THESIS

INDIVIDUAL PROACTIVE ADAPTATION: INTEGRATING VULNERABILITY AND NATURAL HAZARDS INTO A NEW COGNITIVE MODEL

Submitted by

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ABSTRACT

INDIVIDUAL PROACTIVE ADAPTATION: INTEGRATING VULNERABILITY AND NATURAL HAZARDS INTO A NEW COGNITIVE MODEL

Individual proactive adaptation refers to personal proactive behaviors in response to crisis events (in this study, natural disasters) aimed at minimizing the disruptions caused by such disasters. The process of adaptation is often complex and dynamic, influenced by the synergistic effects of multiple factors. Current research on adaptation motivation and decision-making is largely influenced by Protection Motivation Theory, which emphasizes the role of subjective factors in the cognitive and decision-making processes. However, as adaptation theories evolve, scholars are beginning to acknowledge the role that objective indicators play in the cognitive process of proactive adaptation. This thesis builds on these research trends and theories in two studies. Study 1 conducts a systematic review of current research on indicators of adaptation and integrates those indicators with socio-ecological thinking to develop a new cognitive model. Study 2 involves a plausibility probe based on semi-structured interviews ($N = 27$) among residents of Dujiangyan District of central China, an area which was impacted considerably by earthquakes and COVID-19 in recent years. The probe involves applying the new model to analyze those interviews and identify viable objective indicators for the cognitive process of adaptation. This approach is more cost-effective compared to prematurely conducting more ambitious and systematic tests of model assumptions. Results from Study 1 indicate that individual vulnerability and hazard characteristics, as indicators representing social ecological dimensions, participate in each appraisal stage of the adaptation cognitive process. Results from Study 2 highlight several indicators as crucial objective measures of individual proactive

adaptation. These indicators include the scope of impact, past hazard experiences, income, age, housing condition etc. Overall, the thesis suggests that previous research has failed to account for the role of individual vulnerability and natural hazard characteristics in the *appraisal stages* (as opposed to the *final decision* stages) of cognitive processes of individual adaptation. Additionally, the new model and case study findings point to paths forward for better incorporating objective indicators in future research on cognitive processes associated with individual proactive adaptation.

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THESIS INTRODUCTION

As environmental changes occur with increasing frequency, natural disasters, as one of the most prominent examples, typically bring negative and intense disruptions to the normal functioning of human societies. The focus of current scholarly attention is on how to respond to and mitigate these external shocks to social systems (Berkes et al., 2003; Brown & Westaway, 2011; Nelson et al., 2007). In this context, the concept of adaptation is increasingly seen as crucial for individuals and societies to cope with environmental changes, which entails adjusting behaviors, lifestyles, and habits to buffer against and even leverage these changes for protective and strengthening purposes (Brown & Westaway, 2011; Fedele et al., 2019). The development of the adaptation concept in ecology is inseparably linked to the concept of socio-ecological systems (SES). Serving as one of the three related attributes and functions of SES, adaptation represents the capacity of the system wherein all inner actors from different dimensions act synergistically or independently to respond to various shocks and pressures (Walker et al., 2004). From this perspective, the fundamental components of adaptation involve the human-nature dynamism emphasized in SES thinking. This connection preliminarily reveals the importance of recognizing and utilizing the dynamic interactions between humans and natural systems for understanding the concept of adaptation (Nelson et al., 2007).

Studies increasingly call for integrating SES thinking into natural disaster adaptation research. This is seen, in the "disaster = vulnerability × hazard" framework for disaster mitigation proposed by Wisner et al. (2004), as well as in climate change research which increasingly applies socio-cultural and ecological dimensions in analyzing adaptation (Fedele et al., 2019; Salgueiro-Oterob & Ojea, 2020).

This thesis integrates these dimensions by proposing and then applying an analytical framework based on both individual vulnerability and natural hazards, which respectively represent social and ecological aspects of the cognitive process of individual proactive adaptation. These areas of emphasis draw from previous studies on climate change adaptation (Doria et al., 2019; IPCC, 2001; Lei, 2014; Pielke, 1998) and from recent arguments that individual adaptation capabilities in natural disasters are dual responses to both external environmental changes and internal threats (Jia et al., 2021). At the same time, it is worth noting that natural hazards do not equate to disasters; they are extreme events inherent to ecological systems that may interact with social systems, becoming natural disasters (Wisner et al. (2004).

Having identified the matching agencies that will be used to incorporate SES thinking into the analysis of individual proactive adaptation, I sought an appropriate framework to provide a solid foundation for more practical exploration and analysis. Most current models or frameworks for analyzing adaptation motivation are based on early Protection Motivation Theory (PMT) (Rogers, 1975, 1983). Among the most focused and suitable models based on PMT is the Socio-Cognitive Model of Private Proactive Adaptation to Climate Change (MPPACC) developed by Grothmann and Patt (2005). The MPPACC framework continues PMT's focus on subjective factors (i.e., risk appraisal and adaptation appraisal) while also emphasizing potential objective indicators for the first time. While its objective indicators overlap somewhat with individual vulnerability, it lacks sufficient consideration of natural hazards. Therefore, this thesis builds on previous research by proposing and then applying a new framework that incorporates individual vulnerability and natural hazard characteristics as objective elements enhancing not only the MPPACC but disaster research on proactive adaptation more broadly.

The thesis seeks to accomplish these tasks in two studies. Study 1 systematically reviews existing research on individual proactive adaptation to natural disasters to understand the current state of research in the field. It investigates the use of both subjective factors and objective indicators in research on decision-making and motivations to refine the new cognitive model, mentioned above. Study 2 explores the validity of the central assumption presented in that model: namely, whether individual vulnerability and hazard characteristics, as crucial aspects of SES thinking, represent viable indicators in the proactive adaptation cognitive process. To do so, Study 2 conducts a plausibility probe based on semi-structured interviews (N = 27) with residents of a district in China's Sichuan Province who recently experienced two types of particularly impactful disasters (earthquakes and COVID-19). By adopting a simpler and more convenient research method like a plausibility probe in this theory-building stage, the thesis incurred minimal overall costs while laying a foundation for subsequent research into the interactions and viability of measures of individual proactive adaptation.

STUDY 1: VULNERABILITY, DISASTERS, AND PROACTIVE ADAPTATION: A SCOPING REVIEW AND NEW COGNITIVE MODEL

1.0 Abstract

Objective: The aim of this scoping review was to describe the role of vulnerability and hazard characteristics in proposing a more comprehensive framework for analyzing individual adaptive decision-making.

Introduction: An increasing number of studies focus on individual adaptation as a crucial measure of disaster response. Researchers now apply various behaviour change theories and frameworks to identify factors and pathways for individual adaptation decisions. Studies commonly recognize individual vulnerability, and the way hazards interact with human society as the main influencing factors for individual adaptation decisions.

Inclusion criteria: This review emphasizes empirical research on individual behaviour changes in response to disaster outcomes or future disasters. Studies included in the analysis had to consider individual vulnerability and/or the way hazards interact with humans as influencing factors for individual adaptive behaviours in natural disaster contexts. All human-made hazards were excluded.

Methods: The comprehensive scoping review focused on the fields of disaster resilience building, disaster adaptive behaviours, disaster risk reduction, and disaster vulnerability mitigation, utilizing published literature to identify applications of vulnerability and hazard

characteristics in the study of individual proactive adaptation. The search process was conducted on August 1, 2023, with materials sourced from four scientific databases: Academic Search Ultimate, APA PsycInfo, PubMed Medline, and Web of Science. There were no restrictions on the publication year, and the language was restricted to English-language publications. Filters were applied to include search keywords appearing in the title, abstract, author keywords, and Keywords Plus, as well as Author-Supplied Abstracts. All publications discovered in the process were considered, regardless of their research design, methodology, and quality. The final data was extracted based on the formulated research questions to determine how vulnerability and hazard characteristics were represented and their respective positions in influencing pathways, whether directly or indirectly.

Results: The investigation revealed that current research on individual proactive adaptation widely uses vulnerability and natural hazard characteristics as factors. Most studies use factors for the characteristics of natural hazards that align with the definitions of recognizable genotypical features proposed in the genotypical classification of natural hazards. Among these, the use of subjective vulnerability factors (e.g., self-efficacy, subjective vulnerability), based solely on vulnerability conditions, has noticeably declined compared to objective counterparts (e.g., socio-economic status, demographic).Meanwhile, for natural hazard characteristics, the application frequency of both objective (e.g. speed of onset, duration of impact) and subjective dimensions (risk perception, subjective severity) in studies is not vastly different. Additionally, a small portion of current research has employed subjective factors developed based on both objective vulnerability and hazard characteristic factors. Such factors (e.g. adaptation appraisal, subjective probability) more effectively present the complexity of the influence pathways in adaptation decisions. Current research still leans towards exploring direct associations between

influencing factors and individual adaptation decisions, with analyses on indirect influence pathways significantly less common.

Conclusions: This review organizes and summarizes different influence pathways and factors used in current research to analyse individual adaptation decisions. It introduces an analytical framework, based on findings from the review and theories and models that are widely adopted in current research. This framework fully encompasses all identified factors and their influence pathways for individual proactive adaptation, providing a more comprehensive analytical perspective for future research.

Keywords: *proactive adaptation, disaster resilience, vulnerability, scoping review*

1.1 Introduction

Current Studies often recognize environmental changes in ecosystems that have the potential to affect human society as natural hazards. Concurrently, most scholars concur that natural hazards are not synonymous with disasters. Natural hazards are extreme events that occur inherently within nature. However, for such an event to be transferred to natural disaster, it must interact with human societies and yield adverse outcomes (Burton et al., 1993; Nigg & Mileti, 1997; Puttick et al., 2018). As these environmental changes become more intense and evident, their negative impact on human society continues to expand. Since 1960, studies have documented over 11,000 disasters attributed to natural hazards, with a discernible upward trend from 33 annual occurrences in 1960 to 441 by 2000 (Kharb et al., 2022). In this context, adaptation becomes paramount as a primary component of resilience, representing an ability of social-ecological systems to self-adjust and adapt in response to various shocks and stressors (Brooks,

2003; Fedele et al., 2019; Walker et al., 2004). Meanwhile, adaptation is integral in effectively equipping individuals to respond to the impacts of socio-ecological changes (IPCC, 2015). Therefore, adaptation plays a crucial role in building resilience and maintaining sustainability in social-ecological systems in this era of unprecedented uncertainty. Investigating the influencing factors of individual proactive adaptation decisions and actions will assist in providing more effective and concise guidance for enhancing individual adaptation and community resilience toward natural disasters.

The adaptation concept remains widely utilized in climate change research and is often associated with vulnerability (Doria et al., 2019; IPCC, 2001; Lei, 2014; Pielke, 1998). Evaluating vulnerability is extremely complex and typically involves two distinct perspectives. The first is based on post-event damage to the socio-ecological system by external environmental changes with a primary focus on the interaction between environmental hazards and human systems. The second is based on the internal state of the human system and mainly concentrates on structural factors within the system, such as economic status, political status, social inequality, etc., that are independent of external influences (Brooks, 2003). Concurrently, some scholars have posited that the development of individual adaptability is a reaction to the dual stimuli of environmental alterations and inherent threats (Jia et al., 2021). This is consistent with the logic of the second perspective just mentioned, where vulnerability as an internal threat within human systems is independent of the external pressure brought by environmental changes. The current study adopted this perspective, defining vulnerability as the structural deficiencies within both society and individuals that can impede a person's adaptive capacity.

Grothmann and Patt's (2005) Socio-Cognitive Model of Private Proactive Adaptation to Climate Change (MPPACC), based on Protection Motivation Theory (Rogers, 1975, 1983), underscores the impact of subjective climate change risks and response capacities on individual proactive adaptive behaviour. The original Protection Motivation Theory highlights vulnerability and the severity of the event as the two major components of risk perception (Rogers, 1975, 1983). Grothmann and Patt (2005) extend this by considering fundamental personal and social capitals that constitute vulnerability as factors of adaptation appraisal and capacity. Meanwhile, the "disaster = vulnerability × hazard" framework by Wisner et al. (2004) suggests that disasters don't arise from social internal vulnerabilities or external natural hazards acting in isolation, but from their interaction. The "Pressure and Release Model" proposed by Wisner et al. (2004) provides a more direct illustration of how different aspects of vulnerability and natural hazards interact as objective elements, cumulatively contributing to individual's risk of experiencing disasters. Natural hazards, compared to the enduring and progressive impacts of climate change, impose more abrupt and intense environmental changes, leading to more acute risk perceptions. Therefore, whether viewed from the perspective of objective or subjective factors, both internal vulnerability factors (societal/individual) and external stimulation brought by environmental changes have a certain impact on individual adaptability and need to be included in its assessment.

Despite its importance, research on adaptation to natural disasters is nascent compared to that of climate change. However, adaptation studies from engineering and the natural sciences continue to concentrate on both exposure concerns and technological solutions associated with damaging events (Thomalla et al., 2006). The field of disaster studies has yet to comprehensively measure individual adaptability from a social science perspective, especially in terms of synthesizing

internal (societal / individual) vulnerabilities or the external (environmental) stimuli generating the natural hazards in the first place. The absence of a standardized framework clarifying individual adaptation factors points to a crucial research need. Hence, the purpose of this this study is to review the literature on vulnerability and natural hazard characteristics as adaptability factors for individuals, leading to an encompassing analytical framework based on these insights.

1.2 Study Design

1.2.1 Review question

Drawing on previously published empirical studies and systematically identified original publications, this study conducts a scoping review across different disciplines to investigate the following primary question: How do previous studies describe the pathways by which individual vulnerabilities and characteristics of natural hazards influence post-disaster adaptive behaviours?

The relationships described in each study were assessed to offer more detailed insight around the following subset of questions:

- Are individual vulnerabilities and characteristics of natural hazards considered simultaneously in the formation pathways of individual adaptive behaviours?
- Are individual vulnerabilities and characteristics of natural hazards measured as subjective or objective factors?
- How are genotypic (as opposed to phenotypic) classifications of natural disasters applied in the study of individual proactive adaptation?
- What are the interactive pathways between vulnerabilities and characteristics of

natural hazards (as subjective or objective factors) and individual adaptive decisions?

