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Flood Risk Management via Risk Communication, Cognitive Appraisal, Collective Efficacy, and Community Action

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Abstract: Climate change and more frequent severe storms have caused persistent flooding, storm surges, and erosion in the northeastern coastal region of the United States. These weather-related disasters have continued to generate negative environmental consequences across many communities. This study examined how coastal residents' exposure to flood risk information and information seeking behavior were related to their threat appraisal, threat-coping efficacy, and participation in community action in the context of building social resilience. A random sample of residents of a coastal community in the Northeastern United States was selected to participate in an online survey (N = 302). Key study results suggested that while offline news exposure was weakly related to flood vulnerability perception, online news exposure and mobile app use were both weakly associated with flood-risk information seeking. As flood vulnerability perception was strongly connected to flood severity perception but weakly linked to lower self-efficacy beliefs, flood severity perception was weakly and moderately associated with response-efficacy beliefs and information seeking, respectively. Furthermore, self-efficacy beliefs, response efficacy beliefs, and flood-risk information seeking were each a weak or moderate predictor of collective efficacy beliefs. Lastly, flood risk information-seeking was a strong predictor and collective efficacy beliefs were a weak predictor of community action for flood-risk management. This study tested a conceptual model that integrated the constructs from risk communication, information seeking, and protection motivation theory. Based on the modeling results reflecting a set of first-time findings, theoretical and practical implications are discussed.

Keywords: community action; flood risk management; information seeking; protection motivation; risk communication

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1. Introduction

Climate change has created severe environmental impacts on communities in the coastal regions from Maine to Texas in the U.S. [1]. The flooding and erosion caused by increased heavy rainfalls, storm surges, and sea-level rise have posed a constant threat to the environmental safety and destruction of low-lying communities in these coastal areas [2]. These environmental impacts have been evidenced by recent storms such as Hurricane Sandy, Harvey, Irma, and Maria in the past decade, which resulted in devasting effects on human suffering, local economies, properties, and infrastructure [3].

Flood-related preparedness planning usually begins with awareness and perception of the flood risk [4]. Hence, it would be necessary to assess which risk communication sources may be effective in triggering further flood risk information seeking, which is essential to preparedness and mitigation planning [5]. Prior work has shown that family, friends, and other people in an individual's social circle could be the first sources of disaster news, followed by additional information searches through traditional media and the Internet to keep up with the emerging weather hazard [6].

Nonetheless, past research has suggested that informing the public about the risk of severe weather events did not often succeed, as demonstrated by the failure in storm

warning in advance of Hurricane Katrina [7–10]. While scientific evidence has been found to stimulate critical thinking and rational choice behavior [11], many decisions are made based on beliefs and attitudes that are detached from objectivity or even reality [12]. For this reason, examining how individuals appraise and cope with the storm- and flood-related threat via the guidance of protection motivation theory [13] could help explain whether they would be motivated to take action to mitigate or adapt to the environmental hazard [14].

In terms of people's efficacy perception to cope with their perceived flood risk, research has shown that individuals often feel that they lack the ability to effectively prepare for or mitigate a flood risk [15]. Prior work suggested that community-based flood-risk management could be an effective approach to educate residents and encourage their participation in mitigation policy planning and implementation [16,17]. As effective flood-risk mitigation will require both individual and collective community actions, it would be important to understand why individuals may choose to participate in mitigating their own flood risk alongside other community members.

Few studies, if any, have investigated risk communication, protective motivation, and collective community action factors in one empirical project. The current study intends to bridge this literature gap by integrating these different conceptual dimensions to explain how the influence of flood risk communication may lead to cognitive appraisal, motivation, and participation in community-based flood-risk management. This research will implement an online survey among a random sample of residents of a northeastern coastal community in the U.S.

2. Theoretical Literature and Research Hypotheses/Questions

2.1. Risk Communication and Information Seeking

Communication is the process of organizing facts into information for presentation to receivers; receiver engagement with the information presented is influenced by social-psychological, behavioral, and environmental factors [4,18]. Influential information sources for risk communication can include a wide range of individuals and institutions [19]. For instance, the actions of family, friends, and neighbors in response to a flood threat can influence an individual's motivation to adopt protective measures [20,21], in addition to flood risk communication conducted by grassroots community groups [22] or citizen-led action groups [19,23]. Moreover, emergency management units and relevant government agencies are the primary information sources that provide details and updates about the environmental threat to the public [24].

Above and beyond these interpersonal and institutional information sources, traditional media and Internet outlets provide the primary channels for information transmission as well as the amplification of risk communication content [25,26]. In particular, traditional news media, including newspapers [27], radio [28], and television [29], have all been found to be the primary channels for government agencies to disseminate disaster advisory and warming messages [30]. Other studies have similarly established the effects of these offline news sources on informing the public about an impending weather disaster [31,32].

Past studies have also reported that social media was utilized for sharing and receiving updated disaster development [33]. For example, social media platforms such as Twitter could provide an outlet for individuals to share continuing disaster updates [34]; peer interaction on a social media platform could function as a useful venue to supplement government-disseminated information [35]. The largest social media platform, Facebook, was reported to be an information source adopted by its users for staying current with the weather disaster warning system [36].

As for whether becoming aware of flood risk through different risk communication sources—ranging from friends and neighbors to government agencies—triggers additional risk information seeking, empirical research addressing this aspect of risk communication is scarce. Drawing from the limited literature, Rainear and Lin [19] reported that stronger trust in flood-risk information sources was a positive predictor of greater mitigation information seeking. Bird et al. [37] found that Facebook users in Queensland and Victoria, Australia,

sought information about the flood condition in their own community as well as their family and friends' communities. Oh et al.'s study [38] further confirmed that individuals would be most interested in localized, accurate, clear, and timely information about crises and disasters. To test and verify these preliminary past findings, a hypothesis is proposed below.

