Exploring Stakeholder Views on Disaster Resilience Practices of Residential Communities in South Florida

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Abstract: Disaster resilience is a shared responsibility among all stakeholders. There is sorely a need to engage multiple stakeholders in collaboratively creating and facilitating the disaster resilience of residential communities. However, different stakeholders could have different priorities and make different decisions on implementing the resilience practices; such differences are affected by stakeholder views on the importance and current implementation conditions of the resilience practices. Without identifying and integrating multistakeholder views, disaster resilience decisions could become ineffective, time-consuming, costly, and conflict-prone. To address the gap, this paper focuses on identifying the disaster resilience practices in residential communities and analyzing stakeholder views on the importance and implementation of these practices in South Florida. The disaster resilience practices are identified from (1) the domain literature, (2) documents on resilient community planning, and (3) systematic interactions with stakeholders through in-depth surveys and interviews. The paper discusses the survey design, implementation, and results. Overall, the results show that, on average, the identified resilience practices are highly important, and they are moderately implemented. The results also show that, for a considerable number of resilience practices, there is a significant difference in the ranks of importance and implementation of these practices between different stakeholders. In addition, stakeholder views on the importance and implementation of the resilience practices are affected by factors such as stakeholders' ages, regions, types of dwellings in which they live, and the occurrence of the disaster. This research contributes to the body of knowledge by providing both theoretical and empirical knowledge on the importance and implementation of community disaster resilience practices from the stakeholders' perspectives; it could improve human-centered decision-making by integrating multistakeholder views into community resilience planning toward more robust, adaptive, and recoverable residential communities. **DOI: 10.1061/(ASCE)NH.1527-6996.0000319.**

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Introduction

A report published by the National Research Council (NRC 2012) defined the research on understanding and analyzing the disaster resilience of our communities as a "national imperative." Natural disasters lead to large-scale consequences for the nation and its communities. To cope with the catastrophic impacts of natural disasters, planning and implementing disaster resilience practices could strengthen the ability of a community to prepare for, absorb, adapt to, and recover from actual or potential natural disasters in a timely and efficient manner, including continuing or restoring vital services, basic functions, and structures (NIST 2017; Cutter et al. 2014). Disaster resilience is a challenging task because it is a shared responsibility among all the stakeholders, and "achieving this kind of resilience encompasses actions and decisions at all levels of government, in the private sector, and in communities" (NRC 2012). There is a need for "a broader and a more people-centered approach" to achieve disaster resilience, and disaster resilience practices need to be "multisectoral, inclusive and accessible in order to be efficient and effective" (UN 2015). Multiple sectors of stakeholders need to unite and devote resources to support the resilience of buildings and infrastructures, the provision of the health and public services, and the restoration of transportation and delivery systems (FEMA 2011). However, every stakeholder is different, and may make different decisions regarding the priorities of implementing resilience practices (e.g., enhancing the disaster-adaptive energy supply chain versus adding emergency energy supply). Such difference is affected by the different views of the stakeholders (Yang et al. 2014) on disaster resilience, such as their opinions about the most important resilience practices to implement or their assessments on the current implementation conditions of these practices. The differences in stakeholder views could cause conflicts and disputes during the decision-making processes, resulting in longer decision-making time and millions of dollar losses (Maiese 2003). "Conflicts arise over how to move toward enhancing resilience, how to manage the costs of doing so, and how to assess its effectiveness" (NRC 2012). Thus, without understanding and integrating the different views of different stakeholders, disaster resilience decisions could become ineffective, time-consuming, costly, and conflict-prone.

To integrate stakeholder views on disaster resilience, firstly there is a need to understand and identify the different resilience practices of residential communities. Various studies (e.g., Amaratunga et al. 2017; Chang et al. 2008; Djalante 2012) have been conducted in different domains to identify, plan, and implement disaster resilience practices. However, these attempts to characterize disaster resilience revealed various theoretical challenges, including different definitions, interpretations, and characterizations of disaster resilience in the diverse fields of study. The concept of disaster resilience and the

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practices to enhance disaster resilience are domain-specific. For instance, in the engineering domains resourcefulness is defined as the ability of the system to be restored using available resources (McDaniels et al. 2008), whereas in the social science domain it is defined as the capacity of a community to respond to disasters by using substitutable skills or scenarios (Cutter et al. 2008). Therefore, a theoretical framework needs to be established to represent and classify disaster resilience practices in the context of the residential community. In addition, existing studies are often limited by the availability of information (e.g., opinions about disaster resilience) that stakeholders are willing to share with the public, which seriously reduces the efficiency and effectiveness of the planning and implementation of disaster resilience practices (Gopalakrishnan and Peeta 2010). Stakeholder opinion solicitation and stakeholder engagement are the keys for increased awareness of hazard risks and successful implementation of resilience practices (Burnside-Lawry and Carvalho 2016). Although a number of studies (e.g., Bostick et al. 2017; Djalante 2012; Chang et al. 2008) have contributed to multistakeholder engagement and stakeholder collaboration in disaster planning and management, these studies have not focused on understanding the priorities and perspectives of different stakeholders. Thus, there is sorely a need for empirical studies that analyze different stakeholder views on disaster resilience (Chang et al. 2008).

To address the gaps, this paper presents the authors' work on multistakeholder decision-making to enhance the disaster resilience of residential communities. The paper focuses on identifying the disaster resilience practices in residential communities and analyzing stakeholder views on the importance and implementation of these practices in South Florida, which is vulnerable to a variety of disasters (especially hurricanes) that threaten its communities. A set of disaster resilience practices of residential communities is identified from (1) the domain literature (e.g., literature on disaster resilience, reliability, and system engineering), (2) documents of resilient community planning, and (3) systematic interactions with stakeholders through surveys and interviews. The following sections discuss identification, classification, and definition of disaster resilience practices, and the survey design, implementation, results, and conclusions.

Literature Review

Defining and Classifying Resilience Practices by Integrating Divergent Views

Abundant research has been conducted on conceptualizing and defining disaster resilience (Cutter et al. 2014). Similarly, many research efforts (e.g., Rogers et al. 2015; Bruneau et al. 2003; O'Sullivan et al. 2013) have focused on planning, designing, and implementing disaster resilience practices to achieve and strengthen disaster resilience. Disaster resilience is the ability of individuals and communities to plan for, absorb, recover from, and adapt to hazards and adverse events without compromising long-term prospects for development (NRC 2012). Disaster resilience has become a community planning goal, principle, or guideline (Awotona 2016), and a disaster resilience practice is a process or an activity that is implemented to reduce disaster risks and to achieve the goal of disaster resilience. In the context of community planning, disaster resilience is multidimensional, ranging from those that consider resilience as attributes of a particular physical system such as a building or an infrastructure system (e.g., Perera et al. 2017; McAllister 2016) to those that consider it as a set of different capitals such as economic or social capital (O'Sullivan et al. 2013; Aldrich 2012). Thus, there is a need to integrate the physical, environmental, and socioeconomic elements into one comprehensive framework to define and classify community disaster resilience (Paton and Johnston 2006).

On the one hand, a number of studies on community resilience (e.g., Perera et al. 2017; McAllister 2016; Rogers et al. 2015) emphasized that the physical built environment, such as buildings and civil infrastructures, is an inseparable component of a residential community, and the physical built environment serves as the foundation for building a more resilient community. Thus, these studies focus on the robustness, reliability, redundancy, and/or rapid recovery of these physical buildings and infrastructure systems. For example, Bruneau et al. (2003) focused on enhancing the resilience of communities by improving the robustness and rapid recovery of the physical structures of buildings. Cimellaro et al. (2010) proposed a framework for analytical quantification of physical resilience of buildings. Miles and Chang (2003) introduced a method of recovery simulation for a variety of built environments in an urban area. Rogers et al. (2015) focused on postdisaster damage of residential housing and proposed methods to build homes in a more affordable, resilient, and readily repairable manner.

On the other hand, other researchers (e.g., O'Sullivan et al. 2013; Aldrich 2012; Norris et al. 2008) studied community resilience from the aspects of human factor, social capital, and economic development. For example, O'Sullivan et al. (2013) built a framework for critical social infrastructures and developed a model to promote population health and resilience of the community. Aldrich (2012) highlighted the critical role of social capital in the ability of a community to withstand and recover from disasters, and found that communities with robust social networks were able to better coordinate community disaster resilience. Norris et al. (2008) emphasized that community resilience emerges from four main adaptive capacities—economic development, social capital, information and communication, and community competency. The present paper defines, conceptualizes, and classifies community resilience practices in a comprehensive manner by integrating both the physical built environment element and the socioeconomic element.

Importance of Multistakeholder Views in Disaster Resilience Decision-Making

To plan and implement resilience practices in residential communities, there is a need to understand the views and priorities of multiple stakeholders, including not only the responsible stakeholders such as the emergency managers, community planners, or housing contractors who are making the decisions, but also the impacted stakeholders such as the community residents who are affected by the disaster resilience decisions. Decision-making bodies usually comprise stakeholders from multiple sectors who perceive the same problem with different perspectives, realize their interdependence for solving it, and come together to agree on action items and strategies for solving the problem (Steins and Edwards 1999). Community disaster resilience decisions are characterized by complexity and uncertainty with multiple sectors of stakeholders (e.g., community residents, multilevel government, and housing contractors) involved (Kapucu and Garayev 2011; Smith and Wenger 2007). Many organizations [e.g., the United Nations Office for Disaster Risk Reduction (UNISDR) and NRC] have called for a "broader and a more people-centered" approach to collaboratively make decisions on implementing the disaster resilience practices, and disaster resilience practices need to be "multi-sectoral, inclusive, and accessible in order to be efficient and effective." (UNISDR 2018). Thus, this demands transparent and collaborative decision-making processes that are flexible to the dynamically changing environments, encompass a diversity of resilience practices and strategies, and integrate multistakeholder views (Reed 2008). Therefore, multistakeholder participation is becoming increasingly important in disaster resilience decision-making to reflect the voices of all parties, ages, ethnicities, and income levels of a community (Chang et al. 2008; UNISDR 2018). The integration of stakeholder views and knowledge on the community disaster resilience practices facilitates more collaborative, effective, and efficient decision-making (Linnerooth-Bayer et al. 2016). This integration is the starting point of knowledge co-production processes that shape how stakeholder views are considered and translated into inputs for decision-making (Scolobig et al. 2014).

Research Methodology

Theoretical and empirical investigations were used to investigate stakeholder views on disaster resilience in residential communities. Theoretical investigations focused on reviewing relevant documents and literature (e.g., the literature on disaster resilience, reliability, and system engineering). Empirical investigations involved structured interactions with individual stakeholders using questionnaire surveys and interviews. Accordingly, five main research tasks were conducted: (1) development of a disaster resilience hierarchy (identification and classification of disaster resilience practices); (2) design of the survey; (3) validation of the survey; (4) implementation of the survey; and (5) analysis of survey results. An overview of the research methodology is presented in Fig. 1. The following sections discuss each of the research tasks in detail.