1.2.2 Eligibility criteria

1.2.2.1 Participants

This scoping review imposes no restrictions on the demographic characteristics of the populations presented in empirical studies; however, the review only covers cases that populations have experienced natural disasters to develop post-disaster adaptation behaviours or intentions.

1.2.2.2 Natural Disasters

The review covers studies on individual adaptation to natural disasters, encompassing all natural hazards induced by ecosystems, such as earthquakes, floods, epidemics, etc. It does not include man-made disasters generated by human societies, such as wars, nuclear contamination, biological/chemical threats, etc. Climate change was also considered distinct from natural disasters, as current research highlights climate change as a driver or influencing factor for climatologically related disasters; that is, as an ecological change separate from natural disasters (Simpson, 2021). Studies focused solely on individual adaptation to climate change were excluded. However, studies incorporating natural disasters induced by or related to climate change, such as extreme weather events, floods, typhoons, etc., were included.

1.2.2.3 Individual Adaptation, Vulnerability, and Hazard Characteristics

According to Brooks (2003), adaptation refers to modifying the behaviours and characteristics within a system to enhance its ability to cope with external pressures. Our current study followed

this by defining individual adaptation of natural disasters as the adjustment of individual behaviours and features to enhance the ability to cope with the pressures of future natural hazards possessing similar characteristics. Consequently, this review included all research studying changes and adjustments in intention and behaviour at the individual level in response to a natural hazard. It excluded any studies discussing only macro-level adaptive behaviours and intentions such as societal adaptation, institutional adaptation, community adaptation, or architectural adaptation.

Additionally, this article adopted Allen's (2003) view of vulnerability as including the time before encountering hazards. We regard vulnerability as structural flaws and weakness characteristics inherent within societal and individual systems that are prone to external damages. This review thus encompassed all studies describing the analysis and measurement of vulnerability-related societal and individual capitals from an individual perspective, whether objectively or subjectively. The review excluded studies focusing primarily on vulnerabilities tied to macro-level considerations such as the physical environment, society, community, institutions, etc.

Finally, this study defined hazard characteristics based on the genotypical classification developed by Quarantelli (1989, 1993) and Barton (1969), which refers to all subjective and objective factors explaining the social attributes of hazards. These factors demonstrate the complex dimensions of interaction between natural hazards and individuals.

1.2.3 Methods

The proposed scoping review was conducted in accordance with the JBI methodology for

scoping reviews (Peters, 2020).

1.2.3.1 Search Strategy & Sources

Authors searched the English-language articles in the following standard databases: Web of Science, Academic Search Ultimate, PubMed Medline, and APA PsycInfo. The study employs a method of multiple keyword search, with "adaptation", "natural disaster", “vulnerability”, and "pathway" as four primary keywords. These keywords or their variations need to be found in limited areas of the article as title, abstract and key words to be included. We adapted the search strategy, including all identified keywords and index terms, for each included database. The search strategy for each database is presented in Appendix 1. We did not restrict the search by publication date, study design, study setting, methodology and quality. Since not all the selected databases offer search restriction on research design, authors conducted the identification of empirical studies manually. The search strategy aimed to locate published empirical studies on individual adaptation to natural disasters. Qualitative and quantitative studies were both considered equally.

1.2.3.2 Data Extraction & Analysis

Following the search, we collated and uploaded all identified citations into EndNote version 21 (Web of Science Group) (EndNote, 2023) and duplicates removed. Following a pilot test, we then screened titles and abstracts based on the eligibility criteria for the review. We retrieved potentially relevant sources in full and imported their citation details into the Colandr (Cheng et al., 2018) for the Unified Management, Assessment and Review of Information. Our team assessed the full text of selected citations in detail against the inclusion criteria. We recorded and

reported reasons for excluding sources at the full text-screening stage that did not meet the inclusion criteria. We adopt the Preferred Reporting Items for Systematic Reviews and Meta-analyses extension for scoping review (PRISMA-ScR) flow diagram (Page et al., 2021) presents the results of the search and the study inclusion process.

After selecting the included studies for the in-depth review, we added their full text to Colandr (Cheng et al., 2018) and Excel for qualitative and quantitative analysis, summarizing, and drawing conclusions. Then we applied 'theoretical' and inductive thematic analysis (Braun and Clarke, 2006; Van den Bulck et al., 2019a) and inductive content analysis (Van den Bulck et al., 2019b) to interpret different aspects of the factors of adaptation and identify the main themes for vulnerability, hazard characteristics and influencing pathways in each study. The main objective of content analysis is to identify crucial features related to the research question within the studies, including individual vulnerability, characteristics of natural hazards, and the pathways through which both serve as determinative factors affecting individual adaptability. Then we categorized the results of the content analysis into different thematic groups using deductive analysis based on existing theories and inductive analysis (Puppis, 2019).

In the early stages, natural disasters as different environmental changes were classified based on phenotypic characteristics, such as earthquakes, volcanoes, cyclones, epidemics, floods, and so on, to distinguish the various impacts they had on humanity (Wisner et al., 1994). However, scholars have contended that a classification based purely on phenotypic characteristics is insufficient, as it overlooks the social dimensions of disasters essential for analysing the interactions between natural hazards and societal structures (Barton, 1969; Perry, 2017; Quarantelli, 1993, 1998). The Disaster Genotypic Classification System, introduced

predominantly by Quarantelli (1989, 1993) and Barton (1969), aids in discerning the similarities and distinctions among various hazards, focusing on vital social attributes such as the scope of impact, the speed of onset, recurrence, unfamiliarity, etc. These attributes can traverse disparate and similar disaster agents. Therefore, this review categorizes the characteristics of natural hazards in the included studies within both phenotypic classification and genotypic classification.

Presently, a wealth of theories and approaches applied to study individual responses to shock events place considerable emphasis on the role of individuals' subjective perceptions in the evolution of behaviour. Examples include the Protection Motivation Theory (Rogers, 1975 and 1983) and, building upon this, the Model of Private Proactive Adaptation to Climate Change (MPPACC) (Grothmann & Patt, 2005), the A Person-Relative-to-Event (PrE) Approach (Duval & Mulilis, 1999), the Theory of Planned Behaviour (Najafi, 1999), and the Protective Action Decision Model (PADM) (Lindell & Perry, 2012). These individual subjective cognition factors are commonly related to an individual's assessment of the shock event (external disturbance), mainly focusing on risk and threat appraisal, as well as the assessment of an individual's ability to cope with such impacts which primarily manifests as coping and response appraisal. Individual risk and threat appraisal, along with coping and response appraisal, are largely based on the physical characteristics of the shock events and the objective capital and resources possessed by the individual. The objective characteristics of shock events tend to influence the individual’s risk and threat appraisal more, whereas coping and response appraisal are primarily affected by the status of objective capital and resources possessed by the individual. However, intersections or joint influences do exist. (Duval & Mulilis, 1999; Grothmann & Patt, 2005; Lindell & Perry, 2012; Najafi, 1999; Rogers, 1975 and 1983).

Based on existing theories and approaches, this scoping review categorized two key factors of adaptation being considered (i.e., vulnerability and natural hazard characteristics) under two themes: objective and subjective. As shown in Figure 1, the objective category encompasses factors related to objective vulnerability and objective characteristics of hazards. Meanwhile, the subjective category encompasses factors associated with subjective vulnerability, characteristics of hazards as subjective by individuals, and combined factors that are formed based on a combination of factors used in measuring vulnerability and natural hazards

Some studies highlight objective characteristics of individual vulnerabilities as capital and resources (socio-economic conditions) possessed by individuals as objective factors for measuring individual vulnerability (Adger & Kelly, 1999; Brooks, 2003; Grothmann & Patt, 2005; O'Keefe et al., 1976). In the current study, these were coded as "Objective Vulnerability Factors". other research highlights genotypic classifications (e.g. speed of onset, duration of impact, type of threat) as objective factors of natural hazards (Barton, 1969; Quarantelli, 1993, 1998; Wisner et al., 1994). In the current study, these were coded as "Objective Hazard Factors".

Studies highlight the importance of people's subjective perceptions of objective individual vulnerabilities and natural hazard characteristics (Duval & Mulilis, 1999; Grothmann & Patt, 2005; Lindell & Perry, 2012; Najafi, 1999; Rogers, 1975 and 1983). These perceptions were thematically coded into three main categories. The first category identified in the studies reviewed focused on people's perceptions of their objective vulnerability conditions. These were coded as "Subjective Vulnerability Factors". The second category focused on people's perceptions of the ways that hazards impacted them and their behaviours. These were coded as "Subjective Hazard Factors". The third category focused on individuals' subjective perceptions

formed based on their objective vulnerability and hazard characteristics. These were coded as "Subjective Combined Factors".

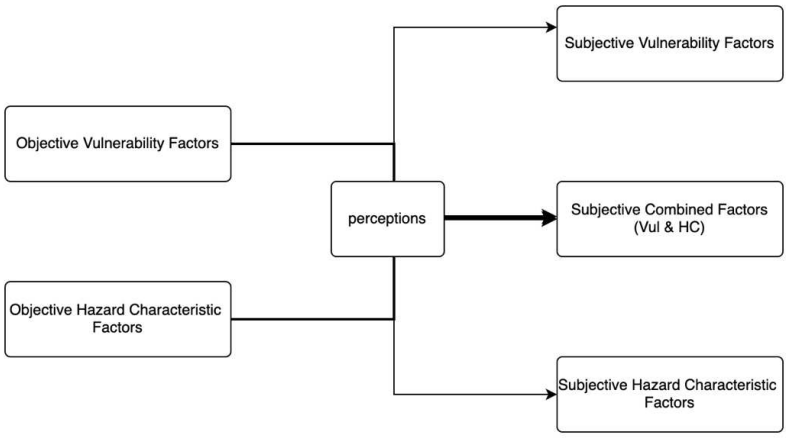


Figure 1. Conceptualizing relationships between objective and subjective factors associated with individual vulnerabilities and natural hazard characteristics.

In the final step, based on the application of vulnerability and hazard characteristics in each included study, the existing influencing and determining pathways for individual adaptation were inductively derived based on the aforementioned results. Identified pathways were categorized as direct or indirect. All factors that directly influenced individual proactive adaptation decisions (e.g. (obj: vul) socio-economic status - adaptation, (sub: vul) self-efficacy - adaptation) were categorized as “direct”. All factors that indirectly influenced individual proactive adaptation decisions (e.g., (obj: vul) socio-economic status - (sub: vul) - self-efficacy - adaptation) were categorized as “indirect”.

Applications of each factor in the studies assessed led to their categorization as objective, subjective, direct, indirect, or combined (Puppies, 2019). Ultimately, we conducted conventional content analysis on each theme to interpret the research findings associated with the theme. The analysis identified the perspectives and overall trends of applying vulnerability and hazard

characteristics in the study of individual adaptation to natural disasters. The analysis then sought to evaluate both the positions, roles, and pathways of vulnerability and hazard characteristics as factors of such adaptation.

1.3 Results

This review began by identifying 3,304 citations from electronic searches, from which we removed 67 duplicates (Figure 2). We subsequently excluded an additional 2,663 articles based on titles. After a review of the abstracts, we excluded another 444 articles. After reviewing the full text of 130 articles, 64 empirical studies met the data extraction criteria. The reasons for excluding 66 articles during this final full-text review included: five focused on climate change; 44 were related to macro-level (non-individual) adaptation; 12 mentioned neither vulnerability nor disaster characteristics; and five were conceptual studies. Of the 64 studies included, 45 used quantitative methods, eight used qualitative methods, and 11 used mixed methods.

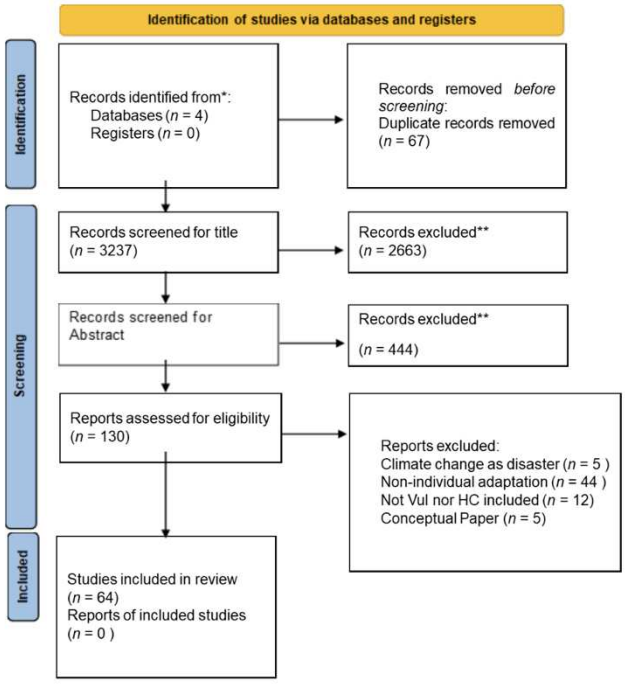


Figure 2. Scoping process flow diagram (adapted from Page et al., 2023).

*Reported the number of records identified from each database or register searched (rather than the total number across all databases/registers).
** These records were excluded through EndNote and Colandr manually

1.3.1 Identifying Vulnerability and Hazard Characteristics

Addressing sub-question 1, the scoping review began by assessing whether studies analysed simultaneous impacts of individual vulnerability and characteristics of natural disasters. Of the 64 studies included, 98% (63 total) considered individual vulnerability as an influencing factor for individual adaptive behaviour or intention. Additionally, 86% (55/64) of studies identified the characteristics of natural hazards, which included disaster features based on phenotypic and genotypic classifications. Additionally, 84% (54/64) considered both individual vulnerability and the characteristics of natural hazards as determining factors for individual adaptive decisions.

Addressing the second question, all the studies included in this review examined factors related to individual vulnerability or the characteristics of natural hazards. However, the assessment of individual vulnerability or hazard characteristics varied across these studies, with some taking an objective approach, and others adopting a subjective approach.