H1. *Exposure to flood risk communication will be positively related to information seeking.*

2.2. Risk Communication and Cognitive Appraisal

Risk communication has been established as a key element in influencing individuals' cognitive appraisal—including threat appraisal and coping appraisal—when confronted with a potentially severe weather-related risk [39,40]. According to Protection Motivation Theory (PMT), while the threat appraisal can involve a cognitive process that evaluates the perceived severity of and perceived vulnerability to a threat, the coping appraisal can reflect the perceived effectiveness of a coping response and the perceived personal ability to perform that coping response [13,41].

Extant literature has demonstrated that the key theoretical assertions of PMT can help identify and explain the cognitive and affective factors that will influence individuals' adaptive or non-adaptive behaviors for engaging in risk mitigation [14]. PMT has been widely applied to study environmental and flood risk research, including research in the contexts of climate change (e.g., [42]), flooding mitigation [43], and flood-risk management policy development [44].

Yet, the relationship between the risk communication concept and PMT has yet to be fully examined. Specifically, the relevant studies tended to theoretically incorporate risk communication into a conceptual model for guiding future research (e.g., [45]), statistically analyze the effects of risk communication strategies utilizing existing data from different databases (e.g., [46]), or experimentally manipulate risk communication in risk message stimuli for effectiveness testing (e.g., [47]). Regardless of the methodologies adopted, the limited research literature suggests that risk communication has been found to play a role in helping to shape individuals' risk perceptions and motivating them to take flood-risk adaptation measures [44,48].

The PMT concept of threat appraisal in the current study context refers to the individual's risk perception as reflected by perceived vulnerability to and severity of the flood threat; the concept of coping appraisal describes the individual's adaptation efficacy as indicated by perceived personal ability and resources (solutions) to cope with the threat [5]. On the whole, it is logical to presume that the more individuals are exposed to flood risk communication, the more likely it is that such communication will influence their flood vulnerability perceptions and flood severity perceptions. To validate these assumptions, two research hypotheses are posited below.

H2a–b. *Exposure to flood risk communication will be positively related to an individual's (a) flood vulnerability perception, and (b) flood severity perception.*

2.3. Cognitive Appraisal and Information Seeking

The cognitive inertia for and/or aversion to engage in preventing and reducing a potential loss can be seen as resulting from avoidance or insufficient threat and coping appraisal [41], which can lead to a maladaptive response and low motivation for adopting a timely or necessary protective action [49]. As a case in point, only about 22% of the Connecticut residents from the impacted flood zones evacuated during Hurricane Sandy [50]. Myer and Kunreuther [51] suggested that decision-making errors in underpreparing for mitigating the risk of a disaster could reflect six cognitive biases: myopia, amnesia, optimism, inertia, simplification, and herding.

A systematic literature review of PMT and mitigation behavior conducted by Bucbeck et al. [14] noted the following major findings: (1) risk perception was a weak or non-significant predictor of protective motivation; (2) higher self-efficacy and response efficacy predicted stronger protective motivation; and (3) demographic characteristics or

socioeconomic attributes were not highly relevant to protective motivation. These findings suggest that the role of risk perception or threat vulnerability in relation to the other threat appraisal variable, severity perception, needs to be better understood. The same is true for the relationship between the risk appraisal and coping appraisal constructs, which also need to be further vetted. To date, an examination of the relationships between the subdimensions of the threat and coping appraisal constructs and the interrelationships between these two constructs has yet to be undertaken empirically.

In particular, PMT proposes perceived threat vulnerability and severity as two parallel concepts without specifying their relationship with each other. It would be logical to assume that an individual who has a stronger vulnerability perception would likely also have a greater severity perception, and vice versa. Similarly, PMT also treats perceived self-efficacy and response efficacy as two unconnected concepts. It would be reasonable to speculate that an individual who has a greater perceived ability to cope with the threat will also be more likely to adapt to threat coping strategies, and vice versa. To empirically verify the findings of Bucbeck et al. [14], the following research questions will explore the conceptual relationships pondered above.

RQ1. *Will flood vulnerability perception be positively related to flood severity perception?*

RQ2. *Will self-efficacy beliefs be positively related to response-efficacy beliefs?*

As PMT does not specify the association between the constructs of threat appraisal and coping appraisal, this is another important theoretical question for empirical exploration. Theoretically, it is plausible that those who perceived greater vulnerability and severity perceptions could develop lower self-efficacy and response-efficacy beliefs, leading to a maladaptive coping approach such as avoidance of protective actions. The opposite may also be true, where greater susceptibility and severity perceptions could stimulate stronger self-efficacy and response-efficacy beliefs, leading to an adaptive coping approach such as the adoption of protective actions. To explore these yet-to-be-tested potential conceptual links, the following research questions are proposed:

RQ3a–b. *Will flood vulnerability perception be positively or negatively related to (a) self-efficacy beliefs, and (b) response efficacy beliefs?*

RQ4a–b. *Will flood severity perception be positively or negatively related to perceived self-efficacy beliefs, and (b) response-efficacy beliefs?*

Kellens et al. [52] reported a positive relationship between flood risk perception and information seeking behavior among Belgian coastal residents; while information needs and demographic attributes were irrelevant to information seeking behavior, permanent residency was significantly related to greater risk perceptions, risk knowledge, and information needs. Kievik and Guttelin's [51,53] experimental study manipulated flood risk level (high vs. low) and found high flood risk perception to be a positive predictor of information seeking behavior among Dutch residents in low-lying regions.

Kim and Madison [54] found a strong relationship between risk perception attitude (i.e., perceived vulnerability and perceived severity) and information-seeking efficacy (i.e., self-efficacy for securing information) before, during, and after a flood event. Van Valkengoed et al.'s [55] experiment examined perceptions of climate change and information seeking associated with adaptation strategies in the Netherlands and United Kingdom; their findings showed that perceived climate change consequences were unrelated to information-seeking intention or behavior, except when the belief about human-induced causes for climate change was strong.

