurricane recovery, according to both the experts' and public's perspectives, (4) demonstrate the extent to which the interrelations of the barriers are and act, and (5) comparatively analyze the experts' and public's perspectives on the effect of barriers on the timeliness of the post-hurricane recovery process. The findings of this study can help the decision-makers in the aftermath of hurricanes to wisely determine the barriers that more significantly affect the timeliness of recovery process by providing a systematic insight toward recovery process.

4.2. Background

4.2.1. Hurricanes and Post-Hurricane Recovery

Hurricanes have been one of the most destructive, frequent, and immortal natural disasters within the last decades, specifically in the US (Mitchell et al., 2012; Nejat and Ghosh, 2016). The very sudden behavior of the deadly combination of wind and flood, as well as its long-term impacts that even might last for several decades caused many of the public and decision-makers to have concerns about it (Sajjad et al., 2020). After the hurricane though, especially when the hurricane is significantly devastating, most of the normal activities in the affected community will stop or slowed-down (Sanders, 2003; Sanusi, 2020). For illustration, the transportation infrastructures may be damaged, which consequently affects the resource allocation and rescue procedure (Sanusi, 2020). In such a situation, emergency and consecutively short-term recovery plans will be prepared and utilized in order to lessen the very first negative effects of this phenomenon (Sullivan et al., 2009). However, long-term recovery and reconstruction plans are needed in order to bring back the affected society to normal functioning (Tyler and Sadiq, 2019).

Since the number of impeding issues and their mutual interactions in the chaotic circumstances after major hurricanes increase dramatically, the preparing a comprehensive and optimized planning in both the short-term and long-term recovery processes is of high importance. However, providing such an integrated planning requires the planers and decision-makers to achieve a proper insight and understanding on the post-hurricane conditions, the barriers that might affect the effective and timely recovery, and the likely interactions among various barriers that lead to extra delays (Verderber, 2008; Weinkle et al., 2018).

4.2.2. Disaster Models and Frameworks

A useful solution toward increasing the understandings of both the public and experts on the recovery process and barriers and to draw their mutual perspectives to a common point is to model the interrelations among the barriers and help understand the most effective combination of barriers causing delays. Rare researches have been conducted in this regard most of which are consider a few issues and barriers in their model or framework. Also, some of the models are related to other types of disasters and not hurricanes. Tatsuli et al. (2003) conducted a very first researches on the barriers of post-disaster recovery process after 1995 Kobe earthquake. The implemented approach in this study was mainly social and the results showed that social recovery has priority over infrastructure recovery. Assaf (2011) introduced a disaster framework for mitigating the socio-physical risks after 1959 Malpasset dam failure, which leaded a big flood in Southern France. Even though a very detailed simulation was performed to develop this framework, the scale of this disaster is not comparable with the ones of major hurricanes that happened in the last 20 years (e.g., Katrina, Harvey, etc.). Nejat and Ghosh (2016) developed a predictive model for post-disaster recovery decision-making. The focus in this study was on housing recovery and the Hurricane Sandy was the case study for developing the model. Mostafizi et al. (2019) presented an agent-based model for evacuation after tsunami and investigated how the evacuation scenarios can affect the life safety after a tsunami. The outputs of this framework showed that there is a significant non-linear relationship between the evacuation behavior and the life safety. This research focused on the emergency phase after a tsunami. Even though there are other such models, but since the models are not comprehensively exploring the issues and rarely focused on short- and long-term barriers, the need for comprehensive models for timely post-hurricane recovery exists.

4.2.3. Experts' and Public's Understanding of the Post-Hurricane process

A potential issue in the recovery process of any disaster, including hurricanes, is the misunderstanding between the experts and public on the situation, the barriers that affect the recovery process, and the interaction among the barriers (FEMA, 2011). As a result, having a proper knowledge on each group's concerns and perspectives could capable the decision-makers to remove the misunderstandings and establish a basis for avoiding delays in the process of recovery (Tuler and Webler, 2020). Not many researches was conducted in this regard. For example, Palttala et al. (2012) demonstrated that miscommunication in the process of recovery leaded to several ineffective recovery processes after hurricanes. Choi et al. (2019) revealed that to prioritize the recovery activities, the decision-makers can partially rely on the affected public's concerns and need to communicate with them.

4.2.4. Barriers to Timely Post-Hurricane Recovery

During post-hurricane recovery, there are obstacles that lead to delays in the process, which are namely the barriers to timely post-hurricane recovery process. Within the last decades, with the increasing attention to the post-hurricane recovery, several researchers focused on these barriers and their corresponding consequences on the time of recovery process (Audefroy, 2010). Through review of literature, 62 barriers were identified and classified into five categories: financial and economic, social, infrastructure and construction, environment, and coordination and resources. For the categorization, an evaluation procedure was considered to check the consistency of the selected categories. Table 4-1 shows the list of identified barriers and their sources.

Table 4-1. List of identified barriers and the resources.

ID	Category & Barrier	Source
	Financial and Economic	
B1	Rate of employment	Audefroy, 2010
B2	Number of active small businesses	Félix et al., 2014
B3	Local government revenue	Bilau and Witt., 2016
B4	Not having insurance or insufficient insurance coverage	Mechler, 2016
B5	Lost household income	Carrasco et al., 2016
B6	Uneven access to governmental financial resources	Wisner et al., 2003
B7	Level of housing value in affected area	Lou and Zhang, 2011
B8	Income disparity and diversification of livelihoods	Minato and Morimoto, 2012
B9	Late allocation of funding resources	MacAskill and Guthrie, 2014
B10	Level of post-disaster blight	Bostick et al., 2017
B11	Lack of legislation for controlling post-disaster blight	Bostick et al., 2017
B12	Delay in disbursement of emergency funds	Zotti et al., 2013
B13	Lack of transport-related businesses	El-Anwar et al., 2010
B14	Tough legislative criteria for low-income groups	Bostick et al., 2017
	Social	
B15	Diversity of culture and languages in affected area	Nakhaei et al., 2016
B16	Lack of disaster recovery public training	Zottarelli, 2008
B17	Lack of voluntary public participation	Lowry, 2009; Aldrich, 2012
B18	Large number of disabled & elderlies	Ganapati, 2012; Beiler et al., 2016
B19	Education level of residents	Chen and Miller-Hooks, 2012
B20	Population density	Lou and Zhang, 2011
B21	Distrust among stakeholders	Schwab et al., 2014
B22	Lack of traditional family and/or friend support	Heaney et al., 2000
B23	Not being experienced in disastrous situations	El-Anwar and Chen, 2014
B24	Unstable mental condition of affected people	Li et al., 2011; Wang et al., 2012
	Infrastructure and Construction	
B25	Land-use determination for rebuilding	Orabi et al., 2010
B26	Damage to residential housing	Jordan and Javernick-Will, 2013
B27	Damage to commercial and industrial buildings	El-Anwar et al., 2010
B28	Damage to major transportation systems	Padgett and Tapia, 2013
B29	Damage to major infrastructure systems	El-Anwar et al., 2010
B30	Unsmooth relocation before reconstruction	Li et al., 2011
B31	Improper physical development patterns and rules	Jordan and Javernick-Will, 2013
B32	Ignorance of traditional resources for reconstruction	Heaney et al., 2000
B33	Obstacles in the legislative for reconstruction approval	Orabi et al., 2010

B34	Unavailability of medical services after the disaster	El-Anwar et al., 2010
B35	Lack of appropriate policies for people's relocation	Pramudita and Taniguchi, 2014
B36	Damage to medical services, like hospitals	El-Anwar et al., 2010
B37	Inappropriate infrastructure maintenance policies	Roosli and Collins, 2016
B38	Incompetence of contractors	Minato and Morimoto, 2012
B39	Illegal construction during recovery	Lou and Zhang, 2011
B40	Insufficient built infrastructures	Padgett and Tapia. 2013
B41	Insufficient construction method, quality, & practices	Arouri et al., 2015
B42	Unclear reconstruction and recovery regulations	Roosli and Collins, 2016
B43	Outdated construction standards and codes	Padgett and Tapia. 2013
B44	Insufficient investment in natural buffers	El-Anwar and Chen, 2014
	Environment	
B45	Slow/Late debris and erosion removal after a disaster	Orabi et al., 2010
B46	Level of water contamination	Weerakoon et al., 2015
B47	Level of environmental harm	Finch et al., 2010
B48	Level of air pollution	Weerakoon et al., 2015
B49	Level of noise pollution	Roosli and Collins, 2016
	Coordination and Resources	
B50	Lack of comprehensive resource database	Pramudita and Taniguchi, 2014
B51	Number of available active contractors	Schwab et al., 2014
B52	Slow/Improper decision-making for recovery actions	El-Anwar and Chen, 2014
B53	Undefined roles and responsibilities in the recovery	El-Anwar and Chen, 2014
B54	Misalignment between Federal policies & local planning	Schwab et al., 2014
B55	Inappropriate material allocation and disbursement	El-Anwar and Chen, 2014
B56	Community engagement in recovery policy development	Ku and Ma, 2015
B57	Weak cooperation among NGOs & governmental entities	Arouri et al., 2015
B58	Occurrence of multiple disasters in a short period	Kronenberg et al., 2010
B59	Unclear moratoria or temporary construction restrictions	Bradshaw, 2012
B60	Local capacity of producing materials	Heaney et al., 2000
B61	Political Pressure	Padgett and Tapia. 2013
B62	Less engagement of technical expertise for planning	McGee, 2011

As shown in Table 4-1, B1-B14 represent the barriers classified into the financial and economic category. Increasing rate of unemployment (Audefroy, 2010) and consequently high rate of lost income (Carrasco et al., 2016), few active businesses (Barenstein, 2006), and inappropriate distribution of the funding (MacAskill and Guthrie, 2014) after hurricanes are the major barriers of this category. For timeliness of the post-hurricane recovery activities, the community significantly relies on the availability and proper distribution of the funding resources; specifically governmental financial supports (Félix et al., 2014; Bostick et al., 2017). In such a circumstance, unemployment and increasing number of inactive businesses could lead to major shortcomings and consequently delays in the recovery process (Alipour et al., 2015).