Among studies assessed, 61 (95%) measured the vulnerability of individuals objectively, based on personal and social capital and resources an individual possesses. A single study sometimes encompassed multiple objective vulnerability factors. Overall, studies included ten factors (Figure 3). The most prevalent was socio-economic status, covered in 81% (52 total) of studies. This encompassed a range of factors such as income, social capital, wealth, property, livelihood capital, employment status, natural capital, ethnicity, social network resources, cultural practices, and access to financial resources. Another significant area of focus was individual demographics

(e.g., age, gender, education, ethnicity, and marital status), which were addressed in 50% (32 total) of studies. According to the broadly adopted Social Vulnerability Index (SOVI) developed by Cutter et al. (2003), household characteristics of each person were categorized as an independent aspect and were explored in 22% (14 total) of studies, focusing on elements such as household size, human capital, and dependency ratio. Seventeen percent (11 total) of studies delved into an individual's information access concerning natural hazards, and 15.6% (10 total) of analysed an individuals' geographic status. Individuals' institutional access as an factor of support from external organizations appeared in 12.5% (8 total) of studies. Knowledge response to natural hazards was included in 11% (7 total) of studies. Only 3% (2 total) of studies included information on an individual's general capacity to respond to challenges, and 8% (5 total) of studies were dedicated to understanding an individual's inherent physical health status. Lastly, a single study (1.5%) delved into the quality of individuals' housing as a measure of vulnerability.

The use of socio-economic status (81%, 52 total) and demographic variables (50%, 32 total) was noticeably higher than other objective vulnerability factors in the literature. This might imply that these two factors, as the most reflective markers of individual vulnerability, have been extensively utilized in vulnerability assessment research (Cutter et al., 2000; Flax et al., 2002; Handmer et al., 1999; Turner et al., 2003). These were also used as foundational factors for measuring vulnerability in disaster research (Fetami et al., 2017).

Studies considering the objective characteristics of natural hazards were less common than those adopting objective vulnerability conditions. Fifty-six percent (36 total) of studies included objective natural hazard characteristic factors. In the objective dimension of measuring natural hazard characteristics (Figure 3), an individual's disaster experience based on objective loss and

damage was the most frequently appearing factor that reflects the social attributes of natural hazard characteristics in the included studies, appearing 28 times (44%). Knowledge (local and/or indigenous) about the disasters and past coping experiences served as other two other factors reflecting individuals' objective understanding of disasters. They only appeared three times (4.6%) and once (1.5%), respectively. The frequency of hazard appeared in 12.5% of studies (8 total), and the severity of the disaster (measured by objective indices specific to certain disasters, such as the inundation depth of floods) was found in 8% (5 total). Among the remaining factors, the speed of onset of natural hazards was used in 3% (2 total) of studies, while the other five factors each appeared in just 1.5% (1 total) of studies. These factors are respectively: quantified weather anomalies such as the number of rainy days, distance categories of threats to individuals such as health, property, and safety threats, the scope of impact, and the duration of impact.

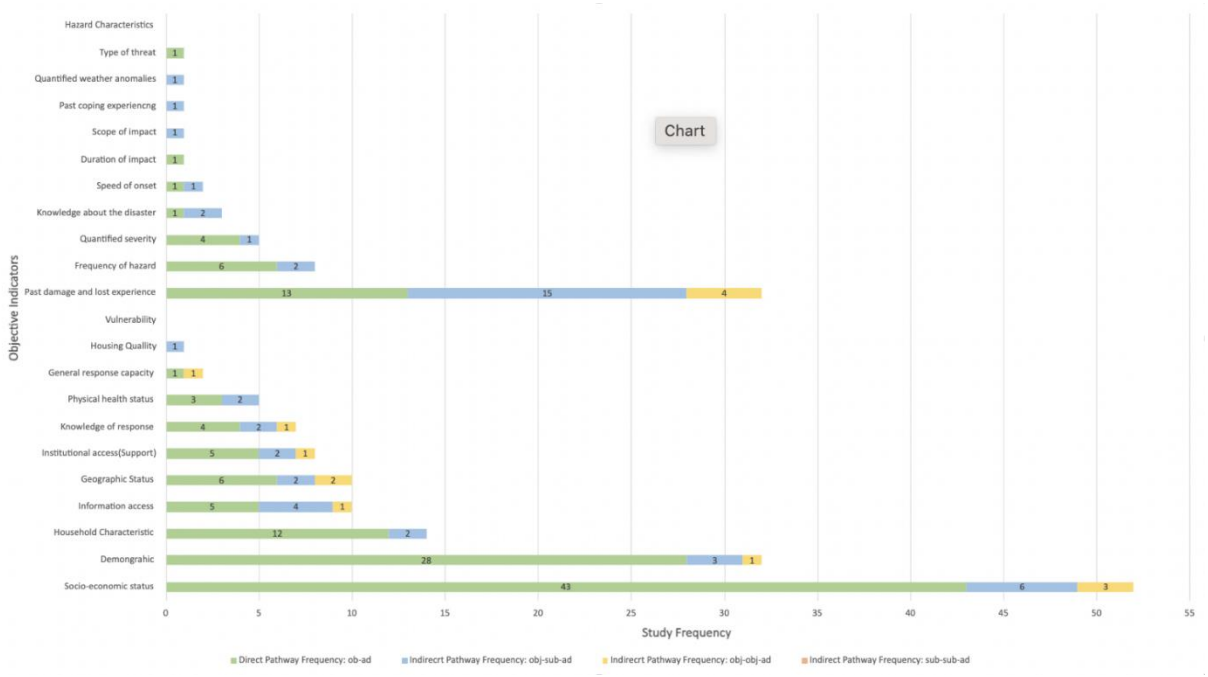


Figure 3. Objective factors and their pathway frequency.

Studies focusing on subjective factors of individual vulnerability were significantly less common than those focusing on objective factors. Out of the 63 studies discussing vulnerability,16 studies (25%) included vulnerability factors that were subjectively in nature (Figure 4). Among these, self-efficacy based on subjective vulnerability conditions was the most frequently used, appearing in 22% (14 total) of studies. This was followed by individual subjective vulnerability, which was used in 11% (7 total) of studies. Three percent (2 total) of studies mentioned subjective knowledge as a factor of subjective vulnerability. Lastly, there were four objective vulnerability factors, each appearing in a single study (1%): self-rated health, other concerns, living uncertainties in a new place, and subjective community support.

Studies presenting subjective measures of hazard characteristics were as common as those focused on objective measures, included in 56% (36/64) of studies. In the 55 studies discussing natural hazard characteristics, 28% (18 total) included both objective and subjective natural hazard factors. Among studies that included subjective factors reflecting natural hazard characteristics (Figure 4), the most prominent factor was risk perception/awareness, appearing in 31% (20 total) of studies. Risk perception/awareness was also represented as subjective threat or pressure in some studies. Subjective severity (intensity) was the second most common subjective factor used to measure the influence of natural hazard characteristics on adaptive behavior, included in 22% (14 total) of studies. Twelve-point five percent (8 total) of studies exploring climate disasters considered individual perceptions of climate change. The subjective cost of adapting to disasters had the same frequency at 12.5% (8 total). 11% (7 total) of studies discussed individuals' emotions towards disasters in terms of concern, worry, and fear. Individual subjective response efficacy of adapting to disasters and subjective probability of disaster occurrence were included in 9.4% (6 total). Individual subjective responsibility to cope with

disasters was subjectively evaluated based on objective disaster characteristics in 3% (2 total) of studies. Finally, subjective frequency as a factor of subjective hazard characteristics was included in 1.5% (1 total) of studies.

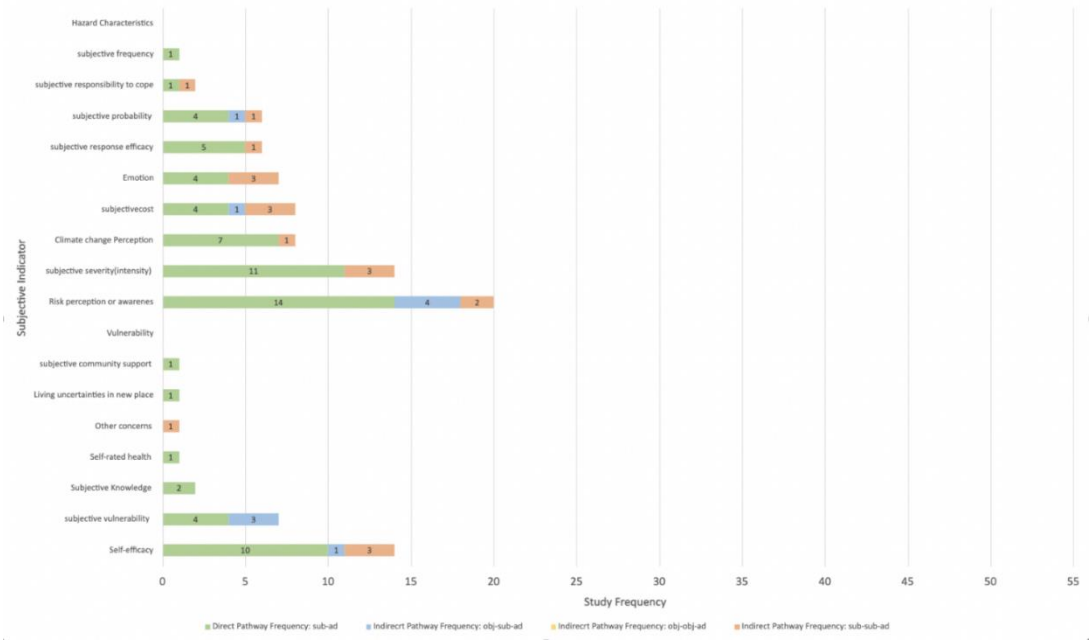


Figure 4. Subjective factors and their pathways.

Based on the 64 included studies that discuss the influencing pathways of individual adaptation decisions, a total of 12 combined subjective factors were identified that serve as factors in the pathway (Figure 5), which are individuals' perceptions influenced both by vulnerability and disaster characteristics. These combined subjective factors were used in 25% (16/64) studies. The most frequently occurring factors were risk perceptions of the hazard and subjective severity which were both mentioned in 12.5% (8 total) studies. Subjective vulnerability was another factor used in 9.4% (6 total) of studies. Adaptation appraisal was found in 8% (5 total) of studies. Subjective response cost was discovered in 6% (4 total) of studies. Then, five combined subjective factors appeared twice (3%): subjective coping demand, awareness of adaptation strategies, subjective hazard knowledge, subjective coping efficacy and subjective probability.

Lastly, subjective individual coping ability and sensitivity to hazard each appeared in 1.5% (1 total) of studies, respectively.

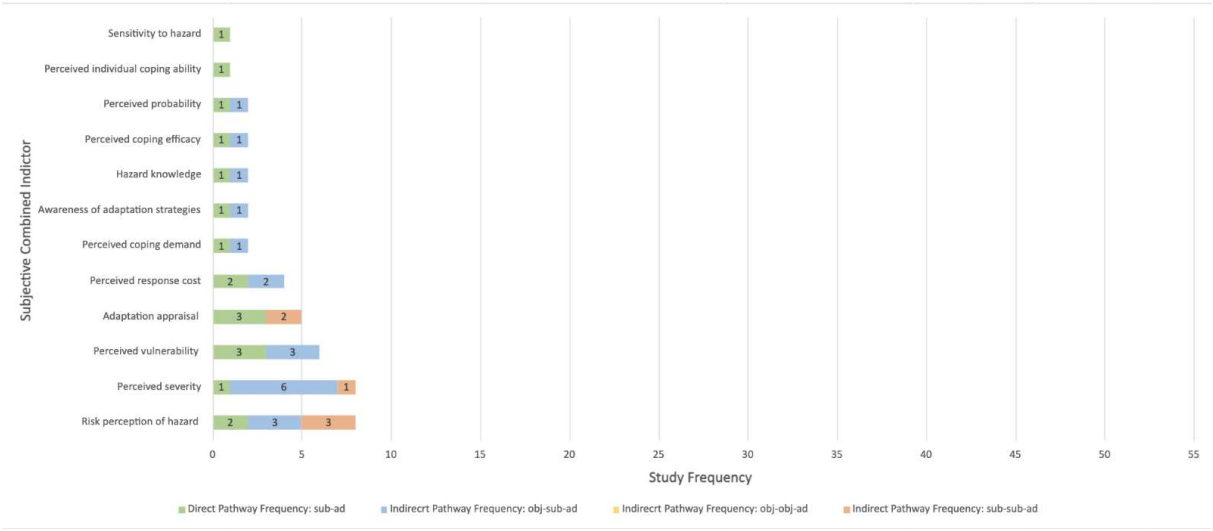


Figure 5. Combined subjective factors and their pathways.

1.3.2 Classifying Hazard Characteristics

Based on the findings in the review, the characteristics of natural hazards described based on phenotypic classification and genotypic classification have both been widely applied. Studies that incorporate characteristics of natural hazards based on phenotypic classification amount to 56 (87.5%), while those based on genotypic classification have 55 (86%) in total, showing little difference between the adoption from the two classifications. 78% (50/64) of the studies include natural hazard characteristics based on both phenotypic and genotypic classifications.

Fifty-six studies defined the characteristics of disasters in groups based on phenotypic classification of the disasters, which categorized disasters based on its surface features. The results highlight the high diversity of literature on disaster types in individual adaptability study. This covered 12 individual disasters: floods were the most common with 18 cases, followed by

droughts with 11, earthquakes with three, and heatwaves, volcanic eruptions, wildfires, storms, tornadoes, hurricanes, storm surges and cyclones, landslides, and pandemics each having one case. Additionally, 10 studies focused on general climate disasters in specific regions, such as extreme weather, droughts, and rainfall. Two studies focused on general hydrological disasters and another two on general geological disasters. Lastly, one study focused on generic coastal disasters.