Disaster Resilience Hierarchy Development

The authors conducted a comprehensive literature review on disaster resilience in the context of residential communities. Several search engines, including Google Scholar, Science Direct, Florida International University Library, and the American Society of Civil Engineers Library, were used. A set of key words, such as disaster resilience, disaster resilient community, stakeholder views on disaster, resilient residential community, disaster management, environmental resilience, social resilience, economic resilience, resilient building, resilient infrastructure, and stakeholder-based decision-making, was used to search for relevant literature on community disaster resilience. Based on the reviewed literature (e.g., Cutter 2016; Cutter et al. 2008; Bruneau et al. 2003; Cimellaro et al. 2010; Rogers et al. 2015; Ladipo 2016), 33 practices (and corresponding subsets) that are most commonly used to enhance disaster resilience in residential communities were identified. A partial list of the resilience practices and the corresponding literature is summarized in Table 1. These practices were then classified into four main categories: physical, environmental, social, and economic resilience. Physical resilience focuses on one of the major components of residential communities—the built environment (e.g., buildings or civil infrastructures). It refers to the practice that enhances the ability of a physical system to withstand and/or recover from a disruption. The other three main categories are environmental, social, and economic resilience of the residential community. This classification benchmarks the triple-bottom-line (TBL)-sustainability perspective. A TBL-sustainability perspective was used to classify resilience practices because (1) a TBL sustainability perspective offers a holistic and comprehensive approach to identify and classify resilience practices by considering the multifaceted aspects of disaster resilience, and (2) sustainability and resilience are interconnected because both resilience and sustainability are guiding principles behind effective disaster management for a community (Tobin 1999). A partial concept hierarchy (taxonomy), displayed in the form of a Unified Modeling Language (UML) class diagram, is shown in Fig. 2. Numbers R1–R33 were assigned to these practices.

For physical resilience practices, four main subcategories were defined (Fig. 2)

- Robustness is the practice that enhances the strength or ability of residential community elements, systems, and/or other units of analysis to withstand a given level of stress or demand without suffering degradation or loss of function.
- Redundancy is the practice that enhances the extent to which residential community elements, systems, and/or other units of analysis are substitutable (i.e., capable of satisfying functional requirements in the event of disruption, degradation, or loss of functionality with redundant elements, systems, or other units of analysis).
- Resourcefulness is the practice that enhances the capacity to identify problems, establish priorities, and mobilize resources when conditions exist that threaten to disrupt some elements, systems, and/or other units of analysis.
- Rapidity is the practice that enhances the capacity to meet priorities and achieve goals in a timely manner to avoid losses and future disruption.

For social resilience, three main subcategories were defined

- Social preparedness and adaptability is the practice that enhances the ability of community residents to prepare for, adjust to, or adapt to disruptive conditions caused by a disaster.
- Social vulnerability assistance is the practice that assists vulnerable community residents (e.g., economically disadvantaged, the elderly, and the homeless) to withstand adverse impacts from a disaster to which they are exposed.
- Social recovery is the practice that recovers the social capital, socioeconomic status, and physical and emotional conditions of community residents after a disaster.

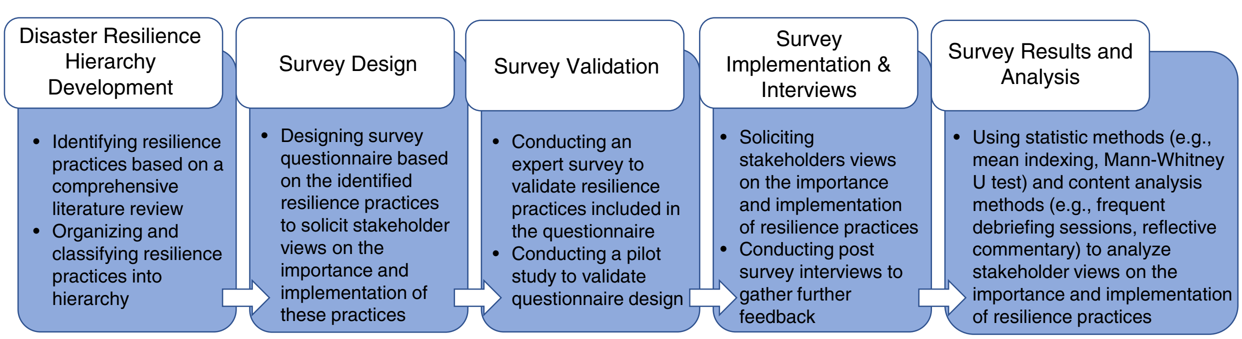

Fig. 1. Research overview.

Table 1. Summary of literature review on disaster resilience practices (partial list)

Source	Resilience practice[a]															
	R2	R4	R6	R8	R10	R12	R14	R16	R18	R20	R22	R24	R26	R28	R30	R32
Aly and Abburu (2015)	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Amaratunga et al. (2017)	X	X	X	—	—	—	—	—	—	—	—	—	—	—	—	—
Anderies (2014)	—	X	X	—	X	—	—	—	X	X	—	—	—	—	—	—
Awotona (2016)	—	—	—	—	—	—	—	X	X	—	—	—	—	—	—	—
Barnes et al. (2008)	—	—	—	—	—	—	—	X	X	—	—	—	—	—	—	—
BBC (2017)	—	X	X	X	—	—	—	X	X	—	—	—	—	X	X	X
Bruneau et al. (2003)	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Chang et al. (2008)	—	—	X	—	—	—	—	X	—	—	—	X	X	—	—	—
Chang et al. (2011)	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—	—
Cimellaro et al. (2010)	X	X	X	—	—	—	—	—	—	—	—	—	—	—	—	—
Disis and Isidore (2017)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	X	—
Flanagan et al. (2011)	—	—	—	—	—	—	—	X	X	—	—	—	—	—	—	—
Fuller-Iglesias et al. (2008)	—	—	—	—	—	—	—	—	X	—	—	—	—	—	—	—
Hassler and Kohler (2014)	X	—	X	—	—	—	—	—	—	—	—	—	—	—	—	—
Kim and Marcouiller (2016)	—	—	—	—	X	—	—	—	—	—	—	X	X	X	X	X
Ladipo (2016)	X	X	X	X	—	—	—	—	—	—	—	—	—	—	—	—
Love (2017)	—	—	—	—	—	—	—	—	—	X	—	—	—	—	—	—
Magis (2010)	—	—	—	—	—	—	—	—	X	X	X	—	—	—	—	—
Mayunga (2007)	—	—	—	—	—	—	—	X	X	—	—	X	—	—	—	X
McAllister (2016)	X	X	X	—	—	—	—	—	—	—	—	—	—	—	—	—
McAllister (2015)	X	X	X	X	X	X	—	—	—	—	—	X	X	X	X	X
Mechler (2005)	—	—	—	—	—	—	—	—	—	—	—	X	X	—	—	X
Mieler et al. (2015)	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mosneaga and Totoki (2015)	—	—	X	X	X	—	—	X	X	X	X	—	—	X	—	—
Norris et al. (2008)	—	—	X	X	X	X	—	X	X	—	—	—	—	—	—	—
O'Connor (2017)	—	—	—	—	—	—	—	—	—	—	—	X	X	—	—	X
Panagiotopoulos et al. (2016)	—	—	X	—	—	—	—	X	—	—	—	—	—	—	—	—
Pelling (2003)	—	—	X	X	—	X	—	X	X	—	—	—	—	—	—	—
Perera et al. (2016)	X	X	X	X	X	X	X	—	—	—	—	X	X	—	—	—
Holley (2017)	—	—	X	—	—	—	—	—	—	—	—	—	—	—	—	—
Reed (2008)	—	—	—	—	—	—	—	—	—	X	X	—	—	—	—	—
Richards (2017)	—	—	—	—	—	—	—	—	—	X	—	—	—	—	—	—
Rogers et al. (2015)	—	—	—	—	X	—	X	—	—	—	—	—	—	—	—	—
Sarkissian (2017)	—	X	—	—	—	—	—	—	X	—	—	—	—	—	—	—
Perera et al. (2017)	—	X	X	X	X	—	—	—	X	—	—	—	—	—	—	—
Straub et al. (2009)	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Thabrew et al. (2009)	—	—	—	—	—	—	—	—	—	X	X	X	X	—	—	—
O'Sullivan et al. (2013)	—	—	—	—	—	—	—	—	—	—	—	—	—	X	—	—

[a]Numbering of resilience practices follows that in Fig. 2.

Four main subcategories of environmental resilience were defined

- Waste treatment is the practice that coverts waste into a recycled object that can be reused or returned to the operational cycle or stored in a temporary or emergency manner with minimal environmental impacts.
- Ecological life cycle protection is the practice that monitors and protects the full life cycle of local ecosystems that are affected by a disaster.
- Habitat and ecosystem preservation is the practice that monitors, preserves, restores, and/or enhances the local ecosystems and habitats affected by a disaster.
- Natural resource restoration is the practice that returns damaged natural resources to the predisaster condition, including analyzing the extent of impacts on natural resources, evaluating the best options for restoring resources, and estimating the type and amount of restoration required to restore the natural resources to the predisaster condition.

Economic resilience has five main subcategories

- Low resilience-related cost is the practice that lowers the disaster preparation cost, recovery cost, and project life-cycle cost with respect to residential community.
- Public service availability is the practice that facilitates the availability and closeness of services such as mass transit, healthcare facilities, financial services, and gas.
- Business rapid recovery is the practice that facilitates the ease and rapidity of recovery of the local business affected by a disaster.
- Tax benefit is the practice that provides the allowable deduction/credit on a tax intended to reduce a taxpayer's burden while developing or owning resilient components or products (e.g., buildings, houses) of a community.
- Insurance promotion is the practice that promotes insurance programs (e.g., the National Flood Insurance Program) to mitigate the risks associated with developing or owning components or products (e.g., buildings and houses) of a community.