Ten barriers (B15-B24) are included into the social category. Nakhaei et al. (2016) revealed that social diversities in race, language, education, and culture causes issues in the process of recovery. This is due to the fact that such variations cause communication obstacles and even lead to distrust between the people and the governors (Zottarelli, 2008). On the other hand, high-populated areas are more prone to delays in the process of recovery after hurricanes due to difficulties in handling the chaos (Li et al., 2011). Jordan and Javernick-Will (2013) declared that lack of public training for the post-hurricane recovery process can be a source of delays in the process, while increasing their participation in recovery stages could be of high importance for timeliness. Therefore, involving the public in the process of recovery would be advantages for reducing the time recovery (Lowry, 2009).

B25-B44 represent the barriers of the infrastructure and reconstruction category. These barriers mainly are relative to issues such as damage to the buildings and infrastructures (Padgett and Tapia, 2013), issues in relocation of the people (Roosli and Collins, 2016), lack of facilitator policies and regulations (Pramudita and Taniguchi, 2014), illegal constructions in destroyed areas (Lou and Zhang, 2011), etc. When after a hurricane the infrastructures, medical buildings, and other important buildings are severely damaged, reconstruction process will be delayed (El-Anwar et al., 2010). Furthermore, in many cases the infrastructures do not function properly after a hurricane due to minor and/or major damages, which slows down the recovery process (Lou and Zhang, 2011). Moreover, conflicts arise among governmental and public stakeholders in a post-hurricane condition, which leads to delays while removing the conflicts (Jordan and Javernick-Will, 2013).

The environment category includes five barriers (B45-B49). Slow debris removal (Orabi et al., 2010) causes late recovery from hurricanes by slowing down the transportation systems, etc. (Finch et al., 2010). Furthermore, timely removal of noise and air pollutions are significant for mental health recovery after a hurricane (Orabi et al., 2010; Weerakoon et al., 2015). In addition, high level water contamination (Weerakoon et al., 2015) and environmental harm (Roosli and Collins, 2016) are less studied but still important environmental barriers.

Thirteen (13) barriers were classified into coordination and resources category (B50-B62). The Lack of resources (Pramudita and Taniguchi, 2014), infirm cooperation (Ku and Ma, 2015), relaxed decision-making (El-Anwar and Chen, 2014), etc. are the major barriers of this category. Moreover, a comprehensive database of available resources is required to optimize the resource allocation and avoid the corresponding delays (Jordan and Javernick-Will, 2013). For example, having the list of important buildings in an area prepared prior to a hurricane, the required resources could be allocated as quick as possible (Pramudita and Taniguchi, 2014). In addition, low number of active contractors after a hurricane could affect the timeliness of the recovery process (Schwab et al., 2014).

4.2.5. Summary

The feasibility of existing plans for post-hurricane recovery has been majorly questioned by the researchers and decision-makers due to not being capable of leading to timely and effective recovery (e.g., after Hurricane Katrina and Hurricane Sandy). To reestablish reliable plans for post-hurricane decision-making, providing reliable models that can consider the effects of different barriers to timely recovery is significantly needed. Furthermore, to consider the concerns of the public in such models, a proper understanding of both sides (experts and public) perspectives on the post-hurricane recovery barriers and priorities is needed.

4.3. Methodology

This research included four main steps, each consisting of several sub-steps, as shown in Figure 4-1. First, 452 selected peer-reviewed articles and other relative documents from the existing literature on hurricanes, post-hurricane recovery process, disaster models, and the barriers to timely post-hurricane recovery were reviewed. Sixty-two (62) barriers to timely post-hurricane recovery process were identified and were classified into five categories: financial and economic, social, infrastructure and construction, environment, and coordination and resources. In step two, data was collected from two targeted groups: experts in post-hurricane recovery process and public with at least one post-hurricane recovery experience.

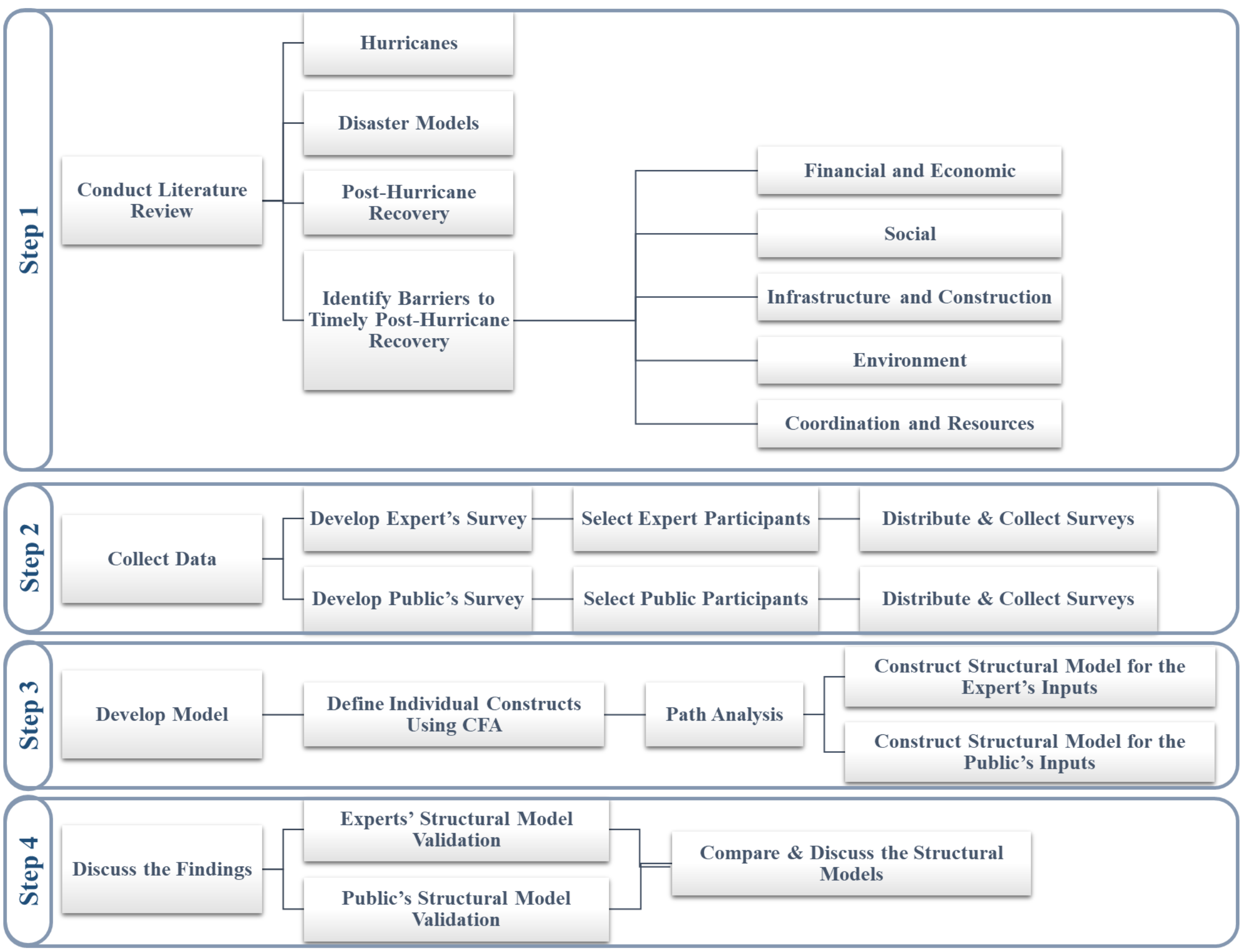


Figure 4-1. Research methodology.

The survey was accessible both online (distributed through social media such as Twitter, Facebook, etc.) and in paper copy. Other than demographic questions on the surveyors and questions on the hurricane they involved in, the survey included 62 Likert-scale questions by which the surveyors were asked to score each identified barrier from one to seven according to each barrier's importance on the timeliness of post-hurricane recovery process. Forty-four experts (out of more than 300 contacted experts) and 195 of the public responded to the survey. In step three, two SEM models were developed according to the experts and the public's input to the survey. The model development process included two main steps: measurement model development (CFA model) and separate SEM models construction and path analyses for both the expert and public inputs. Finally, the SEM models were discussed, evaluated, and compared.

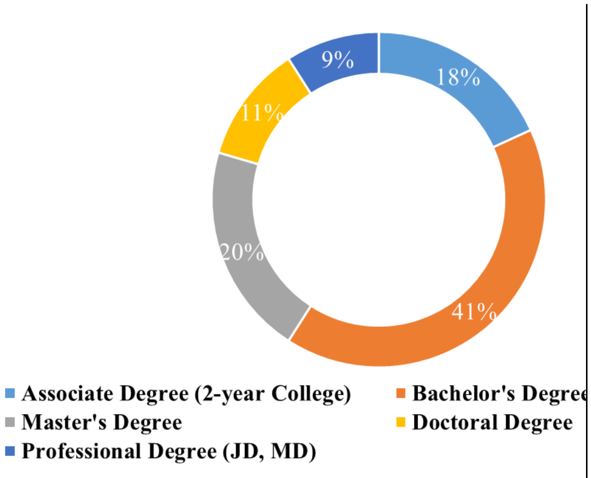
4.4. Data Collection

To collect the required data for model development, a survey was developed in which the importance level of the identified barriers to timely post-hurricane recovery process was asked. The survey included three main sections: demographic information of the participants, the information on the hurricane(s) the participants involved in, and a 62 Likert-scale questions determining the importance level of each barrier (from one: *not at all important*, to seven: *extremely important*). After development of the survey, it was pilot-tested by 10 persons and required modifications were adopted. A sample question of the survey is shown Figure 4-2.