Extant research that examines the relationship between flood severity perception and information-seeking behavior is very scarce, as prior studies tend to evaluate the relationships between risk perception and information-seeking needs [55–58]. Based on the limited empirical evidence reviewed above, which overwhelmingly suggests that perceived

vulnerability and perceived severity are both related to risk-information-seeking behavior, two hypotheses will verify these past findings below.

H3a–b. *Flood vulnerability perception (a) and flood severity perception (b) will be positively related to flood information seeking.*

As empirical research is lacking on the relationship between threat appraisal and information seeking behavior in the context of flood risk management, the same is true for studies examining the relationship between coping appraisal and information seeking behavior. Of the available preliminary evidence, Kievik and Gutteling's [53] study that manipulated the risk perception message by efficacy-belief message found efficacy beliefs (a combined measure of self-efficacy and response efficacy) to be a significant predictor of flood information seeking among Dutch residents in flood-prone regions.

Kellens et al.'s [52] (p. 13) survey study conducted in Belgium found a positive link from response efficacy to flood information seeking; yet the study also concluded, "While we can rely on previous (quasi-) experimental studies and theories to assume that several directions are indeed correct (e.g., the causal effects of risk perception and response efficacy on information seeking behavior have been proven by Kievik and Gutteling [53]), caution should be made when linking up causal connections of specific relations". Rainear and Lin [5] hypothesized and tested the relationship between coping appraisal and flood-mitigation information seeking in the opposite direction; their findings showed that information seeking was positively related to response efficacy beliefs but irrelevant to self-efficacy beliefs.

The limited available research evidence discussed above has suggested two opposite directions for the relationship between efficacy beliefs and information-seeking behavior. Even so, it is logical to surmise that upon learning a severe weather warning through various mediated and non-mediated channels, individuals who seek additional flood information may increase their efficacy beliefs through coping appraisals, which are linked to their threat appraisals. To test this assumption and validate Rainear and Lin's [5] findings, a research question is posed below.

RQ5. *Will flood information seeking be positively related to response-efficacy beliefs?*

2.4. Efficacy, Information Seeking, and Collective Agency

The concept of self-efficacy beliefs stems from the framework of efficacy agency, which enables one's ability beliefs to overcome a challenge or complete an objective [59]. In the context of managing a flood risk, efficacy beliefs in collective action can play a key role in a bottom-up approach that allows the formation and implementation of a community-based adaptation plan [19,60]. Collective efficacy reflects a group's shared beliefs in their ability to organize, plan, and execute required action to achieve shared task objectives; it also serves as the basis for motivating individuals to contribute to the group's action [61]. According to Bandura [59,61], individual-level self-efficacy and group-level efficacy can influence each other because individuals within the group judge their own ability in relation to the group's ability to contribute to the common goals, and vice versa.

The construct of collective efficacy has yet to receive more attention in flood or disaster risk research, even though it has been studied in other environmental conservation contexts, including household waste management [62], sustainable tourism [63], electric vehicle acceptance [64], and more. Based on the limited empirical research, collective efficacy was found to enhance individual self-efficacy and both contribute to explaining pro-environmental intentions [65,66]. Other studies demonstrated that perceived collective efficacy instead of perceived self-efficacy was a positive predictor of pro-environmental intentions [67,68]. Thaker et al.'s [69] study on water supply management in India indicated how individuals with greater collective efficacy beliefs also tended to partake in community action to help preserve efficient water supplies; this tendency was stronger in communities with higher than lower levels of collective efficacy.

The limited literature on efficacy beliefs at the individual and collective levels suggests the following: (1) collective efficacy beliefs are related to self-efficacy beliefs; (2) self-efficacy beliefs are either a weak or unrelated factor to environmental protection intentions; and (3) collective efficacy beliefs are a strong correlate to pro-environmental protection intentions. By integrating Bandura's [59,61] collective efficacy beliefs with the PMT framework in the flood risk adaptation context, it is assumed that these efficacy beliefs will be related to both dimensions of coping appraisal, i.e., self-efficacy and response efficacy beliefs. As self-efficacy and collective efficacy beliefs have been evidenced to predict pro-environmental intentions [65,66] and collective environmental adaptation actions [69], it is further anticipated that individuals with greater self-efficacy, response efficacy, and collective efficacy beliefs in coping with the flood threat will also be more engaged at the community level to collectively manage that threat. To validate these theoretical assumptions, the following hypotheses are advanced:

H4a–b. *Self-efficacy beliefs will be positively related to (a) collective efficacy beliefs, and (b) community action.*

H5a–b. *Response-efficacy beliefs will be positively related to (a) collective efficacy beliefs, and (b) community action.*

H6. *Collective efficacy beliefs will be positively related to community action.*

Flood information seeking is a concept that has been established as a factor capable of influencing individuals to take environmental protective actions, including flood risk adaptation [53,55]. However, researchers have yet to investigate the relationship between flood information seeking and collective efficacy beliefs in flood risk management. As flood information seeking has been found to be related to increased response-efficacy beliefs [5], it is not unreasonable to anticipate that flood information seeking may help enhance collective efficacy beliefs, which can lead to the adoption of collective adaptation actions. To verify the relationship leading from flood information seeking to collective efficacy and community action, two research questions are presented below.

RQ6a–b. *Flood information seeking will be positively related to (a) collective efficacy beliefs, and (b) community action.*

3. Proposed Conceptual Model

To illustrate the interrelationships between all theoretical constructs tested in the proposed research hypotheses and questions, a conceptual model is shown below. In this conceptual model, five different types of information sources are linked to flood information seeking (H1), vulnerability perception (H2a), and severity perception (H2b). Flood vulnerability perception is connected to flood information seeking (H3a), flood severity perception (RQ1), self-efficacy beliefs (RQ3a), and response-efficacy beliefs (RQ3b). Flood severity perception is associated with flood information seeking (H3b), self-efficacy beliefs (RQ4a), and response-efficacy beliefs (RQ4b). Both self-efficacy beliefs and flood information beliefs have a separate path, respectively, leading to response-efficacy beliefs (RQ2 and RQ5), collective efficacy beliefs (H4a and RQ6a), and community action (H4b and RQ6b). Response-efficacy beliefs also has a path leading to both collective efficacy beliefs (H5a) and community action (H5b). Finally, collective efficacy beliefs are related to community action (H6).