A total of 55 studies used genotypic hazard characteristics as influencing factors for individual adaptive decision-making. Genotypic characteristics reflect the social attributes of natural disasters through the interaction between natural hazards and humans (Quarantelli, 1989, -1993; Barton, 1969) The previously defined 10 objective hazard factors, 10 subjective hazard factors, integrate with the12 combined subjective factors influenced by natural hazard characteristics, make up the complete genotypic hazard traits. This review ultimately identified 10 objective genotypic hazard characteristics consistent with subjective hazard factors: frequency of hazard, quantified severity, duration of impact, past damage and lost experience, scope of impact, disaster knowledge, type of threat, speed of onset, past coping experience, and climate anomalies. Meanwhile, the 16 determined subjective genotypic hazard characteristics are made up of the combination of subjective hazard factors and combined subjective factors: subjective response cost, subjective severity (intensity), subjective climate change, risk perception/awareness, subjective coping demand, subjective coping ability, subjective coping responsibility, subjective response efficacy, emotions, subjective probability, awareness of adaptation strategies, disaster knowledge, subjective vulnerability, subjective frequency, adaptation appraisal, and sensitivity to hazard.

1.3.3 Identifying Interactive Pathways

Based on the determination of direct or indirect influence pathways, each path was further clarified in terms of its classification characteristics by categorizing vulnerabilities and natural hazard factors into objective and subjective dimensions. Out of all 64 studies included a total of 14 major mutually exclusive influence pathways were identified based on the subjective and objective classification of vulnerability and hazard characteristic factors, with five being direct influence pathways that are applied in 83% (53/64) of studies and nine being indirect influence pathways that are applied in 41% (26/64) studies.

Only based on objective and subjective classification of factors, in the direct influence pathway categories, the pathways where objective factors directly affect adaptation were used in 72% (46/64) of studies, while those where subjective factors directly influence adaptation were used in 47% (30/64) of studies. A total of three indirect influence pathway categories were identified based on the classification of influencing factors into subjective and objective dimensions. The first category involves objective factors influencing subjective factors, leading to the final adaptation decision. This major category was identified in 36% (23/64) of studies, covering 47 specific influencing pathways, making it the most frequently used and diverse type of indirect pathway. The second category begins with an objective factor influencing another objective factor, which then affects the adaptation decision. This pathway was only used in 6% (4/64) of studies, with 7 specific influencing pathways identified. The last category starts with a subjective factor influencing another subjective factor, ultimately affecting the adaptation decision. 9% (6/64) of studies discussed this indirect pathway, identifying 14 specific influencing routes.

1.3.3.1 Direct Pathways

In combination with the organization of vulnerability and hazard characteristic factors, the direct influence pathways can be divided into five distinct categories (Figure 6).

There were two sub-categorized pathways that objective factors exert a direct impact on adaptation (73%; 47/64). The first category comprises pathways in which objective vulnerability factors directly affect adaptation. Nine such pathways have been identified, and these were observed in 73% (47/64) of studies analysed. The second category involves pathways where objective natural hazard factors have a direct impact on adaptation. Seven of these distinct pathways were recognized, making an appearance in 31% (20/64) of studies.

The pathways through which subjective factors directly influence adaptation appeared in 67% (43/64) of cases with three subcategories. For first subcategory pathway, the subjective vulnerability factors have a direct bearing on adaptation. Six specific pathways were determined across 20% (13/64) of studies for this sub-category. Next, nine specific pathways involve subjective natural hazard characteristic factors that directly influence adaptation decisions; these were present in 39% (25/64) of studies. Lastly, 12 specific pathways were identified with subjective combined factors directly impact adaptation decisions, which were identified in 25% (16/64) of studies.

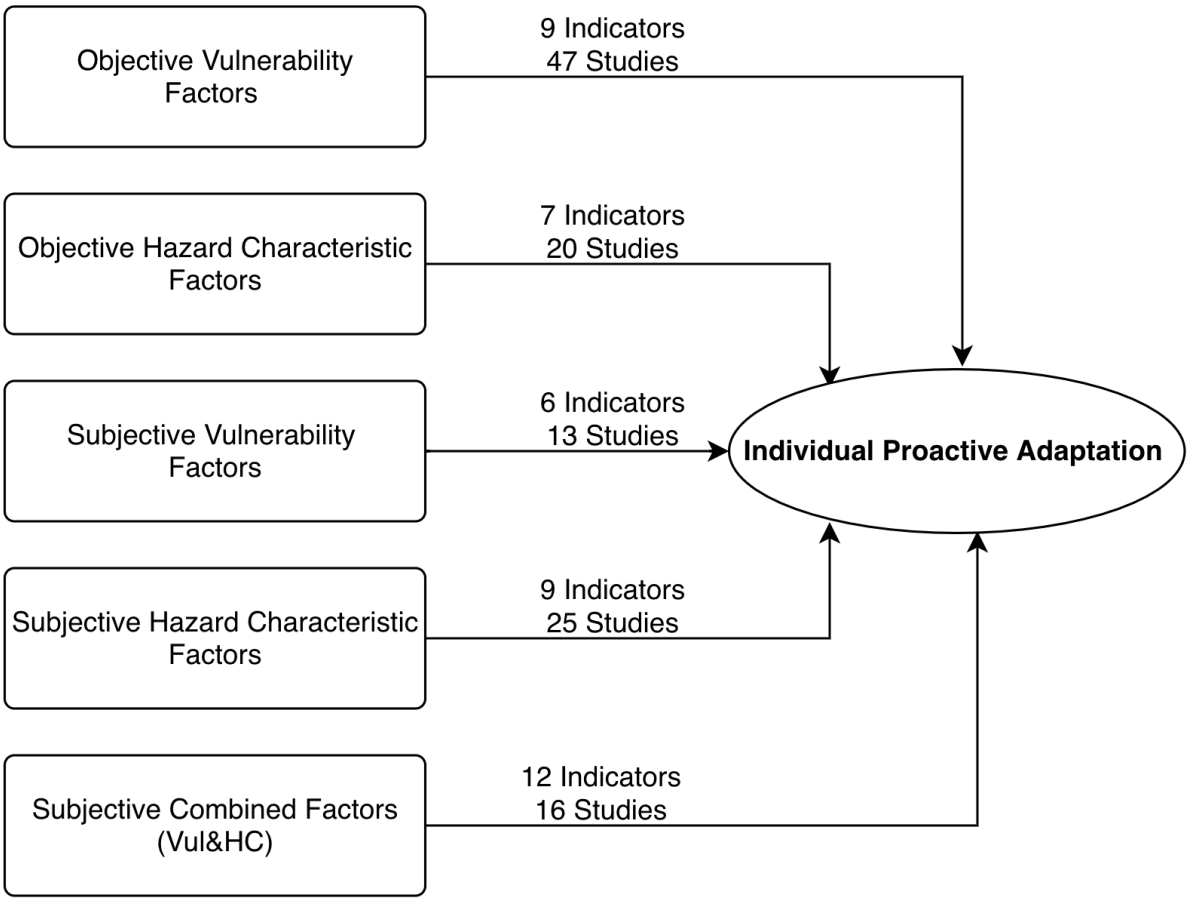


Figure 6. Direct pathways.

1.3.3.2 Indirect Pathways (objective-subjective-adaptation)

The first category of indirect influence pathways traces the progression from objective factors to subjective ones, culminating in adaptation decisions. Within this broader category, there are four subcategories of pathways (Figure 7). Firstly, there's a unique pathway that starts from objective vulnerability factors and leads to subjective vulnerability factors, influencing adaptation decisions. This specific pathway was only cited in a single study (1.5%). The second subcategory focuses on pathways originating from objective vulnerability factors that transition through subjective combined factors before arriving at adaptation decisions. This has been detailed across 22% (14/64) of studies, featuring 32 distinct pathways. The third subcategory highlights

pathways that commence with objective hazard characteristic factors, move to subjective hazard characteristic factors, and subsequently influence adaptation decisions; six such pathways were found over 8% (5/64) of studies. For last subcategory, pathways that start from objective hazard characteristic factors and then transitioned to subjective combined factors before determining adaptation decisions have been applied in 19% (12/64) of studies, spanning 11 distinct pathways.

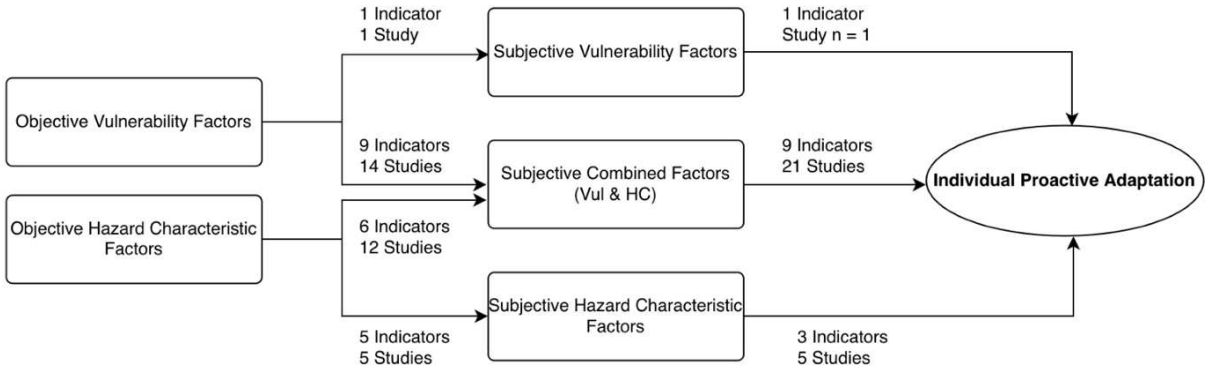


Figure 7. Indirect pathways: objective-subjective-adaptation.

1.3.3.3 Indirect Pathways (objective-objective-adaptation)

The second category of indirect influence pathways involves a progression from objective factors to other objective factors, eventually culminating in adaptation decisions (Figure 8). This category was divided into three subcategories. The first subcategory comprises pathways where one objective vulnerability factor influences another objective vulnerability factor, leading to an adaptation decision. This specific pathway was identified in only 1.5% (1 out of 64) of studies. Which is the geographic status of individuals influencing their access to information about disasters, which affects their adaptation. Similarly, the second subcategory features a pathway that begins with an objective hazard characteristic and transitions to an objective vulnerability, subsequently influencing the adaptation decision. This pathway was also identified in just 1.5% (1 out of 64) of studies. Which are past experiences and impacts of similar disasters affecting

individuals' socio-economic status, which then influences their adaptation. The third subcategory includes five different pathways wherein objective vulnerability factors influence objective natural hazard characteristics, which in turn drive adaptation decisions. For example, individuals' knowledge of response strategies influences their final adaptation through past experiences and impacts of similar disasters. These pathways have been identified in 5% (3/64) of studies.

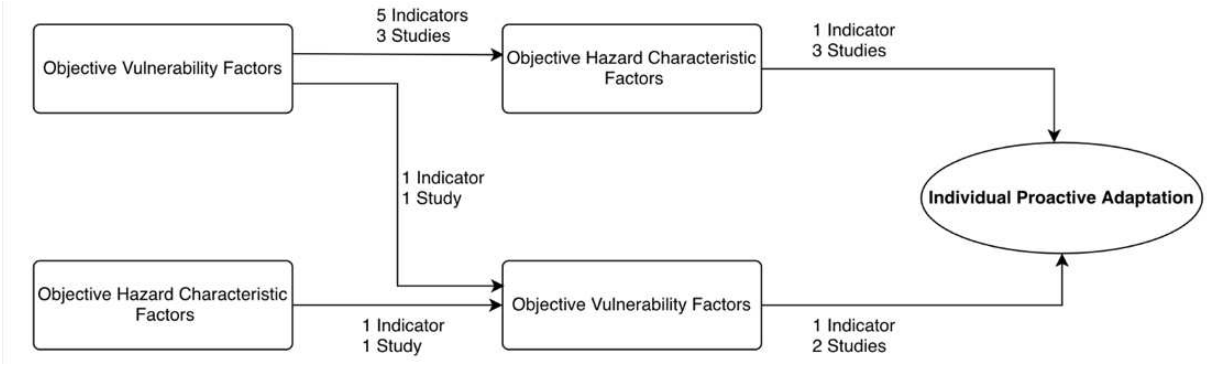


Figure 8. Identified indirect pathways: objective-objective-adaptation.

1.3.3.4 Indirect Pathways (subjective-subjective-adaptation)

The final major category of indirect influence pathways involves one subjective factor influencing another subjective factor, ultimately affecting adaptation decisions. When incorporating classifications based on vulnerability and hazard characteristics, this primary pathway category can be further subdivided into three sub-categories (Figure 9). The most frequently employed pathway in this category, used in 6% (4/64) of studies, has four distinct routes where a subjective vulnerability factor influences subjective combined factors, leading to adaptation decisions. Furthermore, there are four specific pathways that fall under another sub-category where one subjective hazard characteristic influences another, which in turn impacts adaptation decisions. These pathways were identified in 5% (3/64) of studies. Lastly, 5% (3/64)

of studies encompassed six specific pathways starting with subjective hazard characteristic factors, moving to subjective combined factors, and ultimately influencing adaptation decisions.

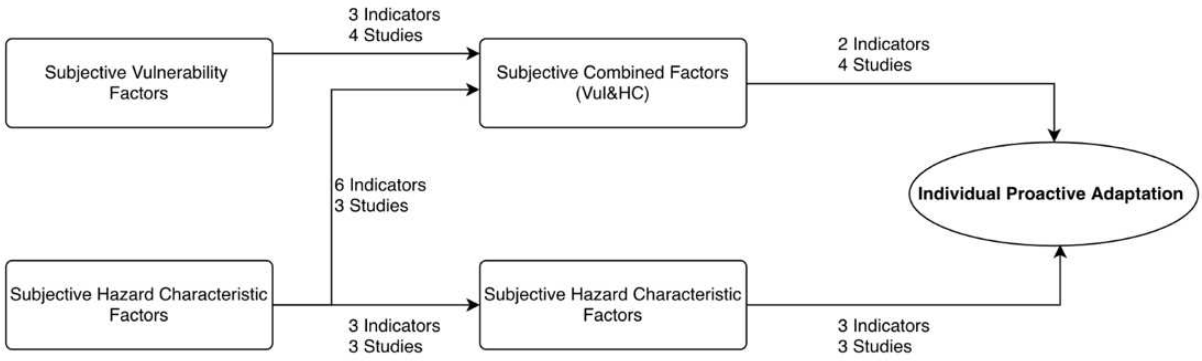


Figure 9. Indirect pathways: subjective-subjective-adaptation.