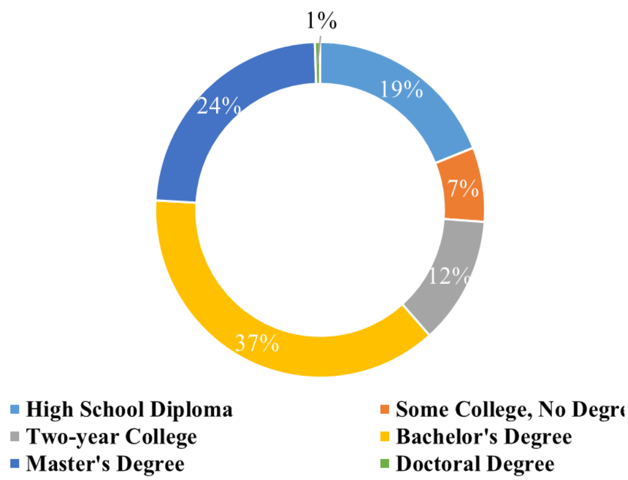
	Not at all Important 1	Slightly Important 2	Somewhat Important 3	Moderately Important 4	Very Important 5	Quite Important 6	Extremely Important 7
Average household income	○	○	○	○	○	○	○
Unemployment levels	○	○	○	○	○	○	○
Average revenue of the local government (e.g., City, etc.)	○	○	○	○	○	○	○
Average housing value	○	○	○	○	○	○	○

Figure 4-2. Sample survey question.

According to the objectives of this research, the experts and the public were separately targeted and contacted to provide their input to the survey. An important requirement for the targeted participants was being involved at least in one post-hurricane recovery process. Out of over 300 contacted experts active in the area of post-hurricane, 44 provided their input to the survey. The experts were from variety of relative organizations in the U.S. such as state emergency management centers, FEMA, National Oceanic and Atmospheric Administration (NOAA), etc. All of the expert surveyors had at least a college or university degree and around 82% of the experts possessed a bachelor's or higher education level. The distribution of education level of the experts who responded the survey is shown in Figure 4-3a. The perspectives of the public was also collected through online distribution of the survey as well as hard copy. One-hundred and nighty-five (195) public including university/college students, engineers, project managers, etc. participated in the survey. The distribution of the education level of the public respondents is shown in Figure 4-3b. As demonstrated, over 80% of the respondent had at least a college or university degree and also over 60% of them had a bachelor's degree or higher.



a. Experts



b. Public

Figure 4-3. Education level of participants in the survey.

4.5. Model Development

The model development of this study includes two steps: measurement model (CFA) and structural model. The measurement model specifies the way the variables are related, while the structural model is a causal model that is used for testing the causal relationships among the variables. For both the experts and public inputs to the survey, first, the CFA is developed and validated and then SEMs are developed.

CFA, also referred as restricted factor model, is often used as the preliminary stage of the SEM procedure. CFA is a method to test the interrelated structure of a network of variables and to measure if a set of data fits a causal model (Jöreskog, 1969; Fung et al., 2020). This technique is widely utilized for verifying one's (e.g. a researcher's) understanding of relations among different factors in a hypothesized network (Yang-Wallentin et al., 2010; Asún et al., 2016). Maximum likelihood (ML) and asymptotically distribution-free (ADF) are the parameters that are alternatively utilized in CFA. Since the variables in the current study are continuous and have an approximate multivariate normal distribution, which is a requirement for ML implementation, ML is the estimation theory used for CFA development.

Simply speaking, SEM is path analysis with latent variables and is known as a flexible method for analysis of direct, indirect, and interactive interactions among factors that are interrelated in a complex manner (Bentler, 2006). This technique includes a combination of multivariate statistical models and algorithms which are used for analyzing structural relationships and assessing latent constructs in a set of data. By a single SEM analysis, the interdependency of the variables in a set of data can be estimated. To perform an SEM analysis, all the variables should be defined as endogenous (equivalent to dependent variables) or exogenous (equivalent to independent variables). The endogenous or latent variable in this study is delay in the process of post-hurricane recovery. All the 62 identified barriers to timely post-hurricane recovery are exogenous or observed variables. In the following, the model development procedure is described in order.

4.5.1. Measurement Model

Using CFA, the hypothetical structure of the observed variables will be developed and validated. According to Bentler (2006), in CFA, the structure of the variables is defined by the researcher, based on his/her pre-knowledge or insight on the topic and the relations among the variables. When doing the analysis in confirmatory way, the key questions to answer are:

- Which observed variables measure which latent variables?
- Which observed variables are unrelated to which latent variables?
- What is the correlation between observed variables and latent variables?

By predefining relation between different observed variables, the parameter restriction will be: the correlations of the covariance between some of the observed variables and some of the latent variables is zero. In this study we have 62 observed variables (B1-B62) and five latent variables are retained: financial and economic, social, infrastructure and construction, environment, and coordination and resources. Based on our pre-knowledge, the defined latent variables explain enough the variability between the observed variables. Figure 4-4 shows the measurement model including five latent variables and the underlying observed variables.

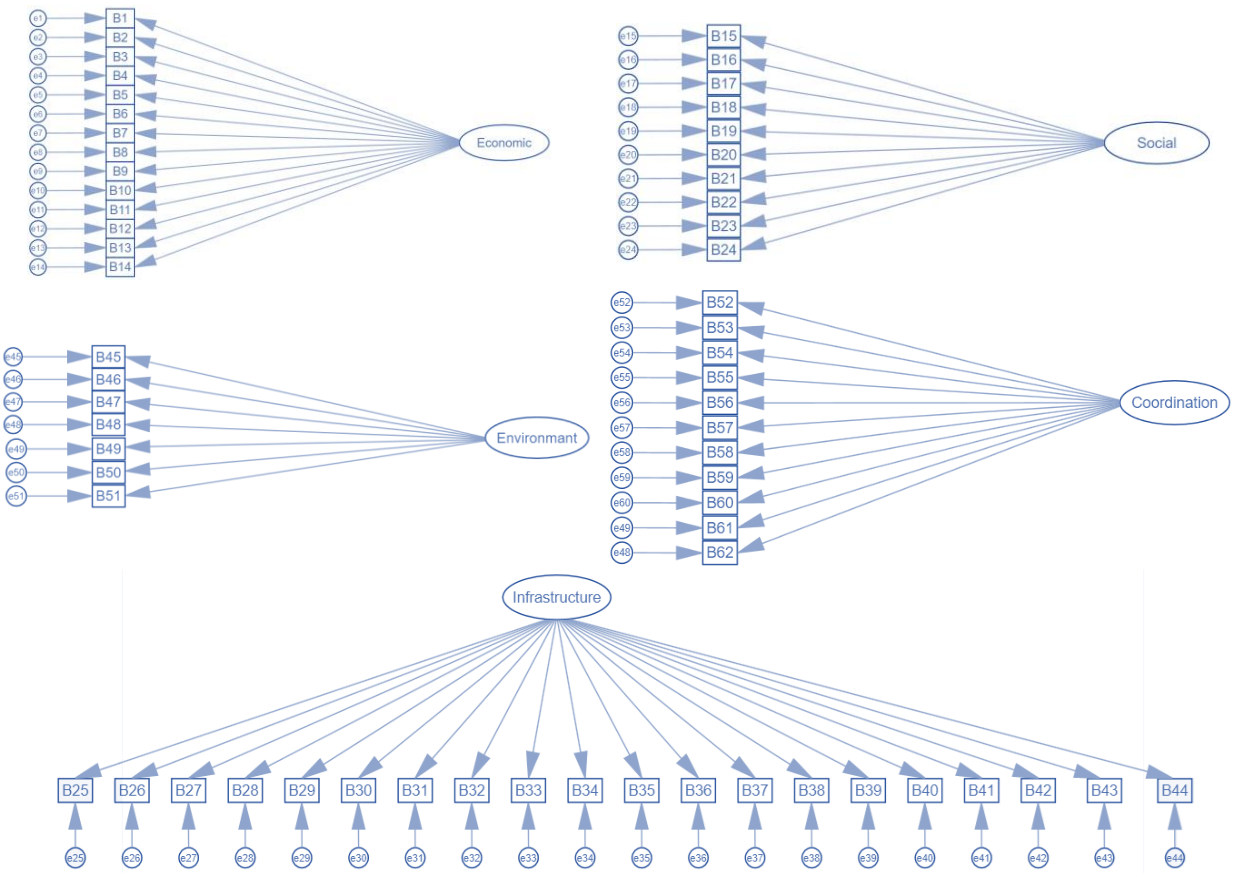


Figure 4-4. The measurement model representing the five latent variables and the corresponding observed variables for each (latent variables are shown with ellipse and the observed variables are shown with rectangular).