4. Materials and Methods

A random sample of coastal residents was selected as survey participants, using a set of random digits to match an emailing list that was randomized. The emailing list was provided by a local citizen-led flood and erosion control board (sanctioned by the city's charter) of a coastal community. The community is a relatively affluent suburb with just over 60,000 residents, located on the shore of the Atlantic Ocean in the northeastern region of the United States. This community suffers from chronic flooding and erosion as well as frequent

storm surges and continuing sea-level rise. An anonymous online survey was conducted over a two-week period. After removing the few incomplete surveys and surveys with response errors (e.g., straight-lined responses), the survey yielded 302 valid responses (d = 0.32) and met the anticipated effect size estimation. While the home ownership rate for the study sample was 78.1% and the median household income was US$150,000, the average age of survey participants was 47.6 years old, 85.7% of them had a four-year college degree, and 46.2% were males. The sample's racial breakdown indicates the following: 88.1% were White, 0.7% were Black/African American, 1.7% were Hispanic, 3.6% were Asian, 0.7% were Pacific Islanders, and 3% were other/mixed race. These demographic attributes were largely similar to those of the municipality's census data, except for a slight underrepresentation of African and Hispanic Americans.

4.1. Procedure and Definitions

Study participants were asked to respond to survey questions based on their experience with a recent hurricane event that severely damaged the city's residential homes and infrastructure. The operational definition for each variable is described below. Demographic attributes were profiled by participants' age, gender, race, education, and income, among others. All multi-indicator variables were measured on a 5-point Likert-type scale, unless otherwise noted. The creation of the rest of the questionnaire items was based on extensive consultation with the relevant body of literature, and the aforementioned citizen-led flood and erosion control board from the city. As the concepts and constructs tested in the current study have yet to be measured in a way that would reflect direct and personalized concerns associated with flood-risk management from a personalized cognitive, affective, and behavioral perspective, original measurement items were created.

Risk communication sources described the frequency with which participants received flood risk information associated with a severe storm from five sets of media and non-mediated sources, as confirmed by exploratory factor analysis. After removing newspapers and radio stations to improve scale reliability, offline news sources included weather coverage on (1) a TV station; (2) the weather channel on cable TV; and (3) cable news networks such as CNN, MSNBC, or Fox (α = 0.81; M = 2.93, SD = 0.98). Online news sources reflected: (1) web portals or search engines such as yahoo.com, msn.com, or google.com; (2) local news outlets on the Internet, e.g., local newspapers, radio stations, or TV stations; and (3) major national news outlets on the Internet, e.g., USA Today, CNN, MSNBC, or Fox (α = 0.74; M = 3.14, SD = 1.07). Social media sources that publish posts generated by government agencies, news media, individual users, and other entities included: (1) Facebook, (2) YouTube, (3) Twitter, (4) Instagram, (5) Reddit, and (7) other social media outlets, such as Snapchat, Tumblr, or WhatsApp (α = 0.90; M = 1.59, SD = 0.77). Relevant weather-related mobile app sources were: (1) weather monitoring applications; and (2) the state government's emergency notification system (r = 0.29; M = 3.55; SD = 1.08). People sources that reflected the individuals in one's social circle were: (1) a family member, (2) a relative, (3) a friend, and (4) a neighbor (α = 0.93; M = 2.98, SD = 1.16).

Information-seeking behavior was assessed with four items. Participants were asked to report, since the last flood-causing severe storm, how often they had sought information on the flood risk of (1) their own property; (2) their neighborhood; and (3) their community; as well as (4) whether they had considered what to do to help manage a possible flood (α = 0.93; M = 2.14, SD = 0.99).

Flood vulnerability perception was gauged by five items. Participants were asked to report whether they would be (1) afraid for their physical safety; (2) fearful for what damage may happen to their home; (3) worried about what damage may happen around their property; (4) anxious about whether they may need to evacuate; and (5) concerned with what financial losses they may suffer if a flood strikes their community during a severe storm (α = 0.91; M = 3.78, SD = 0.96).

Flood severity perception was measured with three subdimensions across six items that estimated the level of severity of participant exposure to—(1) the flood risk, (2) the

flood-induced erosion, and (3) storm surge would be—for (1) their own property, and (2) the properties in their neighborhood (α = 0.94; M = 2.43, SD = 1.02).

Self-efficacy beliefs were reflected in six items via perceived confidence level in taking the following actions to reduce the participant's own flood risk: (1) try to come up with a strategy about what to do; (2) construct an actual plan of action; (3) have enough financial resources to implement the action plan (e.g., a flood-risk reduction project); (4) have enough support from others (e.g., family and friends) to help implement the action plan; (5) decide how to best handle the financial problem (e.g., taking out a loan, as needed); and (6) carry out the action plan regardless of the difficulty (α = 0.90; M = 3.29, SD = 0.86).

Response-efficacy beliefs were indicated by perceived confidence level in the effectiveness of adopting these flood-risk reduction solutions at the community level: (1) raising levees; (2) deepening river channels; (3) improving the storm water network; (4) building structures such as ripraps, revetments, or bulkheads; (5) increasing natural buffers like tidal wetlands, salt marshes, and ponds; (6) laying natural barriers such as dunes or intertidal flats; and (7) constructing flood walls (α = 0.94; M = 3.24, SD = 0.98).

Collective efficacy beliefs were depicted by perceived confidence level in taking the following actions to reduce flood risk: (1) work with others to develop community-based solutions; (2) participate in local activities or events that educate residents about flood risks; (3) contribute money to local events that promote flood risk management; (4) contribute food to local events that promote flood risk management; (5) participate in public meetings to offer feedback on flood-risk management plans; and (6) attend public workshops to participate in flood-risk management planning (α = 0.91; M = 2.68, SD = 0.87).