1.4 Discussion

1.4.1 Principal Findings

An individual's proactive adaptation to disturbances brought about by natural disasters depends on the appraisal of external and internal factors (Rogers, 1975, 1983; Grothmann and Patt, 2005). The nature of individual vulnerability and hazard characteristics, as internal and external factors respectively, may be described through both objective characteristics and individuals' subjective perceptions of them, interacting in various ways to influence an individual's final proactive adaptation decisions. Analyses of individual proactive adaptation should include a comprehensive examination of both the objective status and subjective perceptions of internal factors (individual vulnerability conditions) and external factors (natural hazard characteristics) to understand the fundamental motivators and barriers to individual adaptation under various hazard scenarios. Specifically, the analysis of the interactions between objective and subjective factors is crucial, offering tangible insights into how focusing on and adjusting to real-world objective conditions can enhance individual proactive adaptation. Through analysis of all studies

in this review, with no limitations set on publication year, we found that research continues placing more emphasis on direct connections between subjective and objective factors and proactive adaptation (85%; 53/64). Meanwhile, just 36% of the studies (23/64) analysed interactions between subjective and objective factors and their influence on adaptation. Meanwhile, most of current research has been given comprehensive consideration to the impacts of internal (vulnerability) and external (natural hazard characteristic) factors. Out of the 64 included studies, a total of 54 (84%) discussed both vulnerability and natural hazard characteristics.

At the same time, it's worth noting that the natural hazard characteristics used as objective factors in most current research align with the genotypical features of hazards as defined in the natural hazard genotype classification. The genotypical classification proposed by Quarantelli (1989, 1993) combines generic social dimensions, including predictability, relative loss impact, recurrence, unfamiliarity, rapidity of onset, length of threat, and so on. The natural hazard characteristics identified in the included research can be sufficiently categorized under these dimensions. The most prominent hazard characteristic observed in the review is the individual's quantified past damage and lost experiences of similar event as objective factors, which have been used in research far more frequently than other natural hazard factors (50%; 32/64). As an objective factor, it has broadly impacted seven subjective perception factors. This emphasizes that individual adaptation decisions are not based on isolated singular events but are rooted in continually accumulated related experiences. Finally, while the phenotypic classification of disasters is still mentioned in most research to clarify the study scope and subjects, it doesn't play any functional role in the analysis. This finding affirms the importance of genotypical classification of hazards when analysing individual proactive adaptation.

This study identified the scope of application of individual vulnerability and natural hazard characteristics in research on personal proactive adaptation. Individual vulnerability and natural hazard characteristics reflect the internal and external objective conditions that potentially influence an individual's decision-making process on whether and how to adapt to natural disasters. The investigation results indicate that a large proportion of the studies (84%; 54/64) have consistently included both vulnerability and natural hazards, demonstrating that the field of individual adaptation research currently has a recognized application and consensus on the internal and external factors affecting adaptation decisions. By examining the association between vulnerability and natural hazard characteristics and individual proactive adaptation, we can more comprehensively identify the fundamental objective factors directly influencing individual adaptation in different disaster scenarios. Often, these fundamental objective factors can serve as the primary entry points in design measures to strengthen individual proactive adaptation. Initiatives aimed at improving these directly influential objective factors are more likely to yield noticeable results on promoting and enhancing individual adaptation to disasters.

Based on the theories and models of personal adaptive behaviour (protective behaviour in disasters) that have been widely adopted in existing research (Duval & Mulilis, 1999; Grothmann & Patt, 2005; Lindell & Perry, 2012; Najafi, 1999; Rogers, 1975 and 1983;), factors that ultimately affect individual behavioural decisions often stem from people's subjective perceptions. Therefore, based on the discussion of objective internal and external influencing factors, research on individual proactive adaptation should include analysis of individuals' subjective perceptions of objective factors. This analysis can provide a more comprehensive framework to discover the complete influence pathways for individual adaptive behavioural decisions, ultimately enhancing and promote personal proactive adaptation.

Based on our review, applications of subjective perceptions of objective conditions and their influence on individual adaptation decisions remains under-explored in disaster adaptation studies. Only about a third of the included studies (36%; 23/64) discussed these dynamics. It is worth mentioning that among these, most considered the complexity of the formation of individual subjective perceptions which often depend on more than just a single objective factor. In such studies, 70% (16/23) adopted combined subjective factors, meaning that these individual subjective perceptions are formed based on a combination of factors used in measuring vulnerability and natural hazards. For example, an individual's socio-economic status (a condition of vulnerability) and the frequency of this type of natural hazard (a characteristic of the hazard) together influence the individual's disaster risk perception, ultimately affecting their proactive adaptation. However, despite this, only 25% (16 out of 64) of the studies considered the complexity of individual subjective perception when compared with the total number of included studies in the review. Therefore, we believe that future research on individual adaptation should strengthen consideration of the influence pathways between individual subjective and objective factors and emphasize the complex ways subjective factors influence both internal and external objective conditions.

Lastly, a small proportion of studies (9%; 6/64) delved into how subjective factors further influence individuals' determinant perceptions of proactive adaptation. Among these, 67% (4/6) of the studies discussed how risk perception, as a determinant subjective factor of vulnerability influencing individual proactive adaptation, is itself influenced by other subjective factors. The remaining 33% (2/6) of the studies analysed the influence pathways between risk perception and individual adaptation appraisal. This aligns with the logic of the MPPACC model developed by

Grothmann and Patt (2005), where adaptation appraisal usually occurs after the risk appraisal process and begins when the risk assessment exceeds a certain threshold.

1.4.2 A New Cognitive Model

Synthesizing the above findings, individual proactive adaptation to natural hazards is a complex and dynamic component crucial for reducing societal risks in natural disasters. The factors influencing individual adaptation decisions are multi-dimensional. As such, a framework incorporating these complex pathways can offer guidance for future research. We thus integrated the influencing pathways and factors identified in the review to propose a Cognitive Model of Individual Proactive Adaptation to Disasters (CMIPAD) (Figure 10), drawing from widely adopted behavioural theories and models (Duval & Mulilis, 1999; Grothmann & Patt, 2005; Najafi, 1999; Lindell & Perry, 2012; Rogers, 1975 and 1983). The CMIPAD framework summarizes both direct and indirect pathways identified in the review, as well as the objective and subjective factors considered.

The model is divided into five primary components, categorized as either objective or subjective. The three objective components are based on 1) an individual's actual vulnerability condition, 2) natural hazard characteristics based on genotypical classification, and 3) the actual adaptation behaviour the individual took or intended to take. The two subjective components incorporate individual perceptions of 1) disaster risk appraisal and 2) disaster adaptation appraisal. The three categories of subjective factors, subjective vulnerability, hazard characteristics and combined factors, are allocated across two subjective assessment area: disaster risk appraisal and disaster adaptation appraisal.

At the same time, the CMIPAD model encompasses all the influencing pathways explored in the review. Firstly, two objective factors – individual vulnerability conditions and natural hazard characteristics – respectively influence an individual's disaster risk appraisal, disaster adaptation appraisal, and their final adaptation decision, along with having an internal cyclical impact. Among these, the ways in which individual vulnerability conditions and natural hazard characteristics directly influence an individual's final adaptation decision represent the direct influencing pathways discussed in the review. These factors also indirectly influence individual proactive adaptation through their direct impact on subjective factors, namely disaster risk and adaptation appraisals, as one of the indirect influencing pathways discussed in the review. The second type of indirect influencing pathway is demonstrated through the internal cyclical impact between the two objective factors, where one can affect the other, thereby influencing an individual's proactive adaptation. The last category of indirect influencing pathways is outlined through the sequence and the detailed components of the two objective sections. Furthermore, given the significant emphasis on individuals past experiences in the reviewed studies, an overall cyclical pattern was included to underscore the cumulative effects of experience on adaptation decisions. Lastly, the framework also incorporated the cognitive bias, that is frequently emphasized in existing theories and models but not widely recognized in current empirical studies.

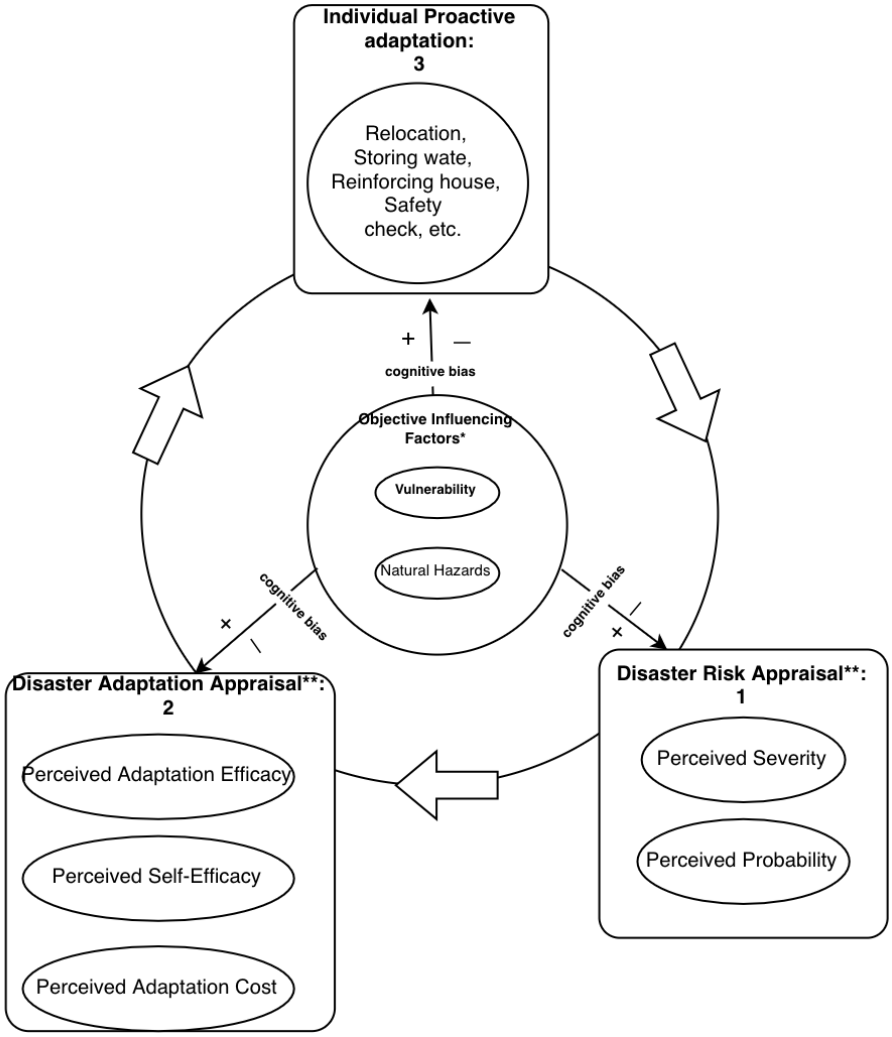


Figure 10. New Cognitive Model of Individual Proactive Adaptation to Disasters (Duval & Mulilis, 1999; Grothmann & Patt, 2005; Lindell & Perry, 2012; Najafi, 1999; Rogers, 1975 and 1983).

*Vulnerability is measured by individual disadvantages such as low income, physical disability, remote residential location, etc.; natural hazards are measured by hazard-human interactions including the speed of onset, duration, frequency, etc.

**Vulnerability, hazard characteristics, and combined factors are assessed in relation to disaster risk appraisal and disaster adaptation appraisal.

1.5 Conclusion

This study reviewed the academic literature to define the scope and relationships of individual

vulnerability conditions, natural hazard characteristics, and individual adaptation. Subjective and objective factors associated with these relationships considered existing individual adaptation behaviour theories and models (including protective behaviours during disasters) to clarify the influencing pathways surrounding individual adaptation. Results indicated that the decision-making pathways for individual adaptation are intricate and varied, involving diverse interactions between subjective and objective dimensions of internal (vulnerability) and external (hazard characteristic) factors. The proposed framework integrated the roles and applications of vulnerability and natural hazard characteristics identified in the review, guiding future individual adaptation research. The proposed CMIPAD framework might also inform the development and implementation of policies and strategies for enhancing individual resilience to natural disasters.

STUDY 2: OBJECTIVE INDICATORS OF INDIVIDUAL PROACTIVE ADAPTATION TO DISASTERS: A PLAUSIBILITY PROBE IN DUJIANGYAN, CHINA

2.0 Abstract

Previous studies remain unclear on the role played by objective indicators like vulnerability and natural hazard characteristics in cognitive processes of individual proactive adaptation. This paper addresses these concerns by conducting a plausibility probe based on semi-structured interviews ($N = 27$) with residents of Dujiangyan, China to empirically identify viable objective indicators of individual proactive adaptation in the context of natural disasters. The probe combines socio-ecological system thinking to test several assumptions associated with a newly developed cognitive model for proactive adaptation, incorporating cases that possess various individual vulnerability conditions and hazard characteristics. Results confirm that individual vulnerability and hazard characteristics, representing social and ecological dimensions, indeed participate as viable indicators in all cognitive stages of individual proactive adaptation. These findings underscore the varied participation patterns characterizing objective indicators across different appraisal sectors throughout the cognitive process, with crucial implications for disaster management and risk reduction.