The obtained insight was the result of an exhaustive literature review through which the causal relations among different barriers (observed variables) and latent variables that lead to delays in the process of post-hurricane recovery were identified. The single-headed arrows running from each latent variable to the observed variables represent that the model will estimate the correlation between that latent variable and the observed variables that the arrow enters to. When there is no arrow pointing from a latent variable to an observed variable, it means that the factor loadings are constrained or fixed to zero in the model, based on the prior knowledge of the researcher. It must be added that in this context the correlation coefficients between the latent variables and the observed variables is called factor loading.

A latent variable is an unobserved and hypothetical variable and has no metric on its own. Thus, metric is needed to be given to the latent variables. This can be performed by scaling or standardizing the latent variable, which means constraining the variance of the latent variable to one. The correlations between variables, directional paths, and the means of the latent variables are of interest in the constructed model in order to investigate the differences between the experts and public perspectives. The latent variables and the underlying observed variables as well as the estimated standardized factor loadings for both the experts and public input are shown in Table 4-2. The consistency of the data with the model or the reliability of the data and model is examined using the internal structural test for which, two approaches are considered: unidimensionality test and individual reliability test. The former test is used for exploring whether an observed variable describes only one specific latent variable. The latter test is utilized to test the extent to which the observed variables underlying a latent variable are consistent.

In case of unidimensionality test, according to Hair et al. (2006), it is assumed that observed variables with a standardized factor loading over 0.5 or closely smaller than 0.5 are significant enough and can be pronounced as a reliable variable that explains an important portion of the variance in the relative latent variable. According to the expert measurement model, in financial and economic latent variable, rate of employment (B1), with factor loading of 0.98, and lack of legislation for controlling post-disaster blight (B11), with factor loading of 0.55, have respectively the highest and lowest correlation. However, all the factor loadings in the public measurement model are bigger than 0.88, which is related to delay in disbursement of emergency funds. Among the observed variables of the social latent variable, the factor loadings ranges between 0.90-0.99, according to the public. On the other hand, according to the experts, there is a big gap of 0.35 between the minimum (0.99) and maximum (0.64) factor loadings of the observed variables in social latent variable; unstable mental condition of affected people (B24) and lack of voluntary public participation (B17).

Table 4-2. Factor loadings for both the expert and public measurement models.

Latent variable	Observed Variable		Standardized Factor Loading	
			Expert	Public
Financial and Economic	B1	Rate of employment	0.98	0.97
	B2	Number of active small businesses	0.93	0.99
	B3	Local government revenue	0.91	0.97
	B4	Not having insurance or insufficient insurance coverage	0.76	0.98
	B5	Lost household income	0.90	0.95
	B6	Uneven access to governmental financial resources	0.94	0.91
	B7	Level of housing value in affected area	0.94	0.91
	B8	Income disparity and diversification of livelihoods	0.96	0.90
	B9	Late allocation of funding resources	0.92	0.91
	B10	Level of post-disaster blight	0.73	0.92
	B11	Lack of legislation for controlling post-disaster blight	0.55	0.99
	B12	Delay in disbursement of emergency funds	0.85	0.88
	B13	Lack of transport-related businesses	0.92	0.95
	B14	Tough legislative criteria for low-income groups	0.97	0.99
Social	B15	Diversity of culture and languages in affected area	0.93	0.96
	B16	Lack of disaster recovery public training	0.78	0.96
	B17	Lack of voluntary public participation	0.64	0.95
	B18	Large number of disabled & elderlies	0.82	0.95
	B19	Education level of residents	0.97	0.98
	B20	Population density	0.85	0.97
	B21	Distrust among stakeholders	0.81	0.98
	B22	Lack of traditional family and/or friend support	0.72	0.99
	B23	Not being experienced in disastrous situations	0.96	0.90
	B24	Unstable mental condition of affected people	0.99	0.91
Infrastructure and Construction	B25	Land-use determination for rebuilding	0.99	0.94
	B26	Damage to residential housing	0.91	0.99
	B27	Damage to commercial and industrial buildings	0.95	0.94
	B28	Damage to major transportation systems	0.95	0.94
	B29	Damage to major infrastructure systems	0.69	0.95
	B30	Unsmooth relocation before reconstruction	0.92	0.96
	B31	Improper physical development patterns and rules	0.93	0.93
	B32	Ignorance of traditional resources for reconstruction	0.92	0.52
	B33	Obstacles in the legislative for reconstruction approval	0.49	0.60
	B34	Unavailability of medical services after the disaster	0.88	0.86
	B35	Lack of appropriate policies for people's relocation	0.97	0.86
	B36	Damage to medical services, like hospitals	0.98	0.73
	B37	Inappropriate infrastructure maintenance policies	0.93	0.84
	B38	Incompetence of contractors	0.68	0.92
	B39	Illegal construction during recovery	0.89	0.84

	B40	Insufficient built infrastructures	0.97	0.92
	B41	Insufficient construction method, quality, & practices	0.97	0.84
	B42	Unclear reconstruction and recovery regulations	0.99	0.90
	B43	Outdated construction standards and codes	0.59	0.96
	B44	Insufficient investment in natural buffers	0.96	0.92
Environment	B45	Slow/Late debris and erosion removal after a disaster	0.88	0.75
	B46	Level of water contamination	0.86	0.84
	B47	Level of environmental harm	0.98	0.80
	B48	Level of air pollution	0.52	0.62
	B49	Level of noise pollution	0.63	0.99
	B50	Lack of comprehensive resource database	0.95	0.87
	B51	Number of available active contractors	0.81	0.84
Coordination and Resources	B52	Slow/Improper decision-making for recovery actions	0.88	0.98
	B53	Undefined roles and responsibilities in the recovery	0.98	0.93
	B54	Misalignment between Federal policies & local planning	0.62	0.92
	B55	Inappropriate material allocation and disbursement	0.95	0.95
	B56	Community engagement in recovery policy development	0.97	0.94
	B57	Weak cooperation among NGOs & governmental entities	0.91	0.93
	B58	Occurrence of multiple disasters in a short period	0.81	0.95
	B59	Unclear moratoria or temporary construction restrictions	0.99	0.91
	B60	Local capacity of producing materials	0.96	0.99
	B61	Political Pressure	0.95	0.99
	B62	Less engagement of technical expertise for planning	0.99	0.99

The infrastructure and construction latent variable has the highest number of observed variables, 20. In this group, the best correlation is related to land-use determination for rebuilding (B25), with factor loading of 0.99, while the lowest one is related to obstacles in the legislative for reconstruction approval (B33), with factor loading of 0.50, according to the expert model. It worth mentioning, B33 has the lowest factor loading among all the 62 observed variables of the expert model. Other than the financial and economic and social latent variables, in the infrastructure and construction latent variable of the public model, there is a big gap (0.47) between the minimum factor loading (0.52) and the maximum one (0.99); the former is ignorance of traditional resources for reconstruction (B32) and the latter is land-use determination for rebuilding (B25). In the environment latent variable, the factor loadings vary between 0.52-0.98 and 0.62-0.99 respectively according to the expert and public model. Furthermore, In both the expert and public measurement models the lowest factor loading of the environment latent variable is related to level of air pollution (B48) observed variable. In the coordination and resources latent variable, the lowest correlation is related to misalignment between Federal policies & local planning (B54), with factor loading of 0.62, according to the expert model. For the same latent variable but in the public model, the factor loadings vary between 0.91-0.99. It must be added that the lowest factor loading of the public model among all the 62 observed variables is related to ignorance of traditional resources for reconstruction (B32), with correlation coefficient of 0.52, from the infrastructure and construction latent variable group. In summary, the variation of the factor loadings was more in the expert model compared to the public model. In addition, as shown in Table 4-2, the estimated factor loadings of all the observed variables are greater than the predefined threshold; for both the experts and public samples. Thus, it can be induced that all the 62 observed variables can explain a significant portion of the variance of their relative latent variable.

For the individual reliability test, the Cronbach's Alpha coefficient is estimated, which is normally used to determine the internal consistency of measurements (e.g. for survey and questionnaire). According to Garson (2008), Cronbach's Alpha coefficient bigger than 0.7 is acceptable. As shown in Table 4-3, the Cronbach's Alpha of all the five latent variables are between 0.96-1.0 according to the experts, and between 0.97-1.0, according to the public. This is satisfactory and verifies that the observed variables of each group are closely related to each other, internally. In the context of reliability, this infer leads to concluding that all the observed variables are individually reliable. One of the most important parts of model measurement is validation of the model construct, which is necessary in order to test the designed structure of a model constructed for a particular purpose. For this purpose, two tests are performed: discriminate validity test and convergent validity test. The discriminate validity test measures the degree of difference between two constructs that are supposed to be different. In contrast, the convergent validity test determines how the variables of a construct are correlated and to what extent the variance is shared between them.

Table 4-3. Reliability and construct validity tests results.

Latent Variable	Cronbach's Alpha		Ave. Variance Extracted		Maximum R^2 Among Constructs	
	Expert	Public	Expert	Public	Expert	Public
Financial and Economic	0.991	0.995	0.875	0.991	0.002	0.003
Social	0.992	0.990	0.847	0.955	0.001	0.004
Infrastructure and Construction	0.994	0.990	0.609	0.599	0.010	0.014
Environment	0.964	0.979	0.804	0.815	0.002	0.008
Coordination and Resources	0.995	0.997	0.910	0.952	0.006	0.010

For the discriminate validity test, the maximum R^2 among different constructs is estimated, which literally is called shared variance. The estimated shared variances for all the latent variables and both the expert and public models are shown in the fourth column of Table 4-3. The criterion to measure the model construct based on this method is that the estimated maximum R^2 to be less than the average variance extracted for each latent variable, shown in column three of Table 4-3. As shown, all the estimated shared variances are significantly smaller than the corresponding average variance extracted. As an illustration, for the financial and economic latent variable, the estimated Maximum R^2 for the expert and public models are respectively 0.002 and 0.003, which both are less than the relative average variances, 0.875 and 0.991 respectively. The same conclusion could be induced for all the other constructs. Thus, all the constructs are validated discriminately.