Community action participation was described in three items. Participants reported the frequency for which they have (1) become involved with a local community group focusing on flood management; (2) communicated with the city hall about how to reduce flood risk on their property; and (3) participated in public meetings related to flood-risk management since the last flood-causing severe storm (α = 0.83; M = 1.44, SD = 0.75).

4.2. Data Analysis

Descriptive statistics for all variables measured on an attitudinal intensity scale were computed to present their means and standard deviations. The zero-order correlations between these variables were also calculated to demonstrate the interrelationships between them. The proposed conceptual model was tested with a structural equation modeling procedure (using AMOS 29). Specifically, a measurement model was first analyzed to ascertain the validity of all latent variables in the model. Exploratory factor analysis was also performed to group the measurement items under the confirmed conceptual dimensions. Afterwards, Cronbach's alpha test was run to generate the inter-item reliability before the measurement items were merged to form the variables described above. This was followed by the analysis of a path model, which tested all the hypotheses and research questions proposed for the study.

5. Results

Descriptive statistics and correlations were computed for all variables tested in research hypotheses and questions (see Table 1). While vulnerability perception (M = 3.79) and mobile app use (M = 2.55) had the highest mean scores, respectively, social media sources (M = 1.59) and community action (M = 1.44) had the lowest mean values (measured on a 5-point scale). In terms of correlates to the risk communication variable, exposure to flood risk communication via social media sources was positively related to severity perception, and exposure to offline and online news media sources was positively related to vulnerability perception. In addition, exposure to all different risk communication sources was correlated with information seeking, except for social media sources.

Table 1. Zero-order correlations and descriptive statistics.

	1	2	3	4	5	6	7	8	9	10	11	12
1 News Media Sources	--											
2 Online News Sources	0.49 *											
3 Social Media Sources	0.21 **	0.30 **										
4 People Sources	0.30 **	0.30 **	0.36 **									
5 Mobile App Sources	0.18 **	0.26 **	0.19 **	0.25 **								
6 Information Seeking	0.15 **	0.22 **	0.03	0.12 *	−0.17 **							
7 Severity Perception	0.07	0.10	0.12 *	0.01	0.02	0.28 **						
8 Vulnerability Perception	0.13 *	0.13 *	0.05	0.10	0.07	−0.20 **	0.55 **					
9 Self-Efficacy Beliefs	0.04	−0.03	0.05	0.07	0.11	0.05	−0.06	−0.20 **				
10 Response Efficacy Beliefs	0.08	−0.03	−0.01	0.03	0.12	0.25 **	0.20 **	0.04	0.28 **			
11 Collective Efficacy Beliefs	0.09	0.014 *	0.16 **	0.06	0.10	0.31 **	0.12 *	0.01	0.32 **	0.39 **		
12 Community Action	0.024 **	0.15 *	0.12 *	0.10	0.07	0.55 **	0.29 **	0.05	0.02	0.20 **	0.31 **	--
Mean	2.93	3.14	1.59	2.98	3.55	2.14	2.43	3.78	3.29	3.24	2.68	1.44
SD	0.98	1.07	0.77	1.16	1.08	0.99	1.02	0.96	0.86	0.98	0.87	0.75

Note: * $p = 0.05$; ** $p < 0.01$; two-tailed.

The confirmatory factor analysis validated the conceptual structure of the proposed model by demonstrating a good model fit: $\chi^2 = 2283.32$, CMIN/DF = 1.25, $p < 0.001$, CFI = 0.96, TLI = 0.95, and RMSEA = 0.029. A path analysis was conducted to ascertain the interrelationships between all components of the proposed conceptual model (Figure 1). The path model indicated that some of the hypothesized paths were not statistically significant, even though they did yield a good model fit: $\chi^2 = 40.15$, CMIN/DF = 1.75, $p = 0.02$, CFI = 0.98, IFI = 0.97, TLI = 0.9, and RMSEA = 0.05. After removing the non-significant paths, a revised path model was tested and yielded a very strong model fit: $\chi^2 = 37.59$, CMIN/DF = 1.45, $p = 0.07$, CFI = 0.98, IFI = 0.98, TLI = 0.95, and RMSEA = 0.038. Table 2 below reports all the statistically significant results from testing the revised path model.

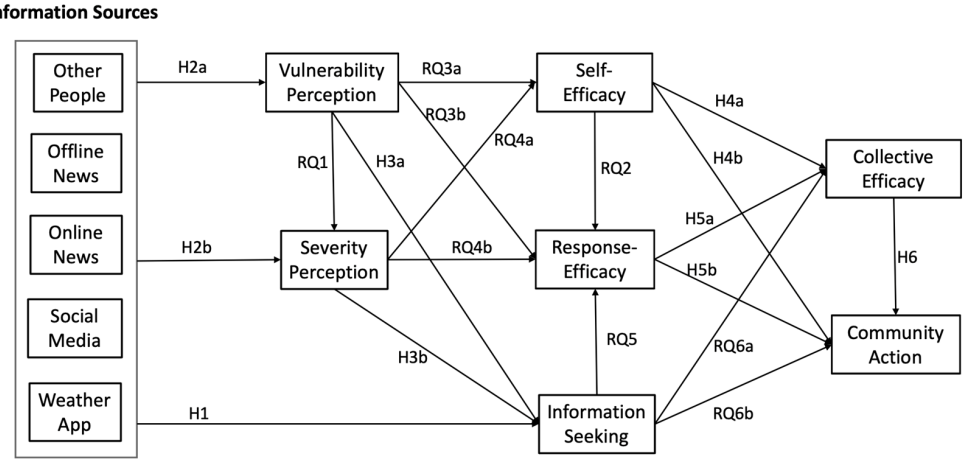

Figure 1. Proposed conceptual model.

Table 2. Revised path model with significant results.