2.1 Introduction

As environmental changes become more frequent and intense, addressing and mitigating the negative impacts of these changes on society has increasingly become a focal point for scholars

(Berkes et al., 2003; Brown & Westaway, 2011; Nelson et al., 2007). Scientists consider adaptation as a key practice for individuals and societies in responding to environmental changes, where people adjust their actions, activities, and life courses to reduce the harm caused by these changes and to capitalize on new opportunities (Brown & Westaway, 2011; Fedele et al., 2019; Nelson et al., 2007; Walker et al., 2004). Adaptation within the context of socio-ecological systems (SES) is built upon the complex relationship between society and the environment, especially the mutual disturbances and responses between the two aspects. (Berkes et al., 2003; IPCC, 2015; Walker et al., 2004;). Adaptability, as one of the three related attributes and function of SES, represents the capacity of actors from all aspects within the system to self-adjust and respond to various shocks and pressures (Walker et al., 2004). This linkage initially reveals the importance of recognizing and leveraging the dynamic interplay between human and natural systems for understanding adaptation (Nelson et al., 2007). Early study on disaster mitigation adopted the same perspective (O'Keefe et al, 1976), with the "disaster = vulnerability × hazard" framework proposed by Wisner et al. (2004) indicating that disasters are not caused by internal (societal) vulnerabilities or external natural hazards acting in isolation, but rather by the interaction of these elements.

Such perspectives, established on social-ecological keystones, offer clear insights into the complexity of adaptation to disasters, making the dynamic flows between different sectors traceable. With the continuous development of adaptation theory in disaster studies, recent scholars have started to apply the perspective of SES theory to study the development of individual adaptive capacity. Jia et al. (2021), for example, argue that the development of individual adaptation within natural disasters is a simultaneous response to both external environmental changes and internal threats. This view succinctly identifies the complex interplay

of human-nature systems in the process of adaptation to natural disasters. Meanwhile, in the extensive literature on climate change adaptation, as a related type of environmental change, the concept of vulnerability is often included in discussions as an indicator or influencing factor for the development of adaptability (Doria et al., 2019; IPCC, 2001; Lei, 2014; Pielke, 1998). This is consistent with the logic of the SES theory discussed above, where vulnerability, as an internal threat and flaw of the social system, meets with environmental changes such as natural hazards arising in the external ecosystem, resulting in negative outcomes in the SES. Therefore, since any SES is characterized by nonlinearity and dynamic features, this study follows others in highlighting vulnerability as an internal structural deficiency of social systems alongside natural hazards as external pressures associated with environmental change.

Current theories and models used to study individuals' adaptation to environmental changes and external shock events place a high emphasis on the role of personal subjective perception in the decision-making and action process compared to the subjective indicators from the social and ecological systems. The Protection Motivation Theory (PMT), initially developed to study people's behaviors and coping mechanisms under stress, emphasizes the influence of individual subjective perceptions-threat appraisal and coping appraisal—on the motivation to take protective actions (Rogers, 1975, 1983). Meanwhile, the PMT identifies vulnerability and the severity of the event as important indicators for measuring the threat appraisal sector. The PMT established a foundation for the development of subsequent related models and theories for protective behavior, such as the Model of Private Proactive Adaptation to Climate Change (MPPACC) (Grothmann & Patt, 2005), the A Person-Relative-to-Event (PrE) Approach (Duval & Mulilis, 1999), the Theory of Planned Behavior (Najafi, 1999), and the Protective Action Decision Model (PADM) (Lindell & Perry, 2012).

Drawing from these widely adopted behavioral theories and models, a previously conducted scoping review paper introduced a new cognitive model: a Cognitive Model of Individual Proactive Adaptation to Disasters (CMIPAD) (Li et al.). The CMIPAD, in addition to continuing the focus on the correlation between individual perceptions and final response behaviors (adaptation) found in previous theories and models, also highlights vulnerability within social systems alongside natural hazards as external environmental pressures as important components of adaptation appraisal. This study agrees that proactive adaptation of individuals to natural disasters, as a complex and dynamic behavioral pattern, could benefit from an integrated theoretical framework incorporating SES perspectives. This will assist future research in more comprehensively and clearly investigating proactive adaptation behaviors of individuals to natural disasters. Therefore, this study will apply the CMIPAD as the theoretical framework to further investigate vulnerability and natural hazards as potential viable indicators of individual proactive adaptation.

This study conducts a plausibility probe utilizing a comparative case study methodology. It involves constructing an initial set of cases based on semi-structured interviews (N = 27) with individuals possessing varying conditions of vulnerability and experiencing natural disasters with different hazard characteristics (Table 1). It focuses on their personal adaptation decision-making processes during these natural disasters. These cases encompass five common conditions of individual vulnerability associated with the social dimension: income, housing and transportation situations, age, and health status. The cases are also tied to the ecological dimension across two types of natural disasters with different hazard characteristics: earthquakes and pandemics (COVID-19). The focus here is on identifying viable objective social-ecological indicators that

were associated during interviews with the two subjective stages of individual proactive adaptation development: risk appraisal and adaptation appraisal.

Table 1. Overview of Individual Proactive Adaptation Cases.

Dimension	Condition	Case
Social Dimension (Vulnerability)	Income	C3; C5; C8; C12; C15; C16; C18; C20; C27: #9 in total
	Housing Situation	C3; C10; C12; C16; C18; C24; C27 #7 in total
	Transportation Situation	C2; C3; C5; C7; C13; C14; C15; C16; C19; C20; C25; C26; C27: #13 in total
	Age	C2; C9; C11; C13; C14; C19; C26: #7 in total
	Health Status	C2; C4; C11; C14: #4 in total
Ecological Dimension (Natural Disasters)	Earthquake	C1; C2; C3: C4; C5; C6; C7; C8; C9; C10; C11; C12; C13; C14; C15; C16; C17; C18; C19; C20; C21; C22; C23;

		C24; C25; C26; C27: #27 in total
	Pandemics (COVID-19)	C1; C2; C3: C4; C5; C6; C7; C8; C9; C10; C11; C12; C13; C14; C15; C16; C17; C18; C19; C20; C21; C22; C23; C24; C25; C26; C27: #27 in total

Although current research on individual adaptation to natural disasters predominantly focuses on subjective determinants, there's a noticeable gap in examining specific indicators within social and ecological dimensions. This study argues for the essential inclusion of a Social-Ecological Systems (SES) perspective in examining proactive individual adaptation. This approach can offer a solid foundation for the development of future adaptation strategies and their practical application. Thus, our aim is to identify potential indicators within social and ecological dimensions at different subjective adaptation stages, with plans to broaden the diversity of our sample in these dimensions. However, it's apparent that the current set of 27 samples falls short for conducting reliable validity "tests" or making strong empirical generalizations. Therefore, we've opted for a 'plausibility probe' using these limited samples to empirically evaluate whether more ambitious systematic testing of the assumptions is warranted (Eckstein, 1975; Levy, 2008).

2.2 Review of Literature and Theoretical Foundations

2.2.1 Social-ecological considerations for adaptation

With the evolving concept of adaptation, recent literature has begun to emphasize that adaptation to environmental changes is a process occurring at the level of socio-ecological systems (SES) (Hossain et al., 2023; Salgueiro-Oterob & Ojea, 2020). Socio-ecological systems are inherently complex, composed of interactions within and between humans and nature, which can either facilitate or constrain human actions in various natural environments (Barnes et al., 2017). Individual adaptations to environmental changes, as micro-level actions, are still encompassed within the SES framework. Therefore, fostering individual proactive adaptation to natural disasters requires a deeper understanding of the constantly changing complexity within the social and ecological domains of SES. Previous SES approaches have transcended the focus on single systems, viewing ecological and social systems as complex and integrated frameworks. These frameworks incorporate the ever-changing social (e.g., vulnerability, as discussed in this article) and ecological (e.g., natural hazards characteristics, as discussed in this article) conditions (Berkes et al., 1998; Hossain et al., 2023). Moreover, in the context of environmental changes, the more mature field of climate change adaptation research has begun to promote the application of SES thinking and encourages the inclusion of both socio-cultural and ecological dimensions in adaptation studies to construct a more comprehensive framework (Fedele et al., 2019; Salgueiro-Oterob & Ojea, 2020).

2.2.2 Vulnerability: social dimension

Previous research on adaptation to environmental changes has largely focused on vulnerability analyses and assessments (Doria et al., 2019; IPCC, 2001; Lei, 2014; Pielke, 1998). Particularly in climate change adaptation, the Vulnerability Assessment Framework has been the most frequently used framework to study the impacts of climate change and adaptation strategies

(Brooks, 2003; IPCC, 2001). In this context, adaptation is considered a response to the risks arising from the interaction between environmental hazards and human vulnerability (Smit & Wandel, 2006). The literature on vulnerability assessments typically includes considerations of a system's exposure and sensitivity to hazardous conditions, as well as its capacity to reduce vulnerability through adaptation (Adger & Kelly, 1999; Smit & Wandel, 2006). Given the complexity intertwined between vulnerability and adaptability, the definition and use of vulnerability vary significantly across studies (Adger & Kelly, 1999). To mitigate this complexity, we adopt the conceptualization of vulnerability from the perspective of natural disasters by Blaikie et al. (1994), which clearly separates ecological and social dimensions. Vulnerability is defined solely from a social perspective as the capital within a social system that can be converted into coping capacity (e.g., socio-economic structures and property relations). Additionally, this definition requires that vulnerability be linked to specific hazard or a set of hazards to maintain the coherence of exposure factors within vulnerability. Where exposure is a measure of the natural hazard. This concept aligns with the SES approach, which advocates for parallel attention to social and ecological dimensions. Therefore, in this study, vulnerability reflects the social dimensional indicators of adaptation which focuses on internal structural factors within the social system, such as economic status, political status, and social inequalities (Brooks, 2003; Cutter et al., 2003).

2.2.3 Hazard characteristics: ecological dimension

Wisner et al. (2004) proposed that disasters occur due to the convergence of natural hazards and social vulnerability. Meanwhile, their proposed "disaster = vulnerability × hazard" framework suggests that a disaster is a result, while a natural hazard is the environmental change. Here, the

terms "hazards" and "disasters" cannot be used interchangeably. Combining the SES approach, which emphasizes the ecological condition (Berkes et al., 1998) and the PMT's which focus on the severity of the event (Rogers, 1975, 1983), natural hazards in this study represent changes within the ecological dimension. Identifying potential indicators related to the natural hazard characteristics within the individual proactive adaptation framework will facilitate efficient and accurate research on natural disaster adaptation.

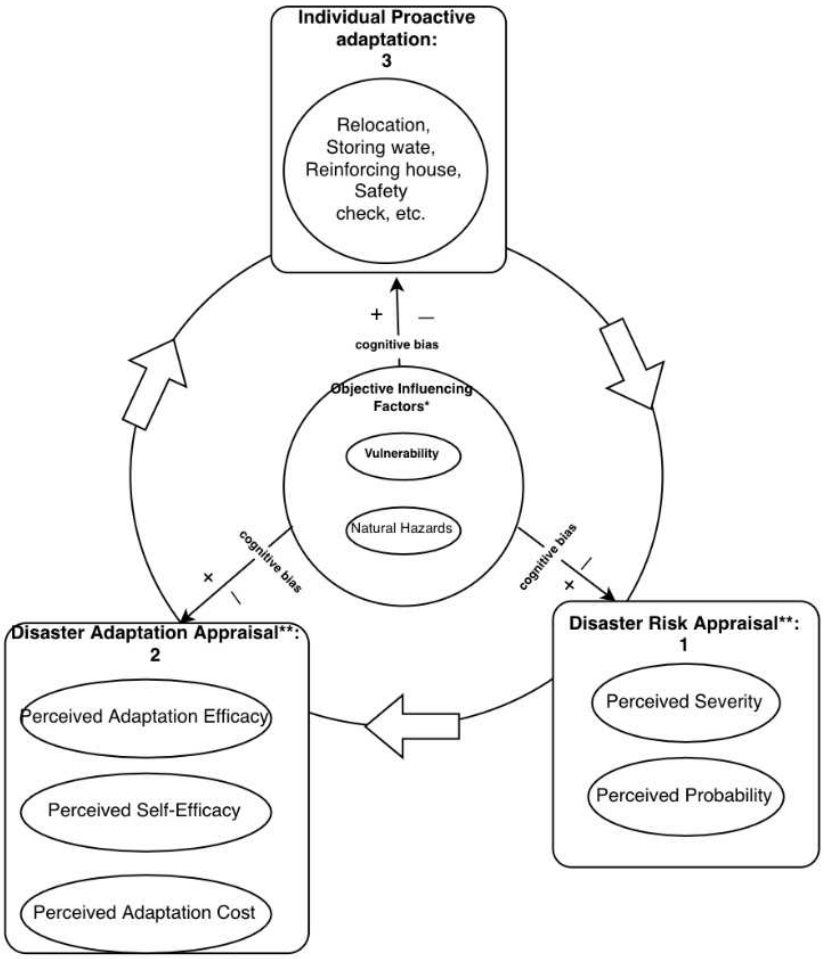
Building on the SES perspective, this study defines hazard characteristics according to the genotypical classification method proposed by Quarantelli (1989, 1993) and Barton (1969), which combines generic social dimensions, including predictability, relative loss impact, recurrence, unfamiliarity, rapidity of onset, length of threat, etc. This genotypical classification method identifies natural hazard characteristics that fully account for the social attributes of disasters required for determining the possible interactions between natural hazards and social structures. These elements aid in conceptualizing the commonalities and differences among various disasters based on key social characteristics, which can cross different and similar disaster agents (Perry, 2017; Quarantelli, 1993, 1998).

2.2.4 The Cognitive Model

Protection Motivation Theory (PMT), proposed by Rogers in 1975 and 1983, inspired most current protective behavior models and serves as the foundational theory for existing adaptation behavior models. According to PMT, human responses to threat situations or events can be categorized into six primary ways, divided into two major categories: Threat Appraisal and Coping Appraisal. In the category of Threat Appraisal, an individual's response or adaptation is

influenced by Perceived Severity, Perceived Vulnerability, and Rewards. In the category of Coping Appraisal, it is influenced by Perceived Response Efficacy, Perceived Self-Efficacy, and Perceived Response Costs. The Model of Private Proactive Adaptation to Climate Change (MPPACC), known as one of the most well-known models for individual adaptation in the field of environmental change (Grothmann and Patt, 2005), also incorporates, with slight modifications, the two major perceptual stages of adaptation from PMT: risk appraisal and adaptation appraisal. Notably, MPPACC introduces an Objective Adaptive Capacity section, which perfectly aligns with the emphasis on social dimensional indicators in the SES perspective adopted by this research. However, MPPACC's limitation under the SES context is its neglect of the ecological dimension, where ecological changes brought by natural hazards are not integrated into the framework.