In case of convergent validity test, the average variance extracted is used for measuring the validity of the constructs. The criterion for the acceptance of the constructs based on this test is that the selected metric to be more than or equal to 0.5. As shown in the third column of Table 4-3, among different constructs, the one for the infrastructure and construction latent variable has the least value of average variance extracted in both the expert and public models, 0.609 and 0.599

respectively, which are still acceptable. All the estimated average variances extracted for both the expert and public models meet this criteria and thus it can be concluded that the validation of the constructs is achieved by this method.

The results of the measurement model shows that the model meets the required standards and the hypothesized constructs are satisfactory. In addition, this constructs and the variables can be utilized for constructing the SEM.

4.5.2. Structural Model

4.5.2.1. Baseline model development

In this section, the process of developing the baseline structural model for both the expert and public datasets is described. Since the final aim of this study is to investigate the causal relations among different barriers to timely post-hurricane recovery process (namely the observed variables), a latent variable is added to the measurement model that was developed and validated in the previous step. The newly added latent variable is called delay which means the delay in the recovery process after a hurricane due to the likely barriers. Then, the structural relationships among all the validated latent variables from the model measurement step were estimated. The baseline model is shown in Figure 4-5.

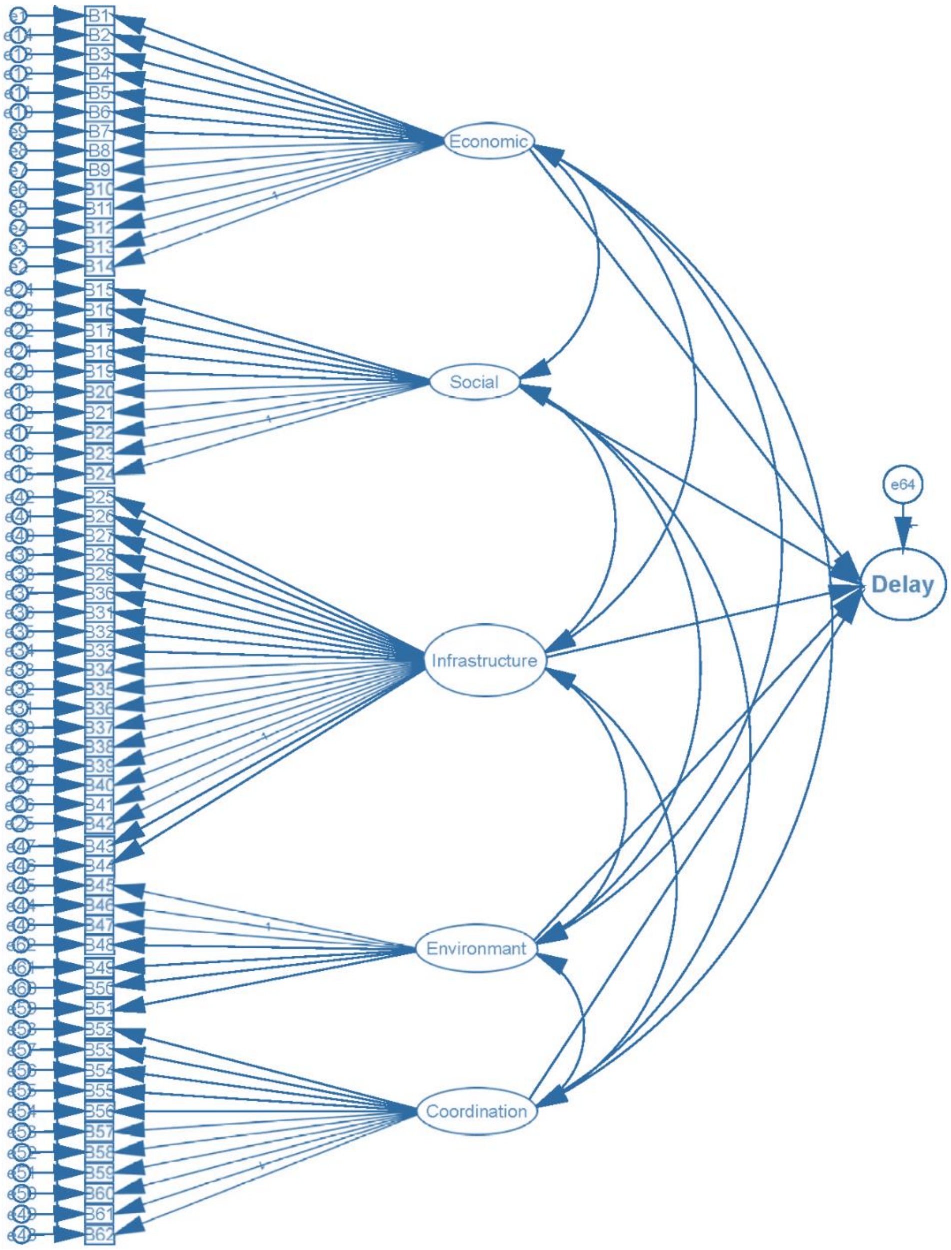


Figure 4-5. The baseline model.

The construct of the developed conceptual model was the same for both the experts and public since for both of the datasets the proposed construct resulted in satisfactory results. In addition, this enables us to compare the results of both models. It must be added that the proposed construct was verified with 10 experts in the area of post-hurricane recovery and their recommendations were considered while developing the model. Furthermore, the significance level of five percent was achieved among the path coefficients and the shown relationships.

4.5.2.2. Path Analysis

In this step, the developed baseline model is analyzed with SEM and with considering several different scenarios of relationships between the latent variables, the final fit model will be presented for both the expert and public. As shown in Figure 4-5, all the latent variables are interrelated in the final model in order to evaluate their causal interactions on the time of recovery after hurricanes. In other words, all the latent variables are considered interdependent in this model, which is justifiable according to the dynamic and complex situation of the affected areas after a hurricane. Considering the likely interactions among the model components, numerous paths passing from the observed variables (the 62 barriers) and latent variables (six) could be possible, which increases the complexity of the condition for the decision-maker who strive reducing the time of recovery. To evaluate the model fit and the extent to which the model could be useful, several metric were estimated for both the expert and public models. According to Jaccard and Wan (1996) at least three metrics are needed for this evaluation. For this purpose, according to the literature, among a dozen of fit statistics, four indices or metrics are selected: Non-Normed Fit Index (NNFI), Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA), and Chi-square divided by degree of freedom (χ^2/DF). The selected metrics are a combination of absolute fit indices and relative or incremental fit indices: the former tests how well a model reproduces the data (goodness of fit) (NNFI and CFI), while the latter measures the badness of fit (RMSEA and χ^2/DF). The results of estimating the above-mentioned indices are shown in Table 4-4, for both the expert and public models. NNFI, also named Tucker Lewis Index (TLI), ranges between 0-1. Byrne (2006) recommended a cutoff threshold of 0.8 for this index. Both the expert and public models have NNFI of greater than 0.8, which means that the models are well fitted. However, the expert model has a lower value for this index (0.801) compared to the public (0.870).

It should be added that in some context a cutoff of 0.7 is suggested for NNFI (Arrindell et al., 1999). CFI also ranges between 0-1 and a threshold of 0.73 is recommended for that (Eybpoosh et al., 2011). As shown in Table 4-4, the CFI for the expert model (0.851) shows a better fit than the public model's CFI (0.74), even though both of the models have a greater CFI value than the cutoff value (0.73). RMSEA evaluates the average divergence between the covariance predicted by the model and the observed covariance. While this index ranges between 0-1, the smaller its value is the more perfect the model would be fitted and vice versa. Reported in Table 4-4, both of the expert and public models are well fitted, according to the estimated RMSEA, 0.045<0.1 and 0.081<0.1 respectively. The utmost estimated index, χ^2/DF, is a variance estimate and tests how different or similar the structure of the model covariance are. The nominator represents the sum of chi-squares and the denominator represents the degree of freedom or the number of independent grids in the model. As shown in Table 4-4, both the expert and public models are well fitted according to this index; due to having χ^2/DF values of less than cutoff (three), 2.240 and 2.111 respectively.

Table 4-4. Results of fit indices for both the expert and public models.

Index	Index Type	Range		Recommended Cutoff	Model Fit	
		Min.	Max.		Expert	Public
NNFI	Goodness of fit	0 (No fit)	1 (Absolute Fit)	0.80	0.801	0.870
CFI	Goodness of fit	0 (No fit)	1 (Absolute Fit)	0.73	0.851	0.740
RMSEA	Badness of fit	0 (Absolute fit)	1 (No Fit)	0.10	0.045	0.081
χ^2/DF	Badness of fit	> 0		3	2.240	2.111

In sum, it could be concluded that both the expert and public models are well fitted since all the estimated indices are in the range and meet the cutoff requirement. However, NNFI estimates show that the public model is fitted better, while the other three indices including CFI, RMSEA, and χ^2/DF indicate that the expert model is fitter better than the public model. Also, the direction of the relationships between the latent variables is determined. The results of path analysis showed that the baseline models for both the expert and public datasets was approved as the final fit model. This is justifiable since the baseline model was accurately designed according to the literature and then it was evaluated and accepted by 10 experts in the process of post-hurricane recovery.