Investigating Stakeholder Views

Survey Design

The 33 resilience practices (R1–R33) were included in a questionnaire to solicit the opinions of stakeholders about their importance and current implementation conditions. Stakeholder input was

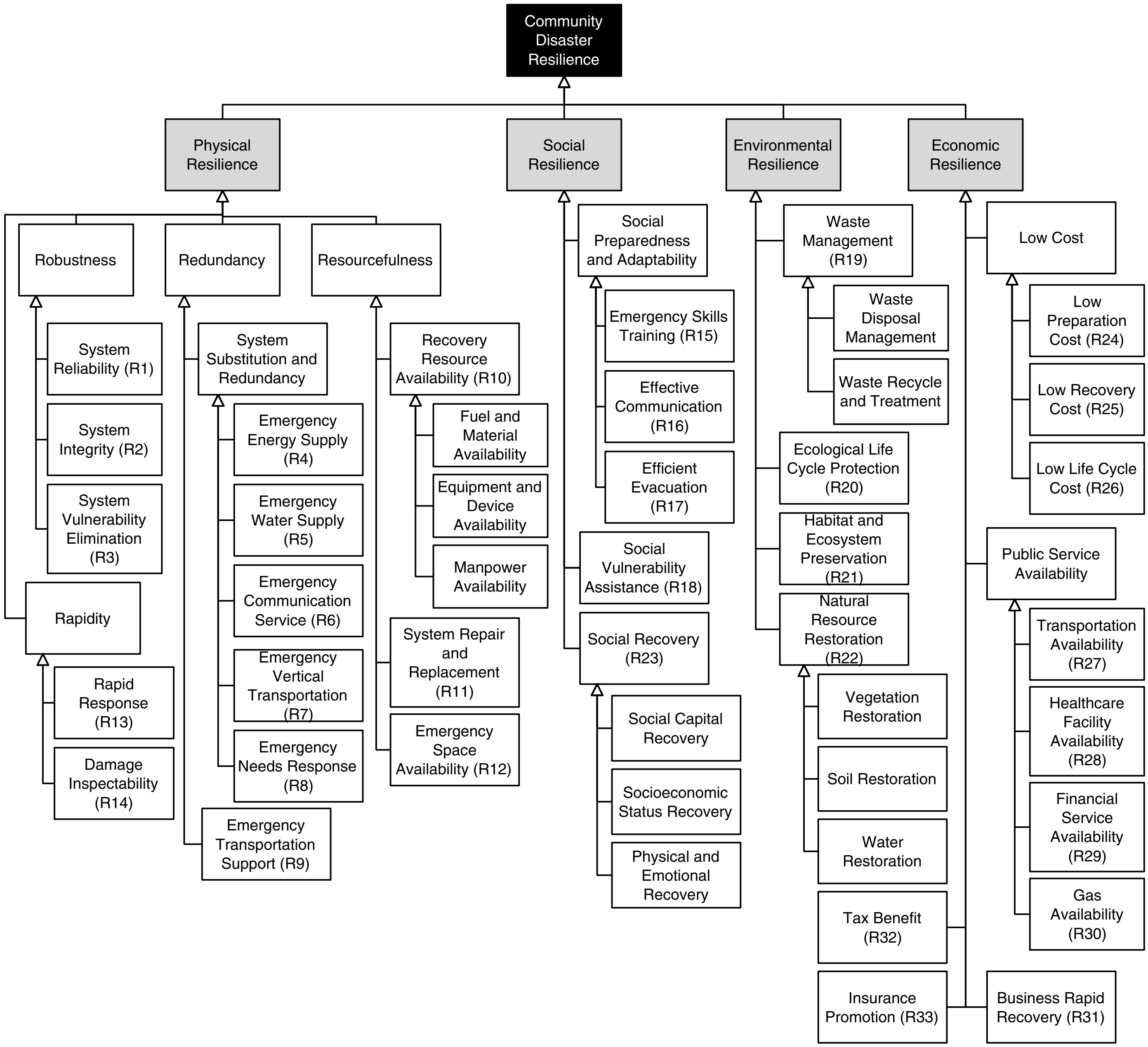

Fig. 2. Hierarchy of disaster resilience practices.

solicited on practices at the fourth or fifth levels of the hierarchy, instead of more-conceptual or more-specialized resilience practices at higher or lower levels in the hierarchy, to balance the need for both coverage and efficiency in surveying because the selected resilience practices at the fourth and fifth levels are representative, descriptive, and detailed enough in covering the domain of resilience practices in the context of residential community, without being overwhelming in number or detail.

The questionnaire was composed of four sections: (1) respondent information, (2) familiarity with disaster resilience, (3) importance of resilience practices, and (4) implementation of resilience practices. Section 1 of the survey acquired respondents' demographic information, such as age, gender, educational background, working/studying/living location, organization characteristics, types of dwelling in which they lived, and, most importantly, the stakeholder group to which they belonged. If a respondent belonged to two or more stakeholder groups (e.g., an emergency manager and also a community resident), the respondent was instructed to answer the questions in the following sections from the perspective of the stakeholder group that he/she selected. Section 2 solicited respondents' familiarity with disaster resilience by asking them to rate their degree of familiarity with a set of resilience practices. In Section 3, respondents were asked to rate the importance degree of each of the 33 resilience practices in the context of the residential community. In Section 4, respondents were asked to rate their assessment of the implementation conditions of each of the 33 resilience practices in the context of the residential community. The definitions of the practices were provided to ensure the clarity of the concept meanings. A five-point Likert scale was used to capture the responses, with 5 being very important or very well-implemented and 1 being very unimportant or very poorly implemented. Likert scales facilitate the quantification of responses so that a statistical analysis can be conducted using the collected data. Research shows that common practice varies in terms of the number of points on

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a Likert scale (Krosnick and Presser 2010). An odd-numbered Likert scale or a moderate option is used when the topic being surveyed is highly sensitive, and thus a midpoint (neutral point) option and/or a don't know option is needed (Losby and Wetmore 2012). Thus, in this survey, an odd-numbered Likert scale was selected to ensure the reliability and coherence of data. Because the neutral-point option was given, respondents were not allowed to skip questions, to ensure the completeness of the collected data. An open-ended question was included at the end of Section 4 to ask respondents if there were any resilience practices other than the 33 identified practices that were important to them. At the end of the questionnaire, respondents were asked about their willingness to participate in a postsurvey interview.

Questionnaire Validation

Validating Resilience Practices

Prior to surveying stakeholder opinions on the importance and implementation conditions of the set of 33 resilience practices, expert surveys were conducted to validate the clarity, representativeness, familiarity, classification, repetitiveness, redundancy, and coverage of the resilience practices. Five face-to-face interviews were conducted to solicit the opinions of a selected set of experts with expertise in the disaster resilience domain. The selected experts included: (1) academic experts—university professors from the domains of disaster and emergency management and resilient building systems and communities; (2) industry experts—senior construction industry professionals; and (3) government officials—emergency management officers and resilience officers of Miami-Dade communities. Each survey was composed of three main parts: (1) a short presentation by the first author to introduce the research purpose, research background, and research task; (2) a walkthrough of the resilience practice hierarchy; and (3) a questionnaire survey to solicit respondent feedback.

The questionnaire was composed of six sections: (1) respondent information; (2) background and familiarity with survey scope; (3) experts' assessment of the clarity of terms; (4) experts' evaluation of the classification of resilience practices; (5) experts' assessment of the conciseness of selected practices; and (6) overall assessment of the hierarchy. Section 1 solicited respondent background information in terms of name, organization, position, years of experience, field of experience, and contact information. Section 2 gathered respondents' familiarity with (1) disaster management and hazard mitigation, (2) resilience practices, (3) resilient communities, and (4) the importance of planning and construction of resilient communities. Section 3 solicited expert opinions about the clarity of the terms in describing the resilience practices. Section 4 asked experts about the classification of the resilience practices. In section 5, experts were asked if they found any useless, redundant, or missing resilience practices. Section 6 was an overall evaluation. It solicited experts' general evaluations of the clarity, classification, conciseness, and representation of the terms in the hierarchy by asking direct questions. A five-point Likert scale was used to record the responses, with 5 being the most favorable and 1 being the least favorable. The results of Sections 2–6 in the questionnaire are summarized in Table 2. Overall, the results indicate that the respondents collectively agreed that (1) the terms used to refer to the resilience practices were clear in communicating the intended meaning of the concepts, (2) the identified resilience practices were familiar, (3) the classification of the hierarchy was appropriate, (4) the resilience practices were representative, (5) there were no repetitive or redundant practices, and (6) the practices were sufficient in covering the main resilience practices in the context of residential communities.

Validating Questionnaire Design

A pilot study was conducted to test the effectiveness of the questionnaire. Eighteen respondents participated in the study. Respondents were randomly selected from the set of potential respondents

Table 2. Summary of expert interview results

Section	Question	Response analysis: Mean	Standard deviation	Median	Interpretation of result (based on median)
Section 2	To what extent are you familiar with disaster management/hazard mitigation?	4.40	0.96	4.00	Very high
	To what extent are you familiar with the concepts about disaster resilience?	4.80	0.86	4.00	Very high
	To what extent are you familiar with resilient communities?	4.40	0.78	4.00	Very high
	To what extent do you think designing and construction of resilient buildings is important for the building industry?	4.2	0.94	4.00	High
Section 3	The items below were extracted from the hierarchy randomly. To what extend do you assess the effectiveness of the terms in representing the intended meaning? (15 items)	3.96	0.96	4.00	High
Section 4	The items below were extracted from the hierarchy randomly. To what extend do you agree with the classification of each item? (15 items)	3.88	0.88	4.00	High
Section 5	Do you find any unnecessary or useless concepts in the hierarchy?	—	—	No	No
	Do you find any redundant concepts (concepts that share the similar or same meaning) in the hierarchy?	—	—	No	No
	Do you find any missing concepts when you review the hierarchy?	—	—	No	No
Section 6	Do you agree with the main classification of disaster resilience of communities into the four superclasses (i.e., physical, social, environmental, and economic)?	4.40	0.86	4.00	Agree
	What do you think of the classification of the concepts in the hierarchy?	4.16	0.86	4.00	Agree
	How familiar are the concepts used in the hierarchy?	4.2	0.80	4.00	Agree
	How representative are the concepts used?	4.2	0.80	4.00	Agree
	What do you think of the conciseness of the hierarchy?	4.0	0.65	4.00	Agree
	How effectively do you think the terms used in hierarchy communicate the intended meaning?	4.0	0.96	4.00	Agree
	Overall, do you think the hierarchy covers the main concepts of community disaster resilience?	4.2	0.84	4.00	Agree

(described in section "Survey Implementation and Postsurvey Interview"). Participants were requested to complete the survey as a stakeholder and then to provide feedback on the format and content of the questionnaire. Feedback was solicited on different aspects of the questionnaire, such as the question wording, response options and evaluation scale, instructions to respondents, visual appearance, and clarity of resilience practices. The questionnaire was then revised based on the feedback. For example, definitions of resilience practices were added, and examples of the practices were included to improve the clarity of concept meanings.

Survey Implementation and Postsurvey Interview

The stakeholder survey was conducted both online using Qualtrics (2017) and distributed in hardcopies from July to November 2017. Survey invitations with a link to the online questionnaire were sent through emails and were posted on social medias (including LinkedIn, Facebook, and Twitter). The survey targeted responsible stakeholders and impacted stakeholders of residential communities in South Florida. The first question in the survey determined whether the person was a resident of South Florida. Respondents who were not residents of South Florida were screened out of the survey. A responsible stakeholder is an organization or an individual who has some degree of responsibility or liability with respect to the development of disaster resilient communities, such as an emergency manager, a resilience officer, a housing contractor, a designer, and so on. An impacted stakeholder refers to an organization or individual who is directly or indirectly affected by the disaster resilience of the communities, such as a resident of the communities, a local business owner, and so on (Zhang and El-Gohary 2016).