As a result, a prior scoping review led to the development of the Cognitive Model of Individual Proactive Adaptation to Disasters (CMIPAD) (Li et al.) to make the MPPACC framework more comprehensive. As proposed by Blaikie et al. (1994), for the integrity of measurement, vulnerability cannot be discussed separately from specific hazards, necessitating the inclusion of ecological dimensional indicators. In the CMIPAD framework (Figure 1), vulnerabilities and characteristics of natural hazards are incorporated as relevant indicators of the social and ecological dimensions, completing the analysis of adaptation.



*Vulnerability is measured by individual disadvantages such as low income, physical disability, remote residential location, etc.; natural hazards are measured by hazard-human interactions including the speed of onset, duration, frequency, etc.

**Vulnerability, hazard characteristics, and combined factors are assessed in relation to disaster risk appraisal and disaster adaptation appraisal.

Figure 1. New Cognitive Model of Individual Proactive Adaptation to Disasters (Li et al.).

2.3 Methods

CMIPAD framework theoretically assumes that social and ecological factors are involved in each subjective perception stage of adaptation as viable indicators. This study will adopt a methodological approach termed "plausibility probe" to explore the empirical support for this core theoretical assumption process before conducting a full-scale validity test.

2.3.1 Data Collection

The empirical data for this study was collected through semi-structured interviews. The study was conducted in compliance with ethical standards for research involving human subjects. Prior to data collection, the research protocol was reviewed and approved by the Institutional Review Board (IRB) at Colorado State University. The IRB approval number is #4599.

To effectively gather cases for comparative case study, this study employed a purposeful sampling approach. Purposeful sampling ensures that the case studies align as closely as possible with the exploratory needs of the theoretical assumptions. This approach also aids in identifying and selecting information-rich cases, thereby making the most efficient use of limited resources (Palinkas et al., 2015). Given the interest here in social and ecological dimensions of individual proactive adaptation, the study focused on sampling around these two aspects. Firstly, for the social dimension, the strategy was maximum variation which enriched individual cases with instances of varying vulnerability conditions, deriving their significance from heterogeneity. The most recent vulnerability assessment index proposed by the Agency for Toxic Substances and Disease Registry (2022), the Social Vulnerability Index (SOVI), guided sampling around the social dimension characteristics. These included individual socioeconomic status, household characteristics, and housing and transportation types. For the ecological dimension, the sampling strategy involved intensity, with cases having a strong contrast. That is, the sample included participants who had experienced both earthquakes and pandemics as two types of natural disasters with fundamentally contrasting genotypical hazard characteristics (Barton, 1969; Quarantelli, 1989, 1993). Compared to pandemics, earthquakes occur more rapidly, have a

shorter duration of impact, and impact a smaller scope. Previous studies recognize these characteristics, and they were confirmed with participants during interviews.

Due to considerations of sampling requirements and feasibility, especially for the ecological dimension, we decided to select the Dujiangyan area in Sichuan Province, China (Figure 2), a district located in an active earthquake zone where pandemics are rare natural disasters (CGTN, 2022).

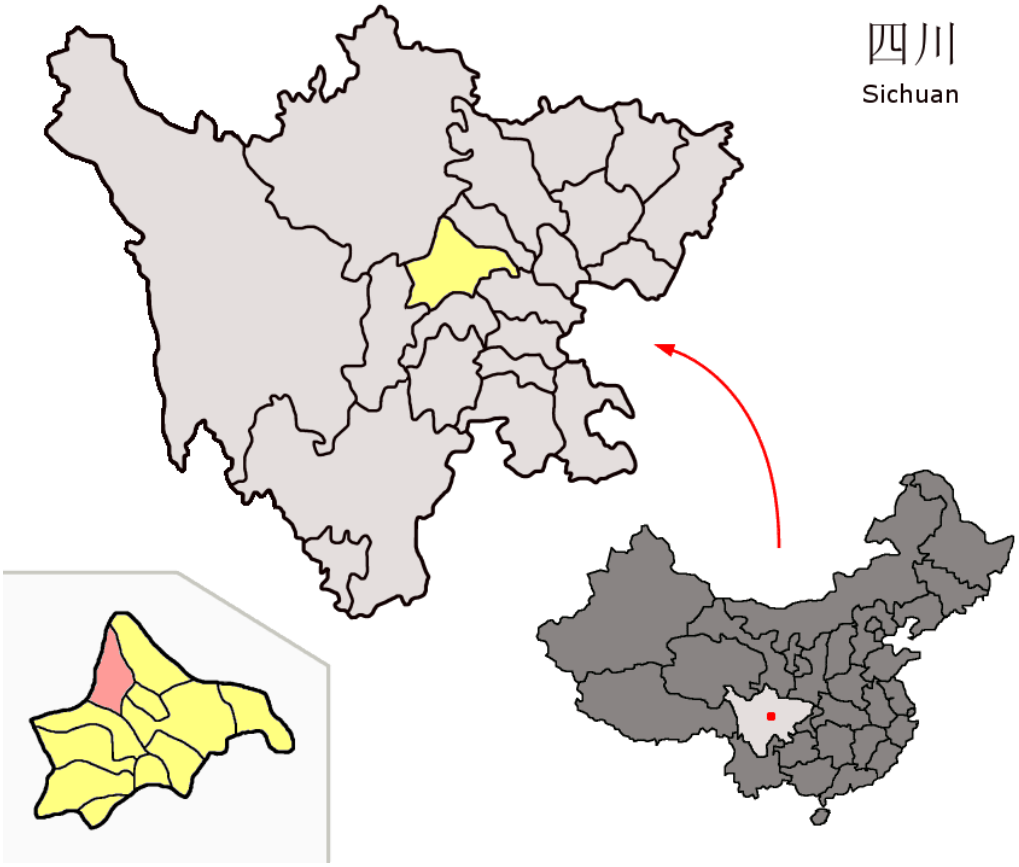


Figure 2. Location of Dujiangyan District in Sichuan Province and China.

The economy, transportation, and environment of this region have been significantly affected in the past 20 years by the 2008 Wenchuan earthquake (magnitude 8) and the 2017 Jiuzhaigou

earthquake (magnitude 7). Additionally, during the COVID-19 pandemic, the infection rate in Sichuan Province, to which Dujiangyan district belongs, was 63.52% (Sichuan Provincial Center for Disease Control and Prevention, 2022). Therefore, the contrast in genotypical hazard characteristics, such as relative loss impact, recurrence, and unfamiliarity related to previous experiences, could be significant. Correspondingly, the participant recruitment for this study was conducted both online (through Xiaohonngshu and Weibo platform) and on-site, targeting residents of the Dujiangyan area (Figure 3).

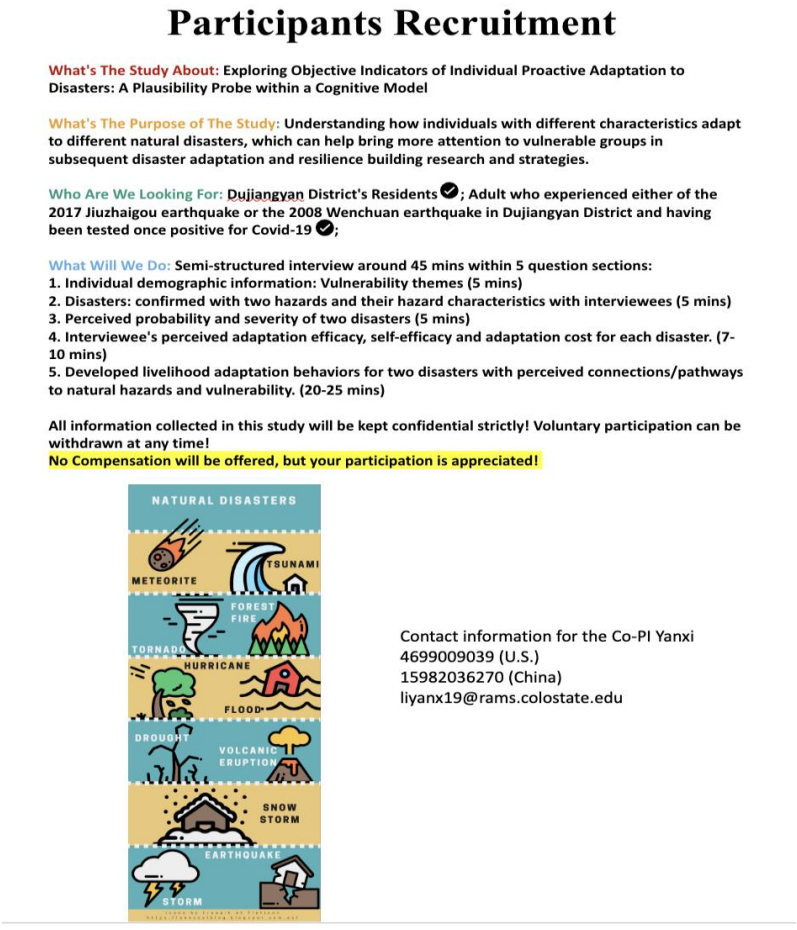


Figure 3. Participants recruitment flyer.

The inclusion criteria for interview participants were developed based on the consideration of social and ecological dimensions described above. Simply put, the inclusion criteria for the social dimension require ensuring that the final sample set has adequate distribution across each vulnerability index sector. During the sampling process, we continuously monitored the status of the existing samples and adjusted the subsequent selection through a screening process. Each potential participant was asked to complete the screening questions about their self-reported vulnerable conditions for the selection (Appendix IIIA).

Among the 27 samples ultimately collected, excluding the 6 in the control group without any self-reported vulnerabilities, 9 participants have self-reported vulnerable conditions in the socioeconomic status sector; 17 participants have self-reported vulnerable conditions in the housing and transportation sector; 8 participants have self-reported vulnerable conditions in the household characteristic sector. A single case may meet multiple vulnerability conditions, for which this study did not impose any restrictions. The inclusion criteria for the ecological dimension are more straightforward. The participants must have experienced both an earthquake and a pandemic. We define "experience" as being present in Dujiangyan during the 2008 Wenchuan earthquake or the 2017 Jiuzhaigou earthquake and agree that the earthquake had a significant impact on their daily lives at the time; additionally, they must have contracted COVID-19 at least once during the pandemic and followed the local government's COVID-19 prevention requirements for at least two weeks. Finally, we conducted semi-structured interviews with 27 eligible participants. Through real-time monitoring of the data, we found that data saturation was achieved at the 24th sample. This means that the newly collected data started to repeat information already encoded in previous samples (Hennink & Kaiser, 2022). For this study, this indicates that from the 24th sample onwards, no new objective indicators or their

influence paths on subjective perception were proposed. To ensure data saturation, we continued to collect 3 additional samples after the 24th sample. The repetitive coding information from these 3 samples confirmed the saturation of the data. Table 1 summarizes the relevant details of these 27 interviewees.

For this plausibility probe case study with exploratory purpose, semi-structured interviews was employed. Since Leech (2002) states that semi-structured interviews with open-ended questions are best utilized as a source of insight to explore new factors, this study will explore the following theoretical assumption: individual vulnerability and hazard characteristics, as social and ecological conditions, could be identified as viable indicators in different adaptation stages. For exploratory purposes, the semi-structured interviews will use subjective adaptation stages or terms as the interview framework. Each subjective adaptation factor will be used as a starting point of prompt questions (Appendix IVA). We will question the interviewees to learn their consideration process related to each adaptation subjective factor. The detail will help identify which indicators they consider valuable within their perceptions.

All recruitment documents and the interviews for this study were conducted in the local dialect or Mandarin. The initial data coding was carried out by this study's bilingual researcher, and the final coding results were analyzed and organized in English. Out of respect for the wishes of the interview participants, 17 of the 27 samples retained the original audio recordings, while the remaining 10 samples retained handwritten interview notes. Fifteen samples were collected through face-to-face interviews with onsite recruited respondents, and the remaining 12 samples were collected through voice call interviews with online recruited respondents. All 27 interview samples used in this study received verbal informed consent from the respondents, and the

informed consent form was reviewed in written format by each participant before the interview began.

2.3.2 Plausibility probe

The study aims to compare these 27 cases to empirically explore the validity and feasibility of the assumption that incorporating the SES perspective into the measurement of individual proactive adaptation. To systematically complete this comparative case study, we used the same analysis structure (coding indicators) in all 27 cases to see if the evidence confirmed our core assumptions. Clearly, using just these 27 cases makes it difficult to thoroughly test the hypothesis concerning the validity of the correlation between social and natural dimensional indicators and individual adaptation. Therefore, our goal is to perform a 'plausibility probe.' Based on our current limited experience, this will assess whether the proposed theoretical assumptions hold enough significance to warrant further, more rigorous testing.

As suggested by Eckstein (1975) "If studies of well-selected cases, no less than comparative studies, can serve the purposes of plausibility probes (the idea of which is, after all, to form estimates of probable validity), could they not also serve, painstakingly selected and rigorously carried out, as tests of validity itself, with similar economies in the work required?". Given our adoption of a purposeful sampling design for data collection and the implementation of a systematic coding framework, we are confident that the 27 meticulously chosen and methodologically sound cases in our study can closely simulate the effect of actually testing the validity of hypotheses. The uniform application of a coding analysis framework across each case can enhance our insight into the possible frequency distribution of subset assumptions. This

approach allows us to ascertain whether the emergence of social or ecological dimensional indicators at various adaptation stages is consistently supported across the sample or remains confined to specific cases. Following the logic of Plausibility probe, hypotheses that have gained widespread support should be subjected to further exploration in a broader set of case samples. Therefore, we suggest that future research should focus on these assumptions.