In addition, according to the complex conditions after hurricanes, the mutual relations between the five initial latent variables (financial and economic, social, infrastructure and construction, environment, and coordination and resources) and the added latent variable (delay) can be understood. In Table 4-5, the final results for both of the expert and public models are shown.

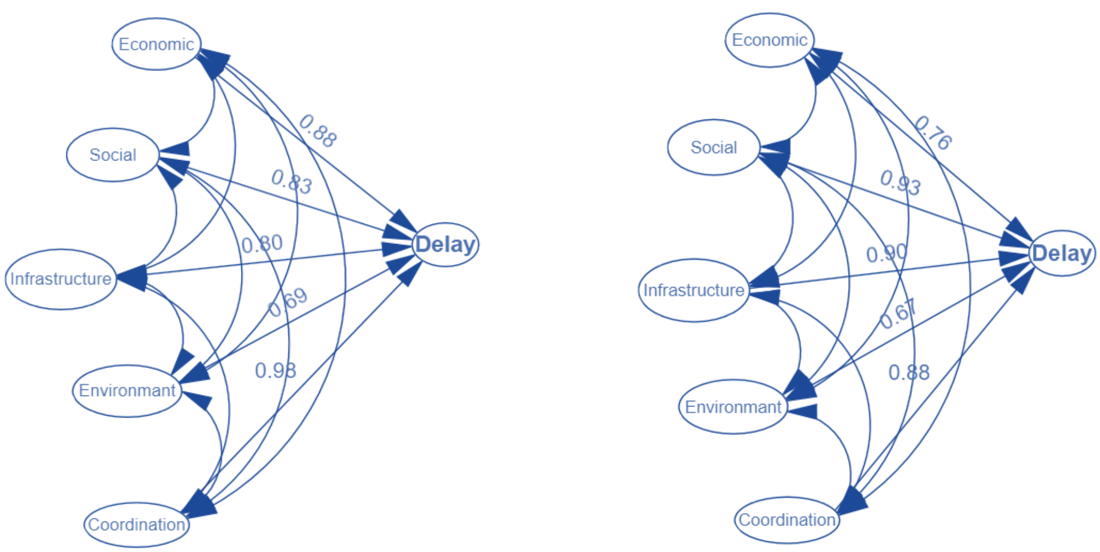
Table 4-5. Results of the structural models.

Expert Model						
Latent Variable	FE	S	IC	E	CR	D
Financial and Economic (FE)		0.96	0.93	0.68	0.94	0.88
Social (S)	0.96		0.90	0.76	0.89	0.83
Infrastructure and Construction (IC)	0.93	0.90		0.77	0.87	0.80
Environment (E)	0.68	0.76	0.77		0.72	0.69
Coordination and Resources (CR)	0.94	0.89	0.87	0.72		0.98
Delay (D)	0.88	0.83	0.80	0.69	0.98	
Public Model						
Latent Variable	FE	S	IC	E	CR	D
Financial and Economic (FE)		0.94	0.84	0.88	0.90	0.76
Social (S)	0.94		0.93	0.81	0.86	0.93
Infrastructure and Construction (IC)	0.84	0.93		0.69	0.89	0.90
Environment (E)	0.88	0.81	0.69		0.81	0.67
Coordination and Resources (CR)	0.90	0.86	0.89	0.81		0.88
Delay (D)	0.76	0.93	0.90	0.67	0.88	

Even though the estimated covariance for the relationships between the latent variables varies from the expert to the public model, but the similar directions of the relationships in the models show that there is a level mutual understanding of the barrier’s that impact on the timeliness of the recovery process after hurricanes between the experts and the public.

4.5.2.3. Discussion

Initially, existence of relationships among the barriers to timely post-hurricane recovery process was explored in this study. As the analysis of the results demonstrate, both of the expert and public models reveal that such an interrelations exist among the barriers and the latent variables. Therefore, constructing robust and reliable models to evaluate the causal relationships among such barriers can lead to avoiding unwanted delays in the recovery process. In addition, the results showed that if the baseline model be constructed accurately, the possibility of finding the interactive relationships among the variables with a perfectly fitted model would be increased. The results demonstrated in Tables 4-4 and 4-5 show that there are similarities between the expert and public model results, even though the expert model was fitted better, as expected. Figure 4-6a and b show the final model of the six latent variables.



a. Expert b. Public

Figure 4-6. Final models of the latent variables and the path coefficients from each latent variable to delay.

According to Figure 4-6a and b, comparing the path coefficients of expert and public models show that in three of the paths the coefficient estimated by the expert model is bigger, which are:

— Economic → Delay (Coefficient=0.88>0.76)

— Environment → Delay (Coefficient=0.69>0.67)

— Coordination → Delay (Coefficient=0.98>0.88)

On the other hand, the path coefficients of the other two paths is greater in the public model, as the following:

— Social → Delay (Coefficient=0.93>0.83)

— Infrastructure → Delay (Coefficient=0.90>0.80)

The lowest value of path coefficient in both of the models is related to the environment variable path to delay: expert=0.69 and public=0.67. From this, it can be concluded that this variable and its corresponding barriers (B45-B51) are not appropriate variables for deciding on the critical paths through the recovery process. On the other hand, the highest value of path coefficient in the expert model is related to the coordination to delay path (0.98), while the social to delay path has the greatest path coefficient value (0.93) in the public model. Therefore, it can be concluded that according to the expert model the coordination barriers are more effective on the time of recovery other than the other variable groups. However, for the public model the highest priority is given to the social group of barriers. This can be understood considering that the social barriers are more sensible for the public since they are directly involved with them.

4.6. Conclusions

This study aimed to investigate if there are relationships among the barriers to timely recovery after a hurricane, identify the causal relationships among the barriers, and determine the extent to which the barriers and their interactions lead to delays of the recovery process. Two SEM models were developed and the analyses were made according to the experts and public's perspectives on the post-hurricane recovery and the corresponding barriers and the results were compared.

To evaluate the model fit and the extent to which the model could be useful, several metric were estimated for both the expert and public models. Both the expert and public models have NNFI of greater than 0.8, which means that the models are well fitted. However, the expert model has a lower value for this index (0.801) compared to the public (0.870). CFI for the expert model (0.851) shows a better fit than the public model's CFI (0.74), even though both of the models have a greater CFI value than the cutoff value (0.73). both of the expert and public models are well fitted, according to the estimated RMSEA, 0.045<0.1 and 0.081<0.1 respectively. both the expert and public models are well fitted according to this index; due to having χ^2/DF values of less than cutoff (three), 2.240 and 2.111 respectively.

There are similarities between the expert and public model results, even though the expert model was fitted better. According to the experts model the barriers underlying coordination latent variable have more impacts on the time of recovery other than the other variable groups. However, for the public model the highest priority was given to the barriers underlying the social group. This research assists decision-makers in understanding the critical paths that lead to delays in the post-hurricane recovery process. In addition, they would be able to predict the impacts of interdependent barriers during the recovery process after hurricanes.

The outputs of this research help the decision-makers to wisely determine the barriers that considerably affect the timeliness of recovery process in the aftermath of hurricanes, by providing insight toward process of recovery.

4.7. References

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CHAPTER 5. CONCLUSIONS, LIMITATIONS, AND RECOMMENDATIONS

5.1. Conclusions

This study strived to identify the barriers to an effective and timely post-disaster recovery process. From the literature, 62 barriers to effective and timely post-disaster recovery were identified and classified in five categories: financial and economic, social, infrastructure and housing reconstruction, environment, and coordination and resources. The rate of employment after a disaster was the most-cited barrier in the financial and economic category, as unemployment can create obstacles in the recovery process and often results in higher crime rates in the affected communities, wasting the human and financial resources needed for enhancing social security. The diversity of culture and languages in the affected area was the most cited barrier in the social category. Variations in the languages of people in affected communities lead to communication difficulties between the people and the supporting organizations. Land use determination was the most referenced barrier in the infrastructure and housing reconstruction category, due to conflicts between governors and homeowners on recovery in hazard-prone regions. Slow/late debris and erosion removal after the disaster was the top-ranked barrier in the environment category, as weeks, or even months are often needed to fully remove the debris and start the recovery work, which delays the recovery process. The most referred to barrier of the coordination and resources category was the lack of a comprehensive resource database that optimizes the allocation of resources and helps avoid delays.

This study also aimed to rank the barriers and provide insight into the different points of view of the experts and the public. A survey was developed and distributed to the experts and the public to determine how they ranked the importance of each barrier, based on a seven-point Likert-scale data format. A total of 239 individuals participated in the survey, of which 44 were experts.

Through statistical analysis, the results of both groups were analyzed and compared, and the barriers were ranked. Interviews with the experts were conducted to evaluate the results. According to the experts, undefined roles and responsibilities in the recovery, improper physical development patterns and rules, and slow/improper decision-making related to recovery actions were the top three barriers that caused delays in post-hurricane recovery. The public's Top-3 barriers included insufficient built infrastructures (B40), insufficient transport-related businesses (B13), and late allocation of funding resources (B9). The higher the number of built infrastructures in hurricane-affected areas, the faster the community returns to the normal functioning. Since transportation plays an important role in smooth and timely recovery, sufficient number of transport-related businesses are needed after a hurricane happening. Moreover, the funding resources need to be allocated and distributed as quickly as possible to provide the required facilities for accelerating the process of recovery.