After the survey was concluded, postsurvey interviews were coordinated with a subset of the survey participants. The postsurvey interviews solicited further feedback, elaboration, and/or comments on the participants' own responses to the questionnaire, and on the overall survey results and the interim research findings. Eight face-to-face structured interviews were conducted with a subset of the respondents who volunteered to participate in the postsurvey interviews. Iterative questioning, a checklist of formal questions, and interview notes were used to ensure that the collected opinions were trustworthy. The member (interviewee) check technique was also used during the interviews to verify the responses of the interviewees and the interpretations and inferences of the responses made by the interviewer (first author). Member check is commonly used in qualitative research (e.g., interviews) to ensure the credibility and validity of the results (Shenton 2004).

Results Analysis and Discussions

The analysis of the survey results addressed the following research questions:

1. To what extent is the designed survey reliable and internally consistent?
2. What are the rankings of the importance and implementation of the resilience practices according to the stakeholder views?
3. What are the most important and least implemented resilience practices?
4. Do responsible and impacted stakeholders have different views on the importance and implementation of the resilience practices?
5. What are the differences in the average ratings of the importance and implementation of resilience practices in terms of factors of (a) age, (b) region, (c) types of dwelling, and (d) before or after a disaster?

To address these questions, three statistical analysis methods were used: Cronbach's alpha reliability analysis, mean indexing, and the Mann–Whitney U test. Cronbach's alpha is the most common measure of internal consistency. It is commonly used for determining scale reliability when multiple Likert questions in a survey/questionnaire form a scale (Laerd Statistics 2015). Mean indexing is commonly used in heuristic and descriptive data analysis (Creswell 2015). The Mann–Whitney U test is appropriate for comparing the differences between two independent samples when the data are not normally distributed and/or when the dependent variables are ordinal variables (Laerd Statistics 2015).

In addition, three content analysis methods were used: (1) frequent debriefing sessions, (2) reflective commentary, and (3) examination of previous research. Frequent debriefing sessions are discussions that are held between the researcher and his/her supervisor (here, the first and second authors, respectively) to widen the vision of the researcher and bring different experiences and perceptions. The discussions also provide a sounding board for the researcher to test his/her developing ideas and interpretations, and probing from others may help the researcher to recognize his/her own biases and preferences (Shenton 2004). Reflective commentary by the investigator aims at continuously evaluating the data/content analysis as it proceeds. It is used to record the researcher's initial impressions of each collected data, interim finding, and inference. Reflective commentary plays a key role in monitoring the researcher's own developing constructions/interpretations, which is critical in establishing credibility (Guba and Lincoln 1989). Examination of previous research findings aims at assessing the degree to which the survey results are congruent with the existing body of knowledge, which is considered to be a key criterion for evaluating survey results and analyses (Silverman 2000).

Classification of Responses

A total of 130 complete responses (excluding 38 incomplete responses) were received, including 30 responses from responsible stakeholders (S1) and 100 responses from impacted stakeholders (S2). The detailed descriptive statistics of the responses are summarized in Table 3.

Data Reliability Validation

Cronbach's alpha reliability analysis was conducted to examine the internal consistency (i.e., reliability) of the survey questions. Internal consistency demonstrates the extent to which all the items in a test measure the same concept. An α value greater than 0.7 demonstrates the adequacy of internal consistency (Laerd Statistics 2015). In this research, the overall Cronbach's α value was 0.928, which demonstrates a high level of reliability.

Ranking of Resilience Practices

Ranking of Resilience Practices with Respect to Importance of Practices

To understand the importance of disaster resilience, resilience practices were ranked based on the corresponding mean scores of the importance ratings (i.e., importance scores). The higher the mean score, the higher was the rank, and the lower the mean score, the lower was the rank. Table 4 lists the rankings of the importance of resilience practices for each stakeholder group and for all stakeholder groups combined. On average, the resilience practices were considered highly important by the stakeholders. According to the results, overall, the practices related to system robustness, including system reliability (R1) and system integrity (R2), and the practices

Table 3. Demographic information of respondents

Demographic factor	Impacted stakeholder	Responsible stakeholder	All stakeholders
Stakeholder group			
Impacted stakeholder	100	0	100
Responsible stakeholder	0	30	30
Region			
Miami-Dade County	52	18	70
Broward County	29	12	41
Florida Keys	19	0	19
Gender			
Male	93	24	117
Female	7	6	13
Age			
20 and younger	0	0	0
21–30	26	6	32
31–40	40	18	58
41–50	20	6	26
51–60	11	0	11
61 and older	3	0	3
Education			
Less than high school	1	0	1
High school graduate	40	0	40
Bachelor's degree	42	17	59
Master's degree	12	8	20
Doctorate	1	1	2
Professional degree	1	1	2
Others	3	3	6
Organization characteristic			
Privately held, for-profit business	63	22	85
Publicly held, for-profit business	25	6	31
Not-for-profit service organization	4	0	4
Primary or secondary school	3	0	3
College or university	5	2	7
Others	0	0	0
Type of dwelling			
Apartment	20	10	30
Condo	22	8	30
Single family home	24	9	33
Mobile home	19	0	19
High-rise building	0	14	14
Townhouse	3	1	4
Others	0	0	0
Before and after disaster			
Pre-Irma	42	21	63
Post-Irma	58	9	67

related to satisfying human basic needs such as food and water (R8) and evacuation facilities (R9 and R12) were the most important resilience practices.

System reliability and system integrity are the fundamental priorities in civil engineering for the resilient design and construction of buildings and infrastructures. For example, to improve system reliability (R1), load and resistance factor design (LRFD) has been recommended by several codes and institutes (e.g., International Building Code and American Society of Civil Engineers) to analyze the probability of system failure by accounting for several factors, such as reliability index, partial safety coefficients, and so on (ICC 2015). System integrity (R2), especially connections and ductility, is always the prioritized focus of structural engineering design (Straub et al. 2009). In recent years, research has been conducted on monitoring the building system integrity in a real-time manner to monitor the design assumptions for structural integrity (Terada et al. 2004) and to analyze whether evacuation is required during a disaster and if rehabilitation is necessary in the recovery phase.

Basic human needs such as food, water, and shelter are the fundamental needs of humans during the disasters. These needs are considered as the first (i.e., physiological needs) and second (i.e., safety needs) levels of needs according to Maslow's hierarchy of human needs (Huitt 2007). According to Maslow's theory, physiological needs and safety needs should be satisfied first before meeting the needs of the next several levels (e.g., love/belonging, esteem, and self-actualization).

Ranking of Resilience Practices with Respect to Implementation of Practices

To understand the implementation of disaster resilience practices based on stakeholder views, the implementations of resilience practices were ranked based on their corresponding mean scores (i.e., implementation score). Table 5 lists the rankings of the implementation of resilience practices for each stakeholder group and for all stakeholder groups on average. On average, based on the stakeholder views, the resilience practices in South Florida were moderately implemented.

Compared with all practices, system reliability (R1) and system integrity (R2) received the highest implementation scores. After Hurricane Andrew, which destroyed more than 63,500 houses, the South Florida Building Code transformed building construction standards to ensure hurricane resistance of building structure (GMB 2018). Thus, system reliability and integrity are required and enforced by one of the most stringent building codes across the country. Damage inspectability (R14) was the least implemented physical resilience practice. Inspectability of the physical built environment (e.g., infrastructures and buildings) is the key element for rapid recovery. Although design for inspectability is required for the design of infrastructure (AASHTO 2014), it is not mandatory for residential houses. In most situations, postdisaster damage inspection still relies on individual building owners/residents or private construction professionals to conduct self-inspection or assessment. During the postsurvey interviews, one of the impacted stakeholders highlighted the importance of the role and responsibility of the government in providing reliable and professional inspections of building damage during the recovery phase.

The best-implemented social resilience practice was resident emergency training (R15). South Florida has implemented regular and systematic emergency training in local communities. For example, a statewide fictional hurricane exercise is conducted on an annual basis at Miami-Dade Emergency Operations Center. In addition, public media plays an important role in ensuring the implementation of resident emergency training, especially during the disaster-preparedness phase. However, ideally, public media needs to take more responsibility not only during disaster preparedness but throughout the whole cycle of disaster management to help residents receive information about and training for emergencies (Barnes et al. 2008). The least implemented social resilience practice was social vulnerability assistance (R18). The needs of the most vulnerable populations (e.g., the economically disadvantaged, the elderly, the homeless, and the disabled) are usually not sufficiently considered in disaster management. For example, 10 residents of a nursing home died in the State of Florida during Hurricane Irma (Sarkissian 2017). During Hurricane Katrina, 49% of victims were people who were older than 75 years, making the elderly the most vulnerable and affected population during that disaster (Brunkard et al. 2008). In addition, real-time evacuation

Table 4. Ranking of importance of resilience practices by different stakeholder groups

Resilience practice[a]	Category[a]	All-group mean	All-group rank	S1[b] mean	S1 rank	S2[b] mean	S2 rank	p-value
System reliability (R1)	Physical	4.43	2	4.32	10	4.8	2	0.000[c]
System integrity (R2)	Physical	4.50	1	4.40	8	4.83	1	0.000[c]
System vulnerability elimination (R3)	Physical	3.64	26	3.47	27	4.20	10	0.000[c]
Emergency energy supply (R4)	Physical	4.34	6	4.43	7	4.03	14	0.019[c]
Emergency water supply (R5)	Physical	4.34	6	4.46	3	3.93	21	0.004[c]
Emergency communication service (R6)	Physical	4.28	10	4.46	3	3.67	31	0.000[c]
Emergency vertical transportation (R7)	Physical	4.39	3	4.44	6	4.23	9	0.211
Emergency needs response (R8)	Physical	4.38	4	4.50	1	3.97	20	0.002[c]
Emergency transportation support (R9)	Physical	4.35	5	4.37	9	4.30	7	0.868
Recovery resource availability (R10)	Physical	3.91	19	3.85	20	4.10	13	0.030[c]
System repair and replacement (R11)	Physical	4.25	11	4.32	10	4.03	14	0.104
Emergency space availability (R12)	Physical	4.32	8	4.45	5	3.90	22	0.000[c]
Immediate risk response (R13)	Physical	4.30	9	4.47	2	3.73	28	0.000[c]
Damage inspectability (R14)	Physical	4.09	14	4.17	14	3.80	26	0.462
Emergency skills training (R15)	Social	3.79	24	3.85	20	3.60	32	0.435
Effective communication (R16)	Social	4.20	13	4.29	12	3.90	22	0.069
Efficient evacuation (R17)	Social	3.63	27	3.73	22	3.30	33	0.143
Social vulnerability assistance (R18)	Social	3.77	25	3.70	25	4.00	19	0.093
Waste management (R19)	Environmental	3.87	21	3.71	24	4.40	4	0.000[c]
Ecological life-cycle protection (R20)	Environmental	3.48	29	3.4	29	3.73	28	0.061
Habitat and ecosystem preservation (R21)	Environmental	3.20	33	3.05	33	3.70	30	0.005[c]
Natural resource restoration (R22)	Environmental	3.32	32	3.18	30	3.80	26	0.009[c]
Social recovery (R23)	Social	3.95	18	3.87	17	4.20	10	0.008[c]
Low preparation cost (R24)	Economic	3.48	29	3.16	32	4.53	3	0.000[c]
Low recovery cost (R25)	Economic	3.46	31	3.18	30	4.40	4	0.000[c]
Low life-cycle cost (R26)	Economic	4.07	15	4.13	15	3.87	25	0.218
Transportation availability (R27)	Economic	4.24	12	4.26	13	4.17	12	0.940
Healthcare facility availability (R28)	Economic	3.56	28	3.46	28	3.90	22	0.029[c]
Financial service availability (R29)	Economic	4.02	16	4.02	16	4.03	14	0.182
Gas availability (R30)	Economic	3.90	20	3.86	19	4.03	14	0.083
Business rapid recovery (R31)	Economic	3.96	17	3.87	17	4.27	8	0.002[c]
Tax benefit (R32)	Economic	3.80	23	3.73	22	4.03	14	0.092
Insurance promotion (R33)	Economic	3.85	22	3.69	26	4.40	4	0.000[c]