Research Hypotheses and Questions	Independent Variable	Dependent Variable	β	C.R.	*p*
H1	Online News Sources	Flood-Risk Information Seeking	0.16	2.87	0.004
H1	Mobile App Sources	Flood-Risk Information Seeking	0.13	2.22	0.027
H2a	Offline News Sources	Flood Vulnerability Perception	0.12	2.09	0.037
H3b	Flood Severity Perception	Flood-Risk Information Seeking	0.27	4.96	<0.001
H4a	Self-Efficacy Beliefs	Collective Efficacy Beliefs	0.23	4.12	<0.001
H5a	Response Efficacy Beliefs	Collective Efficacy Beliefs	0.28	4.50	<0.001
H6	Collective Efficacy Beliefs	Risk-Management Community Action	0.14	2.74	0.006
RQ1	Flood Vulnerability Perception	Flood Severity Perception	0.55	11.32	<0.001
RQ2	Self-Efficacy Beliefs	Response Efficacy Beliefs	0.28	4.20	<0.001
RQ3a	Flood Vulnerability Perception	Self-Efficacy Beliefs	−0.20	−3.41	<0.001
RQ4b	Flood Severity Perception	Response Efficacy Beliefs	0.16	2.33	0.02
RQ5	Flood-Risk Information Seeking	Response Efficacy Beliefs	0.18	2.74	0.006
RQ6a	Flood-Risk Information Seeking	Collective Efficacy Beliefs	0.22	3.94	<0.001
RQ6b	Flood-Risk Information Seeking	Risk-Management Community Action	0.51	10.25	<0.001

Results showed that H1 was partially supported, as only exposure to two of the five flood risk communication sources, online news sources (β = 0.16, $p < 0.01$) and weather/emergency alert mobile apps (β = 0.13, $p < 0.05$), predicted flood information seeking. H2a was also partially confirmed, since only exposure to offline news sources emerged as a significant predictor of perceived vulnerability perception (β = 0.12, $p < 0.05$). As all risk communication sources were non-significant predictors of severity perception, H2b was not supported.

Addressing H3a and H3b, results indicated a significant relationship between flood severity perception and flood information seeking (β = 0.27, $p < 0.001$) rather than flood risk perception; hence, H3b was confirmed but not H3a. Findings also showed that, as self-efficacy beliefs positively predicted collective efficacy beliefs instead of community action, H4a was supported (β = 0.23, $p < 0.001$) but not H4b. While response-efficacy beliefs were a significant predictor of collective efficacy beliefs but not community action, these findings confirmed H5a but not H5b. As collective efficacy beliefs significantly predicted community action (β = 0.28, $p < 0.001$), H6 was supported.

As for RQ1 and RQ3, results showed that vulnerability perception was a positive predictor of severity perception (β = 0.55, $p < 0.001$) and a negative predictor of self-efficacy beliefs (β = 0.28, $p < 0.001$), respectively. Addressing RQ2, severity perception was unrelated to self-efficacy beliefs. On the other hand, RQ4b yielded a different result where severity perception significantly predicted response-efficacy perception (β = 0.16, $p < 0.05$), but RQ4a

did not generate a significant relationship between severity perception and self-efficacy beliefs. Results from testing RQ5 confirmed that flood information seeking was a significant predictor of response efficacy ($\beta = 0.16$, $p < 0.05$). Likewise, results from testing RQ6 and RQ6a also revealed that information seeking was a significant predictor of collective efficacy ($\beta = 0.22$, $p < 0.001$) and community action ($\beta = 0.51$, $p < 0.001$), respectively.

To illustrate the interrelationships between the revised path model components and the research hypotheses and questions that yielded statistical significance, Figure 2 is shown below.

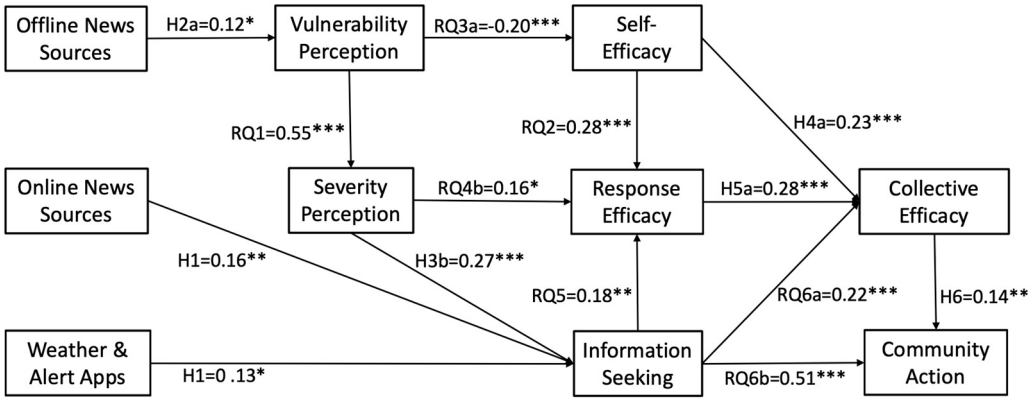

Figure 2. Revised path model. Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$ for β-values.

6. Discussion

This study explored the theoretical and empirical understanding of how risk communication exposure and information seeking behavior may be linked to threat appraisal, coping appraisal, collective efficacy, and community action in the context of flood-risk management. The findings demonstrated that, as residents in the city were familiar with flooding and erosion caused by severe storms, their pattern of flood risk communication exposure seemed somewhat different from that of others from different countries and regions. In particular, they relied primarily on mobile apps and online news outlets for receiving flood risk information, followed by others in their social network [20,21] and offline traditional news channels [27–29,31,32]. The least important flood risk information source was social media platforms; this finding contradicts some of the past work [33], Twitter [34], and Facebook [37]. It is possible that the age (Md = 47.6), education (85.7% with a four-year college degree), and wealth (median annual income = $150,000) of the current study sample were factors that distinguished this upscale community with a rich experience of flooding events from the other types of communities.