This study also aimed to investigate whether there are relationships among the barriers to timely recovery after a hurricane, identify the causal relationships among the barriers, and determine the extent to which the barriers and their interactions lead to delays of the recovery process. Two SEM models were developed, analyses were made according to the experts' and public's perspectives on the post-hurricane recovery and the corresponding barriers, and the results were compared. To evaluate the model fit and the extent to which the model could be useful, several metrics were estimated for both the expert and public models. Both of the models have an NNFI greater than 0.8, which means that they are well-fitted; however, the expert model has a lower value for this index (0.801) than the public model (0.870). The CFI for the expert model (0.851) shows a better fit than the public model's CFI (0.74). Even though the CFI value of both of the models is greater than the cutoff value (0.73), both of the expert and public models are well-fitted, according to the estimated RMSEA, which is 0.045<0.1 and 0.081<0.1 respectively. Both the expert and public models are well fitted according to this index, due to having χ^2/DF values of 2.240 and 2.111 respectively, which are both less than the cutoff (3). There are similarities between the expert and public model results, even though the expert model was fitted better. According to the experts' model, the barriers underlying latent coordination variables have greater impact on the time of recovery than the other variable groups. However, for the public model the highest priority was given to the barriers underlying the social group.

This research will assist decision makers in understanding the critical paths that lead to delays in the post-hurricane recovery process and will enable them to predict the impacts of interdependent barriers during the recovery process following hurricanes. It will also help the decision makers have a better understanding of the public's concerns so they can be taken into consideration while they are establishing post-hurricane recovery plans and strategies. It will assist the decision makers in determining which barriers most affect the timeliness of the recovery process and will assist policymakers in acquiring the knowledge necessary for modeling effective post-hurricane recovery processes and developing practical policies that can achieve successful recovery activities.

5.2. Limitations

The primary limitation in this study was the unequal number of expert and public participants in the survey which could affect the conducted statistical measurement and developed models. In addition, the age distribution of the respondents was another constraint in this research. The public participants were mostly the youth while the experts were majorly middle-aged or older. Thus, their concerns, experiences, and understandings were significantly different which could lead them to be biased while answering the questions.

5.3. Recommendations for Future Studies

5.3.1. Recommended Mitigating Strategies

Effective strategies, based on identified and validated post-disaster reconstruction barriers, can be adopted to achieve timely post-hurricane recovery. In Table 5-1, the Top-10 barriers on which the experts and the public had the greatest different perspectives are shown.

Table 5-1. Top-10 Barriers with Greatest Absolute RII Differences By Experts & Public

#	ID	Barrier	Absolute Difference
1	B28	Damage to major transportation systems	0.20
2	B31	Improper physical development patterns and rules	0.18
3	B27	Damage to commercial and industrial buildings	0.14
4	B13	Lack of transport-related businesses	0.13
5	B18	Large number of disabled & elderlies	0.12
6	B30	Unsmooth relocation before reconstruction	0.12
7	B56	Community engagement in policy development	0.12
8	B53	Undefined roles and responsibilities in the recovery	0.11
9	B20	Population density	0.10
10	B26	Damage to residential housing	0.10

To mitigate the impact of barriers shown in Table 5-1 on the time of recovery, mitigating strategies were developed according to the lessons learned from the previous hurricanes and the interviews conducted by the experts in post-hurricane recovery. Table 5-2 shows the list of the mitigating strategies.

Many of the suggested strategies lead to increasing awareness among the affected communities, recovery teams, technical experts, etc. For example, organizing training programs before the hurricane and during the recovery would be useful. Moreover, the lessons learned need to be documented and published for everyone, to increase the public's knowledge on different aspects of hurricanes, recovery. Also, different organizations and institutions, as well as volunteers from the affected areas and neighborhood locations, and individuals and groups outside the area normally cooperate in the recovery of the affected areas due to hurricanes. For instance, it is highly important to build systematic coordination among individuals and institutions to optimize the efficiency of the reconstruction process. Thus, the establishment of inter-agency group meetings in which activity reports and necessary follow-ups could be shared. Furthermore, only one person should serve as coordinator, and that person should control the entire process, hold the meetings, and manage other interactions.

Table 5-2. Mitigating Strategies

#	**Mitigating Strategy**
1	Develop a proper damage assessment tool
2	Determine the priorities of damaged transportation infrastructures
3	Hold public assistance training programs
4	Build relations between the local and federal organizations
5	Develop a proper damage assessment tool
6	Determine list of important transportation infrastructures
7	Conduct inter-agency group meetings and follow-ups
8	Incorporate media strategies for communications
9	Collect suggestions from the affected public
10	Determine the responsibilities and roles of the stakeholders
11	Develop a proper damage assessment tool
12	Document the lessons learned from the previous disasters
13	Share the information internally and also for the public
14	Hold technical training programs for construction, damage determination, etc.
15	Hold training for the recovery teams
16	Document the lessons learned from the previous disasters

In addition, involving the public and collecting their suggestions, both in the pre-hurricane and post-hurricane process, effectively enhances the likelihood of a timely recovery. Also, determining which private and governmental organizations are responsible for initiating the pre-hurricane and post-hurricane recovery. In addition, clearly defining the roles and responsibilities of those involved in reconstruction would significantly help avoiding potential conflicts during the recovery process. Although the roles are mostly pre-defined in the guidelines, but as the condition after hurricanes is chaotic and difficult to manage, there is a need for an implementation plan including step-by-step recovery strategies.

5.3.2. Future Work

Before developing the causal model capturing the relationships among the barriers to timely post-hurricane recovery (presented in Chapter 4), a conceptual model was developed. In this section, the output of the developed model is presented briefly as a direction for further research in the future. A sample section of this model is shown in Figure 5-1.

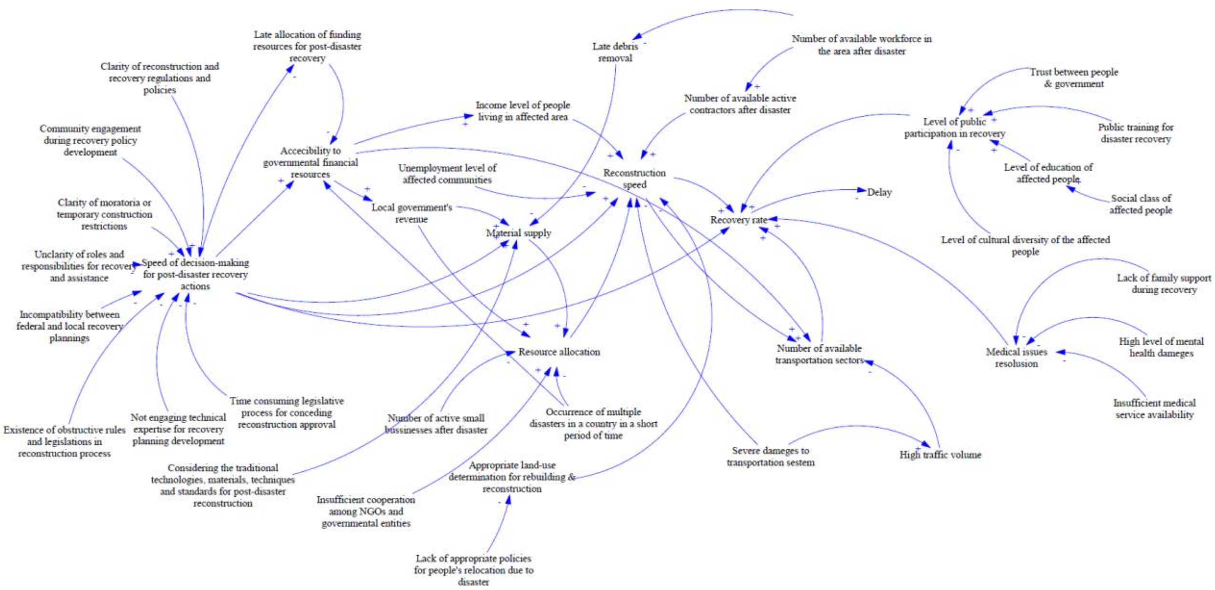

Figure 5-1. Conceptual Dynamic Relations of the Barriers.

As shown, the developed causal diagram shows the cause-effect relationships among the barriers. This loop diagram shows the pathway to which the system works. The + and – symbols on the barriers show the direction of the impact. For example, when the supply of the material increases, the resource allocation time increases as well and vice versa; thus, the speed of reconstruction increases leading to a higher rate of recovery and less delays in the recovery process. As an another example, the speed of decision making, which itself is related to many other legislatives and planning, has an direct impact on the recovery duration, while it can indirectly impact resource allocation process, which itself influences the recovery rate as mentioned before. The proposed conceptual framework draws attentions to the key barriers affecting timely post-disaster recovery process and summarizes the identified relationships.

In addition, there are many opportunities for further comprehensive and complementary studies. Five categories of barriers were analyzed in an integrated framework in this study; however, it is recommended that analytical models be developed for each of these categories. Such an approach would be helpful for managers of non-governmental entities who deal with limited issues and barriers. For implementation of the findings of the current study, it is highly recommended that the users localize the outcomes, based on their area of focus. Utilizing other techniques could provide another direction for future studies and could validate the current research. The results of this study showed that the barriers in the environment category, which are very important to the long-term recovery process, have not been studied in depth by researchers. Because of their importance, it is suggested that more studies be conducted on these barriers.

APPENDICES

Appendix I: Email Content Sent to Survey Participants

Greetings,

You are receiving this letter because we are hoping that you will help us with a very important project. We are conducting a study to better understand barriers to post-disaster recovery and would like to ask you to participate in an online survey. Your expertise and feedback would be valuable as we work to identify current obstacles to help improve recovery efforts. The sponsors of this project are the U.S. Department of Transportation (USDOT) and The Center for Transportation, Equity, Decisions, and Dollars (C-TEDD).