[a]Numbering and classification of resilience practices follow those in Fig. 2.
[b]S1 = impacted stakeholders; and S2 = responsible stakeholders.
[c]p-value is significant at 0.05 level (2-tailed).

information is not generally provided to people who are hearing- or vision-impaired, or to people with language barriers (DOT 2006). Many organizations and individual researchers (e.g., Flanagan et al. 2011; USGAO 2006) have been calling for a voluntary registration program for the disabled, frail, or transportation-disadvantaged to provide those residents with increased assistance. In recent years, some vulnerable-population registry programs (e.g., the Emergency and Evacuation Assistance Program of Miami-Dade County and the Broward County Vulnerable Population Registry) have been gradually established and implemented by South Florida communities.

The best-implemented environmental resilience practice was waste treatment (R19). Waste treatment is an important element in disaster management, and it has received significant attention from government agencies. After each disaster, waste management departments spend tremendous effort to collect and transport waste and debris. For example, after Hurricane Irma, the amount of debris took an estimated 4–6 months to clean up within the city of Miami. The Department of Solid Waste Management of Miami-Dade County added 500 trash trucks to collect debris and waste, which was estimated at 3–5 million cubic yards (Richards 2017).

Among economic resilience practices, bank availability (R29) achieved the highest implementation score. This is probably because financial institutions in the State of Florida have implemented emergency plans to serve their communities in disasters (Stewart 2017). Insurance promotion (R33) was the least implemented economic resilience practice. This result coincides with the results of a survey (GMB 2018) conducted by the Miami-Dade County Office of Resilience that focused on understanding stakeholder perspectives of ways to enhance city resilience, which showed that more affordable and responsive insurance is needed for the government to plan for future disaster preparedness and recovery.

Most Important and Least Implemented Resilience Practices

To support more effective and efficient decision-making for disaster resilience, there is a need to identify the most important and the least implemented resilience practices based on the stakeholder views. These practices could become bottlenecks for more-resilient communities, thus requiring prioritized attentions and more implementation efforts. In order to identify the most important and the least implemented resilience practices, an importance implementation ratio (IIR) is defined

$$\mathrm{IIR}_i = \frac{\sum_{j=1}^{n} \mathrm{IMP}_{ij}/\mathrm{IMPL}_{ij}}{n} \qquad (1)$$

where IIR_i = importance implementation ratio of resilience practice i; IMP_i = Likert score of importance of resilience practice i

Table 5. Ranking of implementation of resilience practices by different stakeholder groups

Resilience practice[a]	Category[a]	All-group mean	All-group rank	S1[b] mean	S1 rank	S2[b] mean	S2 rank	p-value
System reliability (R1)	Physical	3.65	1	3.42	2	4.43	1	0.000[c]
System integrity (R2)	Physical	3.59	2	3.36	5	4.37	2	0.000[c]
System vulnerability elimination (R3)	Physical	3.18	10	3.00	19	3.77	4	0.000[c]
Emergency energy supply (R4)	Physical	3.34	6	3.19	9	3.83	3	0.002[c]
Emergency water supply (R5)	Physical	3.10	13	3.06	12	3.23	16	0.390
Emergency communication service (R6)	Physical	3.25	8	3.30	6	3.10	20	0.193
Emergency vertical transportation (R7)	Physical	3.09	15	2.92	21	3.63	6	0.001[c]
Emergency needs response (R8)	Physical	3.44	4	3.40	3	3.57	10	0.413
Emergency transportation support (R9)	Physical	3.51	3	3.48	1	3.60	8	0.475
Recovery resource availability (R10)	Physical	3.08	16	2.96	20	3.47	12	0.013[c]
System repair and replacement (R11)	Physical	3.28	7	3.21	8	3.50	11	0.129
Emergency space availability (R12)	Physical	3.40	5	3.38	4	3.47	12	0.494
Immediate risk response (R13)	Physical	3.07	18	3.08	11	3.03	23	0.840
Damage inspectability (R14)	Physical	2.95	23	2.91	23	3.07	21	0.399
Emergency skills training (R15)	Social	3.03	19	3.12	10	2.73	30	0.156
Effective communication (R16)	Social	3.02	21	3.02	15	3.03	23	0.937
Efficient evacuation (R17)	Social	3.01	22	2.82	25	3.63	6	0.000[c]
Social vulnerability assistance (R18)	Social	2.64	30	2.53	31	3.00	26	0.044[c]
Waste management (R19)	Environmental	3.15	11	3.02	15	3.60	8	0.009[c]
Ecological life-cycle protection (R20)	Environmental	2.82	28	2.75	28	3.03	23	0.286
Habitat and ecosystem preservation (R21)	Environmental	2.62	32	2.52	32	2.93	27	0.038[c]
Natural resource restoration (R22)	Environmental	2.60	33	2.52	32	2.87	28	0.102
Social recovery (R23)	Social	3.11	12	3.02	15	3.40	14	0.118
Low preparation cost (R24)	Economic	3.03	19	2.82	25	3.73	5	0.000[c]
Low recovery cost (R25)	Economic	2.91	25	2.92	21	2.87	28	0.694
Low life-cycle cost (R26)	Economic	2.82	27	2.90	24	2.57	33	0.058
Transportation availability (R27)	Economic	3.10	13	3.06	12	3.23	16	0.246
Healthcare facility availability (R28)	Economic	3.08	16	3.03	14	3.23	16	0.336
Financial service availability (R29)	Economic	3.24	9	3.22	7	3.30	15	0.433
Gas availability (R30)	Economic	2.78	29	2.69	29	3.07	21	0.114
Business rapid recovery (R31)	Economic	2.89	26	2.80	27	3.20	19	0.113
Tax benefit (R32)	Economic	2.94	24	3.01	18	2.70	31	0.206
Insurance promotion (R33)	Economic	2.62	31	2.63	30	2.60	32	0.946

[a]Numbering and classification of resilience practices follow those in Fig. 2.
[b]S1 = impacted stakeholders; and S2 = responsible stakeholders.
[c]p-value is significant at 0.05 level (2-tailed).

provided by respondent j; $IMPL_i$ = Likert score of implementation of resilience practice i provided by respondent j; and n = number of respondents.

The results of the importance implantation ratios for the resilience practices are summarized in Table 6. Among all the physical resilience practices, emergency vertical transportation (R7) was the most important and least implemented practice. Emergency vertical transportation has been the focus of emergency management ever since the September 11 attacks. The characteristic of multiple floors of a high-rise building creates a cumulative effect requiring greater numbers of persons to travel vertical distances on stairs to evacuate the building, putting higher demand on emergency vertical transportation. A large number of high-rise buildings were constructed in the last decades, especially in the densely populated areas (e.g., City of Miami Beach). However, the timing of awareness and decision-making for evacuation have not been sufficiently considered in the design of high-rise buildings. Therefore, significant rehabilitation is still needed based on evacuation simulation models (Pelechano and Malkawi 2008).

Natural resource restoration (R22) was the most important and the least implemented practice among environmental resilience practices. The local economy of South Florida relies on natural resources not only to provide products and resources but also to enhance the quality of life (SFRPC 2018). The recovery of natural resources is one key element of overall postdisaster recovery; it is the ability to protect natural resources through appropriate response and recovery actions to preserve, conserve, and restore the natural resources in compliance with appropriate environmental resource laws. Restoring natural resources, although important, is very challenging because it could take a long time for complete restoration. For instance, Florida's coral reef ecosystem is an important part of the State of Florida's economy. These natural resources support a vibrant tourism industry, provide jobs, and protect lives and valuable coastal infrastructures. Science divers surveyed more than 50 sites and found widespread damage to sponges due to the catastrophic impact of Hurricane Irma, which could take years to recover (NOAA 2017).

Gas availability (R30) was one of the most important and least implemented practices among economic resilience practices. Twenty million vehicles have been registered in the state of Florida (FDOT 2017) and people rely on private transportation, which makes gas availability indispensable. For example, during Hurricane Irma, a large number of gas stations were out of service during the preparedness and recovery phases. Around 72% of gas stations were out of service right after the hurricane struck (GasBuddy 2017). Lack of power and manpower for delivering fuel was identified as the major reason for gas shortages after the disaster (Disis and Isidore 2017). Future use of electric cars equipped with an emergency energy supply system could be a possible way to make residential communities less sensitive to gas availability.