The paths from risk communication exposure to threat appraisal (H1a and H1b) and flood risk information seeking (H1) variables tell an interesting story, as few past studies have directly assessed these relationships before [27,44,46,47]. Specifically, while offline news exposure was the lone predictor of flood vulnerability perception and exposure to other risk communication sources did not contribute to explaining flood severity perception, only the use of online news and mobile app (for weather tracking/emergency alert systems) sources were the two significant predictors of flood information seeking. These findings suggest that, as severe flooding is a high-impact and low-frequency event, creating beliefs and triggering information seeking about an impending flood risk will require the risk communication target to feel the inevitability of suffering from personal loss and danger. As discussed above, cognitive biases—myopia, amnesia, optimism, inertia, simplification, and herding [51]—could also easily come into play to dull an individual's sense of urgency in confronting an impending flood hazard.

Cognitive biases notwithstanding, the current findings suggest that traditional local and national television channels can influence the flood vulnerability perceptions of a flood-prone community, as these news outlets typically provide timely and live coverage of flood warning, progression, and consequences as top news stories in a reliable and relatable

manner (e.g., featuring local families, properties, and infrastructure in peril). These findings thus support the conclusion from Oh et al. [38], which maintains that individuals are most interested in risk communication that addresses localized, accurate, clear, and timely crises and disasters. For this reason, as exposure to offline TV news sources can provide a comprehensive look at an impending or ongoing storm/flood disaster, the need to seek additional flood-risk information after being exposed to the offline TV news coverage might also diminish accordingly.

As online news sources are irrelevant to shaping vulnerability perception but are capable of prompting information seeking (as established in the current study), it is likely that individuals may wish to seek additional information to validate the overwhelming amount of flood-risk information on the Internet in an infodemic environment where both facts and myths as well as misinformation and disinformation can co-exist [70]. This need for information can be conceptualized as information insufficiency via Griffin et al.'s [71] Risk Information Seeking and Processing model (RISP), which is a model that has been validated to explain the drive for flood-risk information seeking [52,72].

Since social media sources and other individuals in one's social circle typically reshare flood-risk information posted on the Internet, it is plausible that the information seeking needs—stemming from perceived information insufficiency associated with online news sources—can sweep the information seeking needs of accessing social media and interpersonal risk communication sources. Even though this explanation is logical, the current findings contradict Bird et al.'s Australian study [37], which focused only on Facebook users that sought flood condition information about the local community and their family and friends' communities without considering other flood-risk communication sources.

While mobile apps provide storm and flood risk updates 24/7 (based on the data of the U.S. National Weather Service) and selected local storm/flood news stories, the emergency notification system of the state government is a messaging service that issues weather/flood and other danger warnings. In practical terms, neither source has the substance of live weather/flood news coverage involving human conditions to shape flood vulnerability perception, but both sources did prompt flood-risk information seeking. For this reason, the perceived information insufficiency associated with hazard warmings [52,72] and emergency alerts on a mobile app can serve as the impetus for flood-risk information seeking as well.

As a non-significant relationship was found between flood vulnerability perception and information seeking (H3a), this result both contradicts and confirms the very limited existing empirical evidence that addresses the flood risk [52,53] and climate change [55] contexts, respectively. The opposite is true for the significant relationship found between flood severity perception and information seeking (H3b). As no past research has studied this relationship, the finding here provides the first evidence for the conceptual link between these two constructs. By implication, relative to severity perception, it appears that vulnerability perception may not elicit perceived information sufficiency to propel information seeking, as the former tends to measure general fear of the flood risk and the latter can capture the essence of a flood-induced hazard (e.g., erosion on one's own property and the properties in the neighborhood).

Information seeking was found to be a positive predictor of response-efficacy beliefs (RQ5), confirming the finding of Rainear and Lin [5] and contradicting that of Kellens et al. [52]. Based on the rationale constructed to propose RQ5, as information seeking behavior reflects the frequency that individuals can learn about their own flood risk and flood-risk management solutions, they will also have greater confidence in the workable community-based solutions (e.g., flood-risk adaptation via engineering levees, channels, storm water networks, and natural buffers) and hence greater response-efficacy beliefs.

As for the speculated relationship between the subdimensions of threat and coping appraisal constructs, the finding showed two parallel positive conceptual paths: one links vulnerability perception with severity perception (RQ1), and the other links self-efficacy beliefs with response-efficacy beliefs (RQ2). Results also verified two other parallel conceptual

paths: one between greater vulnerability perception and lower self-efficacy belief (RQ3a), and the other between greater severity perception and higher response-efficacy beliefs (RQ4a). Two non-significant links were also yielded from the study, including one from vulnerability perception to response-efficacy beliefs (RQ3b) and the other from severity perception to self-efficacy beliefs (RQ4a).

From a theoretical perspective, even though the connection between vulnerability perception and severity perception was relatively strong, such linkage could vary widely depending on the frequency of flood hazards. In the case of a 50-year or 100-year storm, it is reasonable to imagine that flood vulnerability perception may not be a significant or strong predictor of protection motivation. On the other hand, the weak association between self-efficacy and response efficacy beliefs implies that protection motivation may be estimated by considering the degree of interrelatedness between self-ability and adaptation-solution beliefs. Based on these theoretical rationales, it may be argued that threat appraisal is a broad concept about perceptions and thus not necessarily a good predictor of protection motivation when compared to coping appraisal, which is based on an evaluation of risk-coping ability and adaptation. This argument then indirectly validates Bucbeck et al.'s study [14], which suggested a weak or lack of contribution from risk/threat perception to protection motivation relative to coping appraisal.

The relationship evidenced between threat and coping appraisal components presents yet another explanation about their role in relation to flood-risk protection motivation. Specifically, flood-risk communication should avoid elevating vulnerability perception, as a high level of negative emotion and fear could weaken an individual's ability to adopt protective actions. As demonstrated by the positive relationship between severity and response efficacy, risk communication strategy should focus on sharpening the messages about the realistic and relatable flooding consequences (without hyperbole), accompanied by a set of believable and proven flood-risk adaptation solutions. Furthermore, it may be reasonable to speculate that coping appraisal could potentially act as a mediator between risk/threat perception and protection motivation, even though PMT does not specify such a relationship between threat and coping appraisal.