Your participation is voluntary, and your responses to the survey will be kept strictly confidential. If you have any questions or concerns about the study, please feel free to E-mail the Principal Investigator Sharareh Kermanshachi at sharareh.kermanshachi@uta.edu. Any questions you may have about your rights as a research subject may be directed to the Office of Research Administration; Regulatory Services at 817-272-2105 or regulatoryservices@uta.edu.

We hope that you will take the time to answer the questions and return the results to us. Completing the survey should take no longer than ten minutes. Thank you in advance for your help with this valuable study. To begin the survey, please click on the link below.

https://uta.qualtrics.com/jfe/form/SV_72Lizcna9p3ILFr

Appendix II: Survey

We are conducting a short, confidential survey of how people and communities recover and rebuild from disasters. The purpose of this study is to identify the barrier factors to the rapid post-disaster reconstruction. The procedures you will follow as a research subject are: 1) To read this paragraph explaining the study, and if you agree to participate, clicking "Next"; 2) To complete several survey questions about your experience with disasters and your opinions about disaster recovery efforts. There are no perceived risks or direct benefits for participating in this study. There are no alternatives to this research project, but you may quit at any time. You must be at least 18 years old to participate.

The sponsors of this project are the U.S. Department of Transportation (USDOT) and The Center for Transportation, Equity, Decisions, and Dollars (C-TEDD).

Any identifiable information will be kept confidential with access limited to the research team. We may publish, present, or share the results, but your name will not be used. For questions or concerns, contact the UTA Research Office at 817-272-3723 or regulatoryservices@uta.edu.

It will take about 10 minutes to participate in this research, and your participation is completely voluntary.

Please click the "Next" button below if you agree to take the survey and are ready to proceed.

Q1. What types of disasters have you been involved in? Please check all that apply.

- ☐ Hurricanes
- ☐ Flooding
- ☐ Thunderstorms
- ☐ Tornadoes
- ☐ Earthquakes
- ☐ Tsunami
- ☐ Other __________

Q2. Approximately how many disasters have you been involved in?

- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5
- ○ More than 5

Done

Q3. How would you rate the severity of the worst disaster you have experienced?

	Very low	Low	Medium	High	Very high
Disaster Severity	○	○	○	○	○

Q4. Thinking again of the worst disaster you experienced, where did it occur?

- Africa
- North America
- South America
- Asia
- Europe
- Australia

Q5. For this worst disaster, how long did the recovery process take?

- Less than one month
- 1-3 months
- 4-6 months
- 7-10 months
- 11-12 months
- More than one year

Q6.
Thank you for your time so far. Now we are going to ask you some questions about the importance of several community features, which might affect disaster recovery. How important do you think each of the following factors is in influencing an area to recover from a disaster?

	Not at all Important 1	Slightly Important 2	Somewhat Important 3	Moderately Important 4	Very Important 5	Quite Important 6	Extremely Important 7
Average household income	○	○	○	○	○	○	○
Unemployment levels	○	○	○	○	○	○	○
Average revenue of the local government (e.g., City, etc.)	○	○	○	○	○	○	○
Average housing value	○	○	○	○	○	○	○
Diversity in types of industry or employment sectors	○	○	○	○	○	○	○
Average education level of residents	○	○	○	○	○	○	○
Highway traffic volume after the disaster	○	○	○	○	○	○	○
Population density	○	○	○	○	○	○	○
Occurrence of multiple disasters in a country in a short period of time	○	○	○	○	○	○	○

Q7.
What types of disaster damages do you think make the recovery process especially difficult or slow?

	Not at all Important 1	Slightly Important 2	Somewhat Important 3	Moderately Important 4	Very Important 5	Quite Important 6	Extremely Important 7
Average lost household income	○	○	○	○	○	○	○
Average lost business income	○	○	○	○	○	○	○
Damage to major infrastructure systems (e.g., airport, bridge, etc.)	○	○	○	○	○	○	○
Damage to high-rise buildings	○	○	○	○	○	○	○
Damage to medical services, like hospitals	○	○	○	○	○	○	○
Damage to residential housing	○	○	○	○	○	○	○
Environmental contamination, such as reduced water and air quality	○	○	○	○	○	○	○
Environmental harm that affects industry, such as lost natural resources that reduce fishing or tourism	○	○	○	○	○	○	○

Q8.
What factors do you think are most important to improve the disaster recovery process?

	Not at all Important 1	Slightly Important 2	Somewhat Important 3	Moderately Important 4	Very Important 5	Quite Important 6	Extremely Important 7
Number of available active contractors after a disaster	○	○	○	○	○	○	○
Number of active small businesses after the disaster (e.g., food providers)	○	○	○	○	○	○	○
Voluntary public participation in the recovery process	○	○	○	○	○	○	○
Availability of medical services after the disaster	○	○	○	○	○	○	○
Availability of disaster recovery public training	○	○	○	○	○	○	○
Timely debris and erosion removal after the disaster	○	○	○	○	○	○	○
Timely resolution of air and water quality issues after the disaster	○	○	○	○	○	○	○

Q9. What policies do you think are important to an effective disaster recovery process?

	Not at all Important 1	Slightly Important 2	Somewhat Important 3	Moderately Important 4	Very Important 5	Quite Important 6	Extremely Important 7
Community engagement during recovery policy development	○	○	○	○	○	○	○
Compatibility between federal and local recovery plannings	○	○	○	○	○	○	○
Appropriate land-use determination for rebuilding and reconstruction	○	○	○	○	○	○	○
Appropriate resource and service allocation and disbursement	○	○	○	○	○	○	○
Clarity of reconstruction and recovery regulations and policies	○	○	○	○	○	○	○
Level of accessibility to governmental resources for short-term response	○	○	○	○	○	○	○
Level of accessibility to governmental resources for long-term reconstruction	○	○	○	○	○	○	○
Cooperation among NGOs and governmental entities	○	○	○	○	○	○	○
Speed of decision-making for post-disaster recovery actions	○	○	○	○	○	○	○
Technical expertise engagement for recovery planning development	○	○	○	○	○	○	○
Consideration of the traditional technologies, materials, techniques and standards for post-disaster reconstruction	○	○	○	○	○	○	○
Clarity of roles and responsibilities for recovery and assistance	○	○	○	○	○	○	○
Clarity of moratoria or temporary construction restrictions	○	○	○	○	○	○	○
Investing in natural buffers, such as coastal wetlands to prevent storm surges.	○	○	○	○	○	○	○

Q10. What barriers do you think slow the disaster recovery process?

	Not at all Important 1	Slightly Important 2	Somewhat Important 3	Moderately Important 4	Very Important 5	Quite Important 6	Extremely Important 7
Lack of appropriate policies for people's relocation due to disaster	○	○	○	○	○	○	○
Illegal construction during peak period of the recovery	○	○	○	○	○	○	○
Late allocation of funding resources for post-disaster recovery	○	○	○	○	○	○	○
Inequality in resource distribution	○	○	○	○	○	○	○
Barriers in the legislative process for conceding reconstruction approval	○	○	○	○	○	○	○

Q11. How important is it for people affected by a disaster to have the following?

	Not at all Important 1	Slightly Important 2	Somewhat Important 3	Moderately Important 4	Very Important 5	Quite Important 6	Extremely Important 7
Family or friends who can help them financially	○	○	○	○	○	○	○
Family or friends who can help them emotionally	○	○	○	○	○	○	○
A community that looks out for each other	○	○	○	○	○	○	○

Q12. Are there any other factors or strategies that you think are particularly effective for facilitating the disaster recovery process?

Q13. Are there any other barriers that are especially hinder the disaster recovery process?

Q14. Some studies have shown that environmental factors, such as forest cover to reduce landslides or coastal wetlands to reduce storm surges, can lessen the severity of disaster impacts. Please answer the following question about the importance of environmental factors in timely disaster recovery.

	Not at all Important 1	Slightly Important 2	Somewhat Important 3	Moderately Important 4	Very Important 5	Quite Important 6	Extremely Important 7
How important are environmental factors in timely disaster recovery, relative to other concerns, like improving community infrastructure?	○	○	○	○	○	○	○

Q15. What title best describes your current occupation?

- ○ Engineer
- ○ Project manager
- ○ City official or staff
- ○ Student
- ○ Other

Done

Q16. What is your year of birth?

Q17. What is the highest level of school you have completed or the highest degree you have received?

- ○ Less than high school degree
- ○ High school graduate (high school diploma or equivalent including GED)
- ○ Some college but no degree
- ○ Associate degree in college (2-year)
- ○ Bachelor's degree in college (4-year)
- ○ Master's degree
- ○ Doctoral degree
- ○ Professional degree (JD, MD)

Q18. What is your sex?

- Male
- Female

Q19.
Choose one or more races that you consider yourself to be:

- White
- Black or African American
- American Indian or Alaska Native
- Asian
- Native Hawaiian or Pacific Islander
- Other

Done

Q20. Are you Spanish, Hispanic, or Latino or none of these?

- Yes
- None of these

Q21. Thank you for your participation! For questions or concerns about the study, you may contact the Principal Investigator Dr. Sharareh Kermanshachi at sharareh.kermanshachi@uta.edu. Any questions you may have about your rights as a research subject may be directed to the Office of Research Administration; Regulatory Services at 817-272-2105 or regulatoryservices@uta.edu.

If you have any comments, additional thoughts or would like to clarify any of your answer choices, you are welcome to do so below. Thanks again!