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Table 6. Ranking of resilience practices based on importance implementation ratios

Resilience practice[a]	Category[a]	All-group mean	All-group rank	S1[b] mean	S1 rank	S2[b] mean	S2 rank
System reliability (R1)	Physical	1.37	27	1.45	22	1.13	31
System integrity (R2)	Physical	1.47	15	1.57	11	1.16	30
System vulnerability elimination (R3)	Physical	1.29	32	1.33	30	1.18	29
Emergency energy supply (R4)	Physical	1.45	17	1.55	12	1.12	32
Emergency water supply (R5)	Physical	1.58	9	1.65	6	1.32	22
Emergency communication service (R6)	Physical	1.44	20	1.49	18	1.28	25
Emergency vertical transportation (R7)	Physical	1.67	5	1.76	2	1.37	18
Emergency needs response (R8)	Physical	1.46	16	1.51	15	1.29	24
Emergency transportation support (R9)	Physical	1.39	25	1.40	27	1.35	19
Recovery resource availability (R10)	Physical	1.44	21	1.47	20	1.34	21
System repair and replacement (R11)	Physical	1.42	23	1.48	19	1.25	27
Emergency space availability (R12)	Physical	1.37	28	1.40	26	1.25	28
Immediate risk response (R13)	Physical	1.61	7	1.66	5	1.41	15
Damage inspectability (R14)	Physical	1.60	8	1.67	4	1.34	20
Emergency skills training (R15)	Social	1.45	18	1.39	28	1.65	7
Effective communication (R16)	Social	1.56	10	1.61	8	1.40	17
Efficient evacuation (R17)	Social	1.36	29	1.49	17	0.93	33
Social vulnerability assistance (R18)	Social	1.64	6	1.68	3	1.51	12
Waste management (R19)	Environmental	1.39	26	1.42	25	1.26	26
Ecological life-cycle protection (R20)	Environmental	1.45	19	1.45	21	1.42	14
Habitat and ecosystem preservation (R21)	Environmental	1.44	22	1.43	24	1.45	13
Natural resource restoration (R22)	Environmental	1.50	13	1.49	16	1.52	11
Social recovery (R23)	Social	1.49	14	1.51	14	1.41	16
Low preparation cost (R24)	Economic	1.26	33	1.25	32	1.31	23
Low recovery cost (R25)	Economic	1.34	30	1.21	33	1.79	5
Low life-cycle cost (R26)	Economic	1.68	3	1.59	9	1.96	2
Transportation availability (R27)	Economic	1.55	11	1.51	13	1.68	6
Healthcare facility availability (R28)	Economic	1.34	31	1.28	31	1.53	10
Financial service availability (R29)	Economic	1.40	24	1.36	29	1.55	9
Gas availability (R30)	Economic	1.72	2	1.76	1	1.57	8
Business rapid recovery (R31)	Economic	1.67	4	1.61	7	1.86	4
Tax benefit (R32)	Economic	1.54	12	1.44	23	1.86	3
Insurance promotion (R33)	Economic	1.72	1	1.58	10	2.17	1

[a]Numbering and classification of resilience practices follow those in Fig. 2.
[b]S1 = impacted stakeholders; and S2 = responsible stakeholders.

Differences of Rankings of Resilience Practices across Different Stakeholder Groups

To understand if stakeholders have different views regarding the importance and implementation of resilience practices, the stakeholder views on the four major resilience categories (i.e., physical, environmental, social, and economic resilience) were first analyzed. The resilience practices were compared on an aggregated level, and the mean score of each of the four categories was calculated by averaging the mean scores of its corresponding sublevel resilience practices. The results are presented in Fig. 3.

Different stakeholders had different views regarding the importance of the four major resilience categories (Fig. 3). These differences may be attributed to the different levels of concern, needs, interests, preferences, and/or sense of responsibility between different groups of stakeholders. Economic resilience was the most important resilience practice to responsible stakeholders, whereas physical resilience was the priority of the impacted stakeholders. This is probably due to the fact that responsible stakeholders are responsible for dealing with economic issues for community development, such as budgeting and profit optimization, whereas impacted stakeholders' basic concern is the safety and reliability of their living spaces during a disaster. In addition, the responsible stakeholders attached higher importance to environmental resilience than did the impacted stakeholders. This is mostly because they are responsible for following the regulations on environmental protection such as the National Environmental Policy Act (NEPA), the Resource Conservation and Recovery Act (RCRA), and so on. In contrast, impacted stakeholders considered environmental resilience to be their lowest priority. During the postsurvey interviews, one of the respondents explained that impacted stakeholders tend to attach lower importance to environmental resilience because it does not have direct or evident influence on their personal lives.

Overall, responsible stakeholders attached higher implementation ratings to physical, social, environmental, and economic resilience than did the impacted stakeholders (Fig. 3). During the postsurvey interview, one of the resilience officers explained that, compared with impacted stakeholders, responsible stakeholders have the professional knowledge to understand the overall implementation conditions of resilience practices in Florida communities (by comparing them with communities in other states), whereas impacted stakeholders usually rely on their personal experience within their own communities, which could be limited. However, the results also indicate that impacted stakeholders were not as satisfied as responsible stakeholders with the overall implementation of the resilience practices. Although impacted stakeholders are not involved in the planning, design, and construction phases of resilient communities, they occupy the communities and are eventually largely affected by the disaster resilience of the community. Therefore, this major gap between the views of responsible stakeholders and the views of impacted stakeholders indicates that there

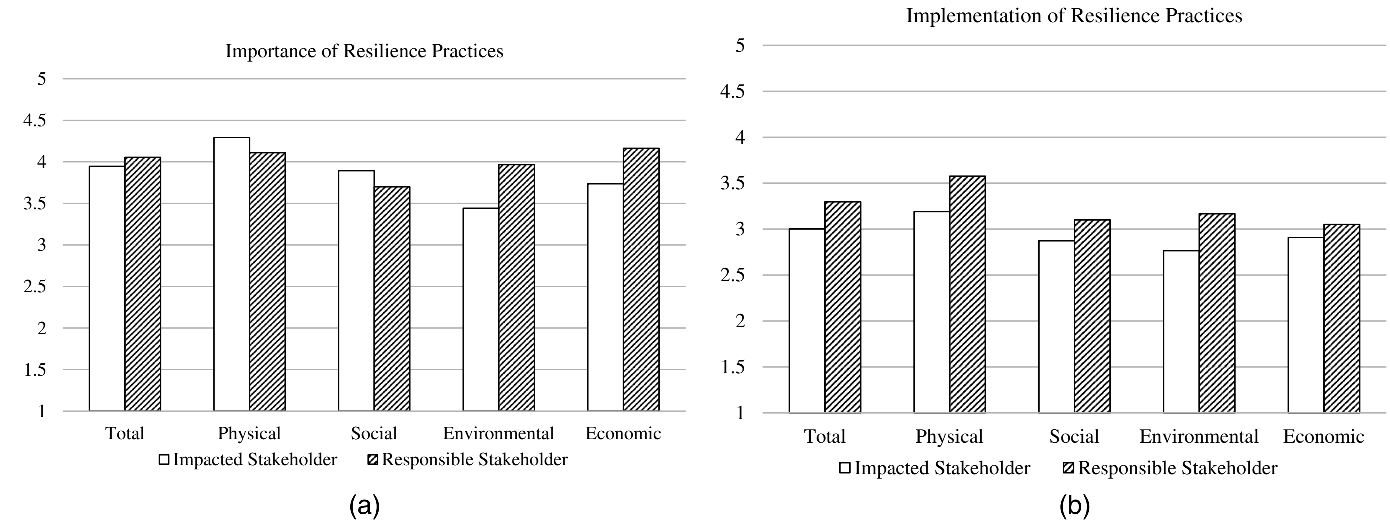

Fig. 3. Comparison of stakeholder views on importance and implementation of resilience practices.

is a need to identify the specific practices with which impacted stakeholders have concerns, and more attention or focus should be placed on these practices by the responsible stakeholders.

The Mann–Whitney U test was then conducted to analyze whether each of the resilience practices was rated significantly differently by different stakeholder groups. The results are given in Tables 2 and 3. Overall, in terms of importance of practices, 19 resilience practices were rated significantly differently by impacted and responsible stakeholders. In terms of implementation of practices, 11 practices were rated significantly differently by impacted and responsible stakeholders. The results further demonstrate that different stakeholders have different views regarding the importance and implementation of disaster resilience practices.

For example, the impacted stakeholders attached significantly higher importance to emergency communication service (R6) than did the responsible stakeholders. This is probably because emergency communication (e.g., emergency service of telephone and internet) is the only alternative when normal communication infrastructures are out of service, and thus it becomes a major concern for the impacted stakeholders. However, emergency communication service is not required or enforced by laws for residential home design and construction, which may contribute to the relative low rating by the responsible stakeholders. Recently, a new technology named goTenna Mesh was used during Hurricane Harvey to allow people to create a special network to stay in touch with others when telecommunications fail (Holley 2017). In terms of implementation, compared with the responsible stakeholders, impacted stakeholders believed recovery resource availability (R10) was poorly implemented. The low rating is probably because the impacted stakeholders have more emergent demand for private property recovery after the disaster, and therefore, any shortage of restoration resources such as fuel, material, equipment, and labor becomes a major lack-of-implementation issue to them. In addition, local inflation of reconstruction resources has become a common problem in disaster recovery. Careful planning and bilateral collaboration between communities about resource allocation and use before disasters are required (Chang et al. 2011).

Comparison of Four Major Resilience Categories by Accounting for Different Factors

The questionnaire survey collected respondent information including age, gender, educational background, region, organization characteristics, and types of dwelling in which they live. In addition, the survey was implemented from July 2017 to November 2017, during which an extremely powerful and catastrophic hurricane—Hurricane Irma—struck the State of Florida. Therefore, the collected data can also be divided into two groups—before and after a disaster. The following sections analyze the differences in stakeholder views on disaster resilience by accounting for the preceding factors. For the factors of gender, educational background, and organization characteristics, there were no significant differences across different stakeholder groups. Therefore, the following sections focus on analyzing the differences of stakeholder views by accounting for the following factors: (a) age, (b) region, (c) types of dwelling, and (d) before or after disaster. The results are illustrated in Figs. 4–7.

Age

Fig. 4 shows the average ratings of importance and implementation of resilience practices by stakeholders of different ages. All groups with different ages had similar views on the importance of resilience practices. However, there was a negative association between stakeholder age and stakeholder views on the implementation of resilience practices in residential communities. Compared with younger stakeholders, older stakeholders believed that resilience practices were not well implemented. During the postsurvey interviews, one of the emergency managers explained this result is attributed to the vulnerability of the elderly. In addition, older people are at an increased risk of being socially isolated or lonely (McMaster University 2016), which results in a lack of information access to current resilience-implementation conditions. Thus, they could have a higher level of dissatisfaction with current resilience performance. Scientists have found that social activities and friendship can act as a facilitator of resilience, because they help older people to cope with and overcome disaster impacts (Fuller-Iglesias et al. 2008).