Finally, a positive relationship was found between self-efficacy (H4a) and collective efficacy beliefs (H4a), which supported past work [65,66]; the same relationship was also true between response efficacy and collective efficacy beliefs (H5a). By contrast, neither self-efficacy beliefs (H4b) nor response efficacy beliefs (H5b) were relevant to community action. The lack of association between coping appraisal and community action raises the possibility that collective efficacy beliefs could be a mediator between coping efficacy and protective action.

Moreover, study findings also revealed that confidence in collective action was weakly linked to participation in community action (H6). Comparatively, information seeking was a much stronger predictor of both collective efficacy beliefs (Q6a) and community action (Q6b); the latter provided confirmation for past work [53,55]. From the perspective of risk communication, it is valuable to learn that information seeking behavior can strengthen perceived collective group confidence, and such confidence is less influential than information seeking behavior in explaining community action participation. In essence, individuals' risk-adaptation knowledge, aided by confidence in their group's ability to take on flood-risk management, can motivate community action participation.

Several study limitations are worth noting here. Owing to the large number of theoretical concepts tested in the structural equation model, demographic variables were not included as control variables. Even though demographic variables were not found to be highly relevant to PMT in Bucbeck et al.'s systemic literature review [14], they could potentially distinguish the effects of risk communication and collective efficacy beliefs on the dynamic of collective agency between a wealthy community (like the one under study) and other types of communities [73]. As the current study tested a set of relationships between existing theories and constructs that had not been empirically examined in the same framework before, the findings reported here will need to be further validated. Fur-

thermore, it could be important to evaluate individuals' trust in the different flood risk communication sources [5] either as an independent variable to predict the two dependent variables—threat appraisal and information seeking—or as a moderator variable between risk communication exposure and these two dependent variables.

7. Conclusions

This study focused on the role of risk communication and psychological factors in impacting the public's decision-making process to participate in flood-risk management at the community level. According to a systematic literature review on community flood risk management research in the U.S., only two of the 60 studies analyzed examined how communities themselves planned for flood events; very little was done to understand the public's perceptions and responses to flood events and policies or their motivation for participating in flood planning/recovery processes [74]. The current study addressed the research needs and filled the gaps in both areas by testing new theoretical assumptions between risk communication, PMT, collective efficacy beliefs, and community action factors to determine how coastal community residents might adopt flood-risk adaptation actions collectively at the community level.

From the perspective of evaluating risk communication effectiveness, it is noteworthy that the risk communication sources via offline and online news media channels, as well as mobile weather tracking and emergency alert apps, did raise risk awareness or lead to flood-risk information seeking. While the two subdimensions of threat and coping appraisal are interrelated, vulnerability perception appeared to have weakened self-efficacy beliefs and strengthened severity perception instead empowering response efficacy belief. Importantly, as coping appraisal and information seeking behavior were both connected to collective efficacy beliefs, information seeking behavior and collective efficacy beliefs combined were able to explain a third of the total variance in participation in community action for flood-risk management.

Several theoretical questions could be further explored conceptually and tested empirically to obtain a better understanding of the complexity involved in motivating flood-risk management and adaptation actions at the community level. In terms of risk communication effects, research is needed to determine what types of communication narrative will help activate risk information seeking behavior, in addition to eliciting a sufficient level of vulnerability perception and flood severity perception to motivate the public to consider participating in community-based flood-risk management actions. Likewise, empirical work should examine how cognitive biases such as myopia, amnesia, optimism, inertia, simplification, and herding [49] may influence exposure to flood risk communication or moderate the relationship between exposure to flood risk communication and information-seeking behavior.

Another line of research inquiries could consider what might be a risk communication strategy that could minimize the negative influence of vulnerability perception and maximize such perception's positive influence on both self-efficacy and response-efficacy beliefs. Finally, future studies should further investigate how the interrelationships between flood severity perception, response-efficacy beliefs, and risk-information seeking may influence collective efficacy beliefs to better understand the role of these interactions in eliciting protection motivation. By the same token, how collective efficacy may prompt protective community actions remains largely understudied and requires further research effort to capture their theoretical significance and practical implications.

The practical implications of the current study findings suggest that when applying an established theoretical framework such as PMT as the basis for promoting flood-risk adaptation actions, practitioners should consider how to tailor their risk communication strategies to build both individuals' efficacy and agency [75]. In particular, these risk communication strategies should account for explaining the science behind climate change and weather disasters—in a manner that is relevant to the lived experiences and physical environment of the local residents—rather than as concepts that seem distant in a physical,

temporal, and psychological sense to them. Ideally, the risk communication content can also elicit an emotional response via feelings of hope to motivate these residents to work collaboratively with other community stakeholders in flood-risk management.

By the same token, practitioners could also consider incorporating a bottom-up approach in conjunction with selected components of a top-down approach when conducting community-based flood-risk management. This is because while the bottom-up approach has been proven useful in gaining community acceptance and understanding local concerns, the top-down approach is valuable when implementing property-level resilient technologies and strategies [76]. In essence, using the bottom-up approach will allow practitioners to appreciate the local residents' motivation for flood-risk management and more effectively utilize risk communication to encourage collective community action on flood-risk management. By incorporating the technical components from a top-down approach, the flood-risk management exercise led by both community stakeholders and partitioners could be guided by sound science and practical policy implementation considerations.

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Informed Consent Statement: Participant-signed consent was waived due to the minimum risks the current study involved. The researchers presented potential participants with an informed consent page on the study website, which explains the purpose, procedure, risks, and benefits of the study and the voluntary nature of their participation.

Data Availability Statement: The data presented in this study are not available as they were not part of the internal review board approval.

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