Region

Fig. 5 shows the average ratings of importance and implementation of resilience practices by stakeholders who lived in different regions—Broward County, Miami-Dade County, and the Florida Keys. There were no significantly different views on the importance of resilience practices across the three regions. However, stakeholder views on the implementation of resilience practices showed a geographic pattern—Broward County had the highest average implementation score, and the Florida Keys had the

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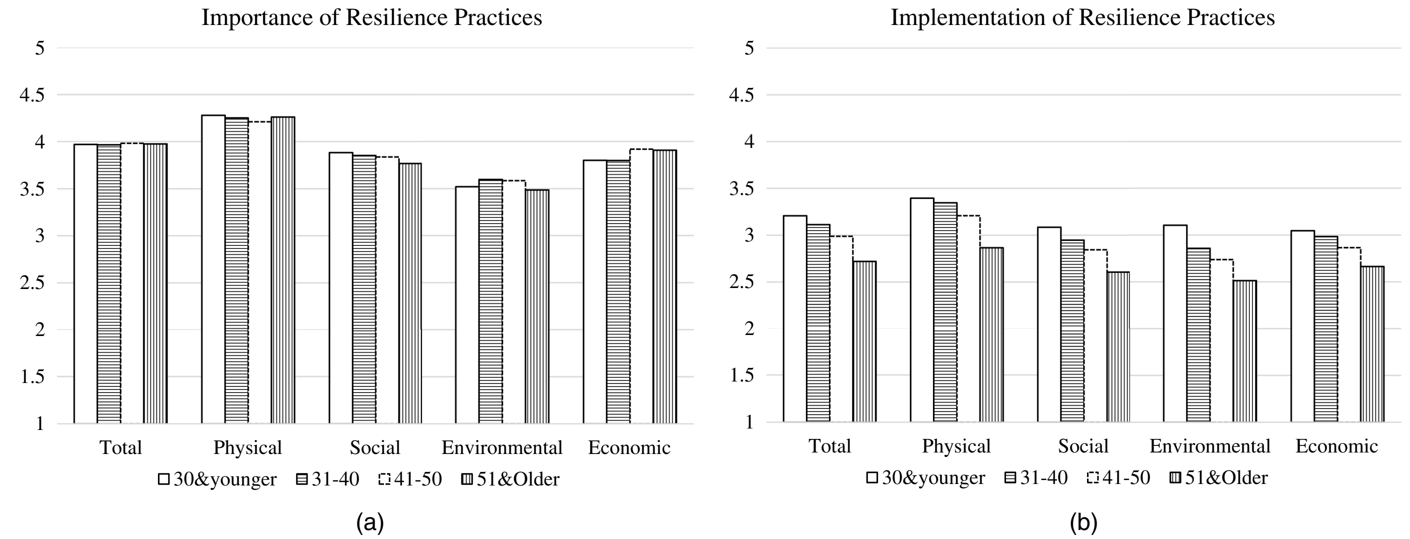

Fig. 4. Comparison of stakeholder views on importance and implementation of resilience practices based on age factor.

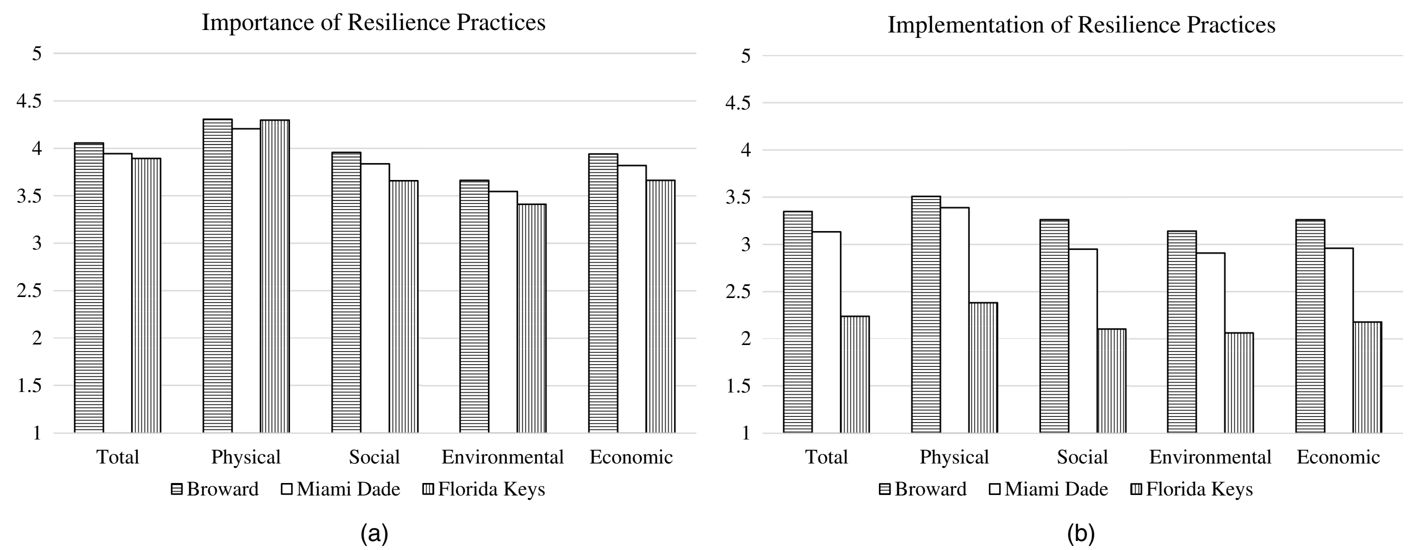

Fig. 5. Comparison of stakeholder views on importance and implementation of resilience practices based on region factor.

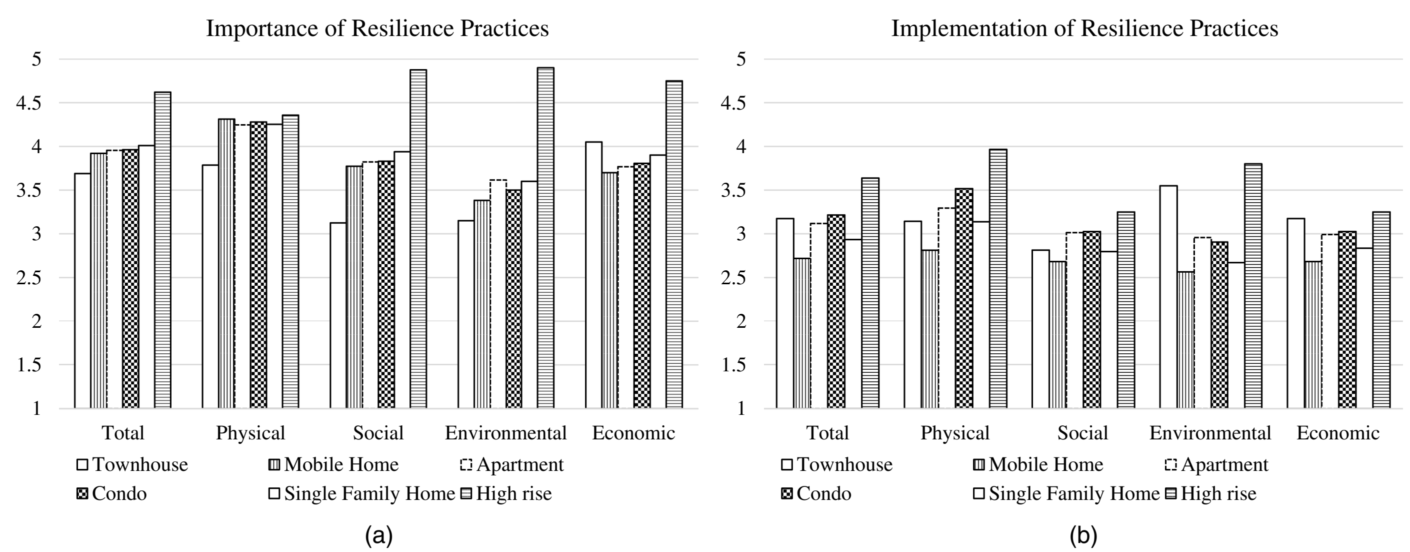

Fig. 6. Comparison of stakeholder views on importance and implementation of resilience practices based on types of dwelling.

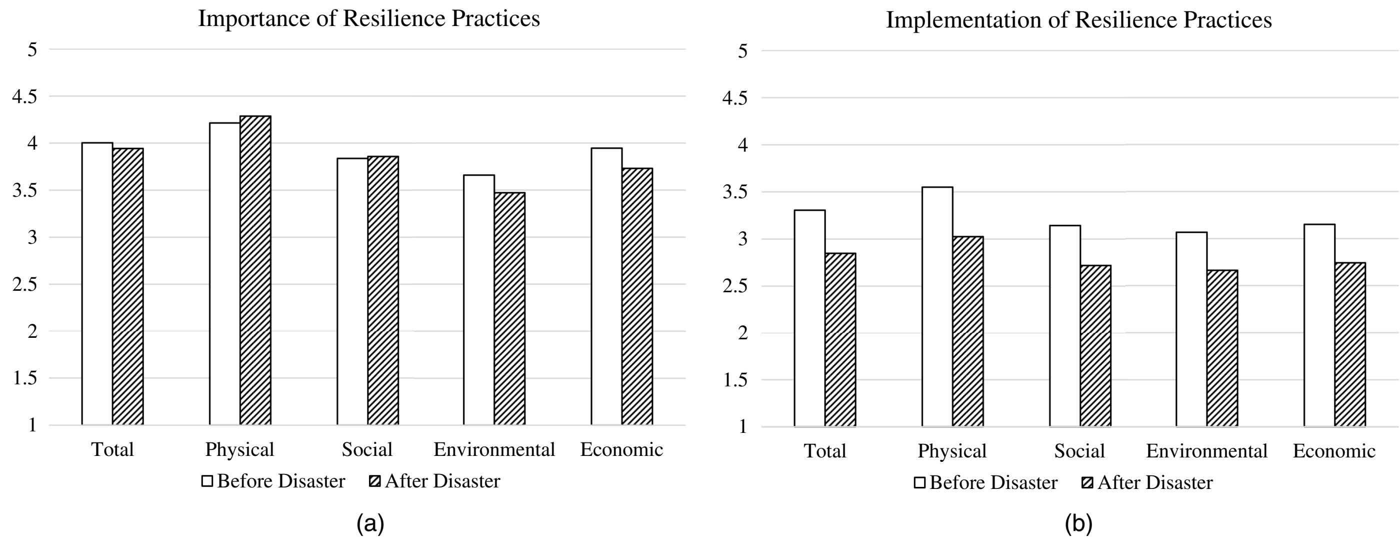

Fig. 7. Comparison of stakeholder views on importance and implementation of resilience practices based on occurrence of disaster.

lowest score. Firstly, this result is due to the vulnerable geographic location of Florida Keys, which are a string of islands stretching about 120 mi off the southern tip of the State of Florida. The implementation of some of the resilience practices, such as effective evacuation, gas availability, and emergency energy supply, is extremely challenging because of the "single way in and out" of the Florida Keys. Secondly, according to the postsurvey interview with one of the county emergency managers, this is probably also due to the reason that, compared with Miami-Dade and Broward Counties, a large percentage of houses in the Florida Keys were constructed before Hurricane Andrew, and thus are not compliant with the most up-to-date building codes of South Florida, resulting in relatively lower ratings of physical resilience.

Types of Dwelling

Fig. 6 shows the average ratings of importance and implementation of resilience practices by stakeholders who lived in different types of dwellings, from low-rise buildings to high-rise buildings. Stakeholders who lived in high-rise buildings attached very high importance or at least high importance to resilience practices, and they also had relatively high ratings of the implementation of these practices. In comparison, stakeholders who lived in mobile homes attached much lower ratings to the implementation of resilience practices. The results further demonstrate the vulnerability of mobile homes—regardless of how recently they were built—to disasters compared with other types of dwellings (FEMA 2018). For example, during Hurricane Irma, people who lived in mobile homes in South Florida regions were under a mandatory evacuation order.

Before and After Disaster

Fig. 7 shows the average ratings of importance and implementation of resilience practices between stakeholders before and after Hurricane Irma. Stakeholder assessments of the implementation of resilience practices were much lower after Hurricane Irma. This could be due to two main reasons. Firstly, the catastrophic impact and challenges that Hurricane Irma placed on local communities led to a rethinking and reassessment of resilience practice implementation in South Florida. According to one of the emergency managers during the postsurvey interview, South Florida has one of the best emergency management mechanisms in the country. This emergency management mechanism has been trained and tested repeatedly due to the frequent disasters that South Florida communities face. However, Hurricane Irma was extremely powerful and catastrophic; it was the strongest storm on record that existed in the open Atlantic region and largely affected residential communities in the State of Florida. The lessons learned from this catastrophic event revealed several resilience challenges and weaknesses in both civil infrastructures and emergency management. Most of these resilience practices were covered by this survey, such as emergency water and energy supply, effective evacuation, gas availability, and insurance promotion and affordability. Hurricane Irma provided a testing bed to evaluate the true implementation conditions of these resilience practices. It also elevated the standards for and requirements of disaster resilience practices from the stakeholders' perspectives. The responses implied that the stakeholders had much higher concerns about, and thus higher requirements for, the implementation of these resilience practices after Hurricane Irma. Secondly, the respondents were still recovering emotionally from the impact of this hurricane, which could have been reflected in dissatisfaction with current resilience performance. Research shows that disasters challenge individual's ability to adapt, which could result in adverse mental or emotional effects (Davidson and McFarlane 2006). The degree of exposure to a disaster determines the risk and level of emotional effect. Individual stressors such as destruction of the family home, threat to life, physical injuries, and the individual's behavior during the disaster can all be viewed as psychological toxins whose effects are greatest with increasing proximity (both geographic and temporal) to the disaster (Davidson and McFarlane 2006). Because respondents were exposed to and affected by the psychological toxins, they could have reflected their emotional stress as concerns about or dissatisfaction with the current resilience performance during the survey.

Suggested Actions for Enhancing Disaster Resilience

Based on the results of this survey, some possible actions to enhance disaster resilience of residential communities of South Florida are discussed.

Comprehensive disaster resilience should be facilitated in community development. Disaster-resilient community development must be comprehensive in nature, and this requires integrated responses to complex disaster challenges. Major disasters could have a huge impact on all sectors of society. If community residents and assets are to be protected, disaster resilience must be built into community planning, infrastructure, housing, livelihoods, and all other broader economic and social dimensions.

Collaboration between responsible and impacted stakeholders should be facilitated. The results of the survey indicate that the importance and implementation of most of the resilience practices were rated significantly differently by the responsible and the impacted stakeholders. Disaster resilience is a shared responsibility among all the stakeholders. Thus, to facilitate community resilience, it is important to integrate the views of both responsible and impacted stakeholders. More systematic and formal collaborations between responsible and impacted stakeholders should be established in community planning and decision-making. Although impacted stakeholders are not directly involved in the planning, design, and construction of resilient communities, they are eventually largely affected by the disaster resilience of the communities. Therefore, their views on disaster resilience, although different from the views of responsible stakeholders, should be considered during community decision-making. In addition, the ultimate goal of community disaster resilience is to increase the satisfaction levels and quality of life of impacted stakeholders. Therefore, for those resilience practices (e.g., emergency communication service and recovery resource availability) that were rated significantly more important and less implemented by the impacted stakeholders, responsible stakeholders should pay particular attention and spend more efforts to increase the satisfaction levels of impacted stakeholders.

Implementation of the most important resilience practices should be prioritized. The results of the survey indicate that some resilience practices (e.g., system reliability, system integrity, emergency space availability, and emergency needs response) are more important than others. Many local communities are still not investing enough on disaster resilience practices, and many decision makers are not yet prioritizing enough support to enhance disaster resilience. Because of limited resources, future efforts to improve disaster resilience should be spent on the most important resilience practices based on stakeholders' perspectives. These identified practices should be integrated into the community/city development plan, meaning that future activities to improve disaster resilience will be prioritized in the state budget. This is especially true for those resilience practices that were viewed as the most important and the least implemented by the stakeholders. The importance of these practices is already acknowledged by the stakeholders, yet there is a lack of implementation efforts, resulting in a major gap in achieving community resilience. Thus, decision makers should prioritize and spend more implementation efforts on these practices.

Communities should learn from disasters. The results of the survey indicated that the implementation ratings of most the resilience practices (e.g., emergency water and energy supply, effective evacuation, gas availability, and insurance promotion and affordability) were lower after the disaster (Hurricane Irma). Previous disasters such as Hurricane Irma could serve as testing beds for the implementation of resilience practices. These disasters could reveal major resilience challenges and hidden problems. Thus, it is very important to take advantage of these unexpected or emergent opportunities to evaluate and further improve current resilience performance in local communities. From these opportunities, lessons learned can be captured and used to inform how to better prepare for and respond to future disasters. Sharing knowledge and experience is an essential element of disaster prevention and preparedness.

The concerns about vulnerable populations, regions, and housing should be addressed. The results of the survey indicate that disaster resilience is sensitive to the factors of age, region, and types of dwelling. To build resilient communities, natural disasters must be addressed in ways which will reduce vulnerability. Vulnerable populations (e.g., the elderly), regions (e.g., Florida Keys), and housing (e.g., mobile homes) require special assistance during disaster preparedness and response. Therefore, resilience practices should be designed in a way that addresses the special needs and concerns of these vulnerable groups. Tackling the root causes of vulnerability, such as poor governance, inadequate access to resources and livelihoods, inequality, congestion, and limited escape routes, is a prerequisite to counteracting vulnerability.

Conclusions

Summary and Conclusions

There is a lack of research on the empirical and theoretical study of stakeholder views on disaster resilience (Chang et al. 2008). To address this gap, this paper presents theoretical and empirical research on exploring and analyzing stakeholder views on disaster resilience practices of residential communities in South Florida. Based on a comprehensive literature review, 33 resilience practices were identified and classified in the context of residential community. The rankings of importance and implementation of these resilience practices were compared and the differences of views between impacted stakeholders and responsible stakeholders were explored in the context of residential communities. The findings of this study show that, on average, the identified resilience practices are highly important, and they are moderately implemented. Among all 33 resilience practices, system integrity, system reliability, emergency vertical transportation, and emergency needs response are the most important practices to the stakeholders, and system reliability, system integrity, emergency transportation support, and emergency needs response are the best implemented resilience practices based on the stakeholders' perspectives. Overall, insurance promotion and gas availability are the most important and least implemented practices to the stakeholders. The results also show that, although there is a general agreement on the importance and implementation ranks for some resilience practices, for the majority of resilience practices there is a significant difference in the ranks between the impacted stakeholders and responsible stakeholders. In addition, stakeholder views on the importance and implementation of the physical, environmental, social, and economic resilience practices are affected by factors such as their ages, regions, types of dwellings in which they live, and the occurrence of the disaster.

Although the results show that responsible and impacted stakeholders have different views on disaster resilience practices, the limited number of responses in each stakeholder subgroup (e.g., emergency manager, resilience officer, housing contractor, and designer) restricts a more detailed statistical analysis or comparison across the stakeholder subgroups. Larger samples in each stakeholder subgroup would yield more data from which to work. Future work could approach the issue with a wider range of survey respondents. Further analysis, such as developing prediction models that predict the priority of resilience practices based on different stakeholder factors (e.g., age, gender, and education), could also be conducted based on greater amounts of collected data to further enhance the relevant body of knowledge in the disaster-resilient-community domain.

Contributions to Body of Knowledge

This research on disaster resilience contributes to the body of knowledge on three primary levels. First, on a theoretical level, it offers a more holistic and explicit understanding of stakeholder views on community disaster resilience by defining resilience practices and classifying them using a disaster resilience hierarchy. This theoretical work serves as an essential preliminary effort for empirical work that investigates the importance and implementation of resilience practices to the stakeholders. Second, on an empirical level, this research advances the empirical knowledge in the area of disaster resilience by empirically investigating the responsible and impacted stakeholders' views on the importance and implementation of physical, environmental, social, and economic resilience practices; the most important and the least implemented resilience practices; and how stakeholder views vary due to factors such as age, region, type of dwellings, and before or after a disaster. Third, on a practical level, the theoretical and empirical knowledge in community disaster resilience can help practitioners to understand the priority of disaster resilience practices from different stakeholders' perspectives, thus supporting more-effective and more-collaborative resilient community decision-making by better embodying stakeholder views into planning, design, and implementation of resilient practices and strategies. This knowledge may offer more insights to both public (e.g., government officials such as emergency managers and resilience officers) and private stakeholders (e.g., home builders and community planners) and drive a rethinking of how to increase the satisfaction levels of the community residents. For example, resilience officers may pay more attention to the prioritized resilience practices ranked by the impacted stakeholders. In addition, the gaps in the implementation scores for certain resilience practices between the responsible and impacted stakeholders could drive a reassessment of the current implementation conditions by the government officials. They could also further analyze the deeper reasons for the dissatisfaction of community residents regarding certain resilience practices and explore how further improvement could be conducted.

This work could also spur more dialogue and research on further important theoretical and practical questions. For example, should trade-offs be involved among competing or conflicting stakeholder views on disaster-resilient community planning? How should stakeholder views on and priorities in disaster resilience practices be predicted? How can stakeholder views on disaster management for a community be qualitatively or quantitively integrated? How can a community disaster management plan better reflect stakeholder views? How can stakeholder views be transformed into technical requirements or guidelines in different phases of disaster management? How can the overall value that a disaster resilience decision delivers to the community stakeholders be measured? Will such measurement facilitate people-centered disaster management for the community?

Future Work

In future/ongoing research, the authors will focus on developing a theory-based decision-making framework that is able to quantitatively measure the overall value that a disaster resilience decision delivers to the community stakeholders. Different stakeholders have different views on disaster resilience, which could result in conflicts on issues such as the best resilience practice to implement or how much value the resilience decision brings to the stakeholders. Therefore, the framework will systematically account for stakeholder views and priorities on resilience practices and inform the stakeholders of the best decision that could offer the optimum value to them based on their divergent views and priorities. Because of the different views of multiple stakeholders, the framework will first mathematically model an aggregated view of a group of stakeholders based on their individual views. It will then quantify the overall value that a disaster resilience decision delivers to the stakeholders based on the aggregated stakeholder view. This work together with future work on the decision-making framework has the potential to transform the way that disaster resilience decisions are made. Stakeholder views can be better integrated into decision-making, and the solutions will be more aligned with stakeholder priorities to support more-adaptive, more-recoverable, and more-robust communities.

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