2.3.3 Analysis

In this study, we adopted a mixed deductive thematic and inductive content analysis to code the initial interview data for a focused exploratory analysis (Kiger & Varpio, 2020; Puppis, 2019). First, we used the CMIPAD model, derived from widely adopted behavioral theories and models, as the theoretical framework to support deductive coding (Duval & Mulilis, 1999; Grothmann & Patt, 2005; Najafi, 1999; Lindell & Perry, 2012; Rogers, 1975 and 1983). Based on the cognitive paths proposed in the CMIPAD framework, several key themes for deductive coding were identified. These themes are centered around the subjective determinants of adaptation cognition that have been validated in current literature (Grothmann & Patt, 2005; Rogers, 1975 and 1983).

Firstly, from a top-down deductive perspective, the two main appraisal stages in adaptation cognition: disaster risk appraisal and disaster adaptation appraisal were identified as the highest-level themes in deductive coding. The disaster risk appraisal stage includes perceived severity and perceived probability, and the disaster adaptation appraisal stage includes perceived adaptation efficacy, perceived self-efficacy, and perceived adaptation cost, which were used as the next level of themes. This study is exploratory in nature, so we were uncertain how the proposed objective indicators, individual vulnerability and hazard characteristics, would be

presented in each appraisal sector. Therefore, this part of the coding will involve mixed inductive content analysis, where we will simplify complex raw data to identify contents related to individual vulnerability and hazard characteristics, and ultimately summarize them into content units with common features. Simultaneously, we will use deductive analysis to categorize them under themes of individual vulnerability or hazard characteristics. Finally, we systematically reviewed 27 cases using this unified coding scheme. Table 2 summarizes these codes by theme.

Table 2. Overview of coded elements.

Theme: Stages	**Coding Indicators**	**Summary description of coding (Grothmann & Patt, 2005; Li et al.)**
Perceived Severity	Vulnerability	When individuals assess the potential harm natural disasters might inflict on them based on their experiences with similar threats in the past, are the vulnerability and hazard characteristics considered as indicators?
	Hazard Characteristic	
Perceived Probability	Vulnerability	When individuals evaluate the likelihood of being harmed in future disasters based on various conditions, are the vulnerability and hazard characteristics incorporated as indicators?
	Hazard Characteristic	

Perceived Adaptation Efficacy	Vulnerability Hazard Characteristic	When individuals evaluate the effectiveness of adaptive actions in protecting themselves, are the vulnerability and hazard characteristics included as indicators?
Perceived Self-Efficacy	Vulnerability Hazard Characteristic	When individuals assess their capability to implement these adaptive behaviors, are the vulnerability and hazard characteristics considered as indicators?
Perceived Adaptation Cost	Vulnerability Hazard Characteristic	When individuals evaluate the costs associated with these adaptive response measures, are the vulnerability and hazard characteristics considered as indicators?

In the analysis process, the examination of the viability of objective indicators depends on whether the identified objective indicator effectively participates in the cognitive process. The deductive analysis framework determined above plays a crucial role here. If a vulnerability condition or hazard characteristic is only vaguely mentioned during the interview without sufficient description to support a clear association with a specific appraisal sector, it will be considered invalid during coding. An example of validity in the sample is: a respondent, while sharing their views on the perceived adaptation cost of long-period evacuation as an earthquake adaptation behavior, explicitly stated that the lack of a private car, a vulnerability condition,

increased the time and monetary costs for long-period evacuation during an earthquake (T17, personal communication, March 11, 2024). Overall, the evaluation of viability determined whether an identified objective indicator would be included in the final coding results.

2.4 Results

We ultimately collected 27 interview samples, with interview times ranging from 36 minutes and 8 seconds to 55 minutes and 46 seconds, with a median interview time of 45 minutes and 27 seconds. The following summarizes the research findings based on the rich information contained in this sample set.

To address our general assumption (Table 3), do individual vulnerability and hazard characteristics, viewed as social and ecological indicators, participate as a viable indicator in different perceptual stages of individual proactive adaptation? Overall, in all 27 cases (100%), hazard characteristics were considered at least once as viable indicators during the adaptation appraisal stages. However, individual vulnerability was considered as viable indicator in only 22 cases (81.5%) throughout these stages. The five cases that did not mention individual vulnerability were selected purposefully through the sampling phase, which are respondents who did not report any vulnerable conditions themselves. Considering under the context, we can conclude that in all cases with reported vulnerabilities, individual vulnerability was considered 100% of the time as a viable indicator during the individual adaptation appraisal stages.

Table 3. General Findings.

Theme: Stages	Coding Items	Percentage

			（*N* = 27）
Disaster Risk Appraisal	Perceived Severity (Subjective & Indirect Impact-Stage 1)	Vulnerability	66.7%
		Hazard Characteristics	100%
	Perceived Probability (Subjective & Indirect Impact-Stage 1)	Vulnerability	29.6%
		Hazard Characteristics	100%
Disaster Adaptation Appraisal	Perceived Adaptation Efficacy (Subjective & Indirect Impact-Stage 2)	Vulnerability	51.9%
		Hazard Characteristics	74.1%
	Perceived Self-efficacy (Subjective & Indirect Impact-Stage 2)	Vulnerability	77.8%
		Hazard Characteristics	88.9%
	Perceived Adaptation Cost (Subjective & Indirect Impact-Stage 2)	Vulnerability	63%
		Hazard Characteristics	74.1%
Sum of appraisal stages	Sum	Vulnerability	81.5%

	Hazard Characteristics	100%
Adaptation	Vulnerability	11.1%
(Subjective & Direct Connection-Stage 3)	Hazard Characteristics	33.3%

We have divided the disaster risk appraisal stage, which is the first stage of subjective perception in the individual proactive adaptation process, into two subsections according to the two appraisal factors determined by the CMIPAD framework: perceived severity and perceived probability. During the perception of disaster severity, 66.7% (18/27) of the cases considered individual vulnerability, while 100% of the cases considered hazard characteristics as viable indicators. When assessing the perceived probability of being harmed in a disaster, only 29.6% (8/27) of the cases considered individual vulnerability, but 100% of the cases considered hazard characteristics as viable indicators.

Following this, we have divided the disaster adaptation appraisal stage, the second stage of subjective perception in the individual proactive adaptation process, into three subsections according to the three appraisal factors determined by the CMIPAD framework: perceived adaptation efficacy, perceived self-efficacy, and perceived adaptation cost. When evaluating the effectiveness of adaptive actions, 51.9% (14/27) of the cases considered individual vulnerability, and 74.1% (20/27) considered hazard characteristics as viable indicators. When assessing individual own capability to implement these adaptation actions, 77.8% (21/27) of the cases considered individual vulnerability, and 88.9% (24/27) considered hazard characteristics as

viable indicators. Finally, when individuals assessed the costs associated with these adaptive measures, 63% (17/27) of the cases considered individual vulnerability, and 74.1% (20/27) considered hazard characteristics as viable indicators.

Beyond the two subjective perception stages, we also included an investigation into the last stage: adaptation. Specifically, we employed the same coding system to investigate whether individual vulnerability and hazard characteristics directly participated as viable indicators in the final decision-making stage of adaptation. The findings indicate that only 11.1% (3/27) of cases mentioned individual vulnerability as viable indicators, while only 33.3% (9/27) of cases mentioned hazard characteristics as viable indicators when deciding whether to implement adaptation measures.

2.4.1 Disaster Risk Appraisal

In the disaster risk appraisal, the first subjective stage of the individual proactive adaptation process, we have identified viable indicators from both individual vulnerability and hazard characteristics groups. We will now discuss in more detail based on the two adaptation subjective factors included in this stage: perceived severity and probability.

Firstly, in assessing the severity of disasters, regardless of the type of natural disaster, both vulnerability and hazard characteristics participate as viable indicators in the consideration (Table 4). However, as the type of disaster changes, the participation of specific indicators varies. For instance, in perceiving the severity of pandemics, the vulnerability aspect identified five specific indicators: 33.3% (9/27) of cases considered their transportation situations, 22.2% (6/27) considered household characteristics, 11.1% (3/27) each considered housing conditions

and health conditions, and 7.4% (2/27) considered economic status. On the hazard characteristics side, four specific indicators were identified: 85.2% (23/27) of cases considered the duration of impact, 59.3% (16/27) considered the scope of impact, and 11.1% (3/27) each considered the speed of onset and previous experiences for unfamiliarity.

In assessing the severity of earthquakes, another type of natural disaster, the vulnerability aspect identified four specific indicators: 22.2% (6/27) of cases considered their household characteristics, 7.4% (2/27) considered economic status, and 3.7% (1/27) each considered housing conditions and health conditions. The hazard characteristics side identified the same four specific indicators: 55.6% (15/27) of cases considered the duration of impact, 48.1% (13/27) considered the speed of onset, 18.5% (5/27) considered the scope of impact, and 3.7% (1/27) considered previous experiences of relative loss impact.

Table 4. Findings in Perceived Severity Sector.

Theme: Stages	**Disasters**	**Coding Items**	**Indicators**	**Percentage (*N* = 27)**
<u>Disaster Risk</u>	Pandemic (Covid-19)	Vulnerability	Transportation	33.3%
<u>Appraisal</u>			Housing (Rent)	11.1%
			Economic Status	7.4%
Perceived Severity			Health Condition	11.1%

(Subjective & Indirect Connection-Stage 1)	Earthquake	Vulnerability	Household Characteristic	22.2%
			Large Scope	59.3%
		Hazard Characteristics	Large Duration	85.2%
			Slow Onset	11.1%
			Previous Experiences: unfamiliarity	11.1%
			Health Condition	3.7%
		Vulnerability	Household Characteristic	22.2%
			Housing (Rent)	3.7%
			Economic Status	7.4%
		Hazard Characteristics	Fast Onset	48.1%
			Short Duration	55.6%
			Small Scope	18.5%

	Previous Experiences: relative loss impact	3.7%

In the investigation of another term of the disaster risk appraisal stage—perceived probability—we have an interesting finding (Table 5). When asking participants to evaluate their likelihood of being harmed in future disasters, individual vulnerability is less frequently considered compared to hazard characteristics. Additionally, compared to another subjective factor, perceived severity, there are some changes in the indicators of hazard characteristics considered, with some new indicators emerging. This pattern is evident across two types of natural disasters.

Firstly, when perceiving the probability of harm from a pandemic, only two indicators of individual vulnerability were considered: 18.5% (5/27) of cases considered household characteristics, and 3.7% (1/27) mentioned health conditions. On the hazard characteristic side, four specific indicators were identified: 74.1% (20/27) of cases considered previous experiences of relative loss impact, 44.4% (12/27) considered broader ecological changes as stimuli for major disasters, 33.3% (9/27) considered previous experience of recurrence, and 7.4% (2/27) considered the speed of onset.

The same individual vulnerability indicators are included in the perception of both disasters. When perceiving the probability of a pandemic: 11.1% (3/27) of cases considered household characteristics, and 7.4% (2/27) mentioned health conditions. The four hazard characteristic indicators mentioned in the pandemic aspect were also considered in the earthquake aspect: 48.1% (13/27) of cases considered both previous experience of recurrence and the speed of

onset, 44.4% (12/27) considered previous experiences of relative loss impact, 37% (10/27) considered a new indicator, the geographic location of the seismic zone, and finally, 3.7% (1/27) considered broader ecological changes as stimuli for major disasters.

Table 5. Findings in Perceived Probability Sector.

Theme: Stages	**Disasters**	**Coding Items**	**Indicators**	**Percentage (*N* = 27)**
Disaster Risk Appraisal	Pandemic (Covid-19)	Vulnerability	Health Condition	3.7%
			Household Characteristic	18.5%
		Hazard Characteristics	Environmental Issues Facilitate Viruses Emergence	44.4%
Perceived Probability (Subjective & Indirect Connection-Stage 1)			Previous Experiences: relative loss impact	74.1%
			Previous Experience: recurrence	33.3%
			Slow onset	7.4%
	Earthquake	Vulnerability	Health Condition	7.4%
			Household Characteristic	11.1%
		Hazard Characteristics	Geographic Location: Seismic zone	37%

	Previous Experience: recurrence	48.1%
	Fast Onset	48.1%
	Previous Experiences: relative loss impact	44.4%
	Environmental Facilitate the Emergence of More Severe Geological Hazards	3.7%

2.4.2 Disaster Adaptation Appraisal

If the risk appraisal stage focuses primarily on the risks associated with environmental changes, the adaptation appraisal stage shifts attention back to the individuals undertaking adaptation actions. We will now discuss our findings in this stage following the three subjective factors included in the adaptation appraisal stage: perceived adaptation efficacy, perceived self-efficacy, and perceived adaptation cost.

When respondents assessed the efficacy of adaptation behaviors during a pandemic, three indicators of individual vulnerability were included in the consideration (Table 6): 30% (8/27) of cases considered their transportation situations, 26% (7/27) considered household characteristics, and 7.4% (2/27) considered housing conditions. Two hazard characteristic indicators were

included: 3.7% (1/27) of cases each considered previous experiences of relative loss impact and the duration of impact.

Unlike in pandemics, during earthquakes, although only one hazard characteristic indicator—the speed of onset—was considered in 66.7% (18/27) of cases, but it was more frequently considered compared to the two included vulnerability indicators: household characteristics were considered in 22.2% (6/27) of cases and health conditions in 3.7% (1/27) of cases. This reflects a distinct pattern in the emphasis on different types of indicators depending on the nature of the disaster and the specific adaptive actions being evaluated.

Table 6. Findings in Perceived Self-efficacy Sector.

Theme: Stages	**Disasters**	**Coding Items**	**Indicators**	**Percentage (*N* = 27)**
Disaster Adaptation Appraisal Perceived Adaptation Efficacy (Subjective & Indirect	Pandemic (Covid-19)	Vulnerability	Household Characteristics	26%
			Transportation	30%
			Housing (Rent)	7.4%
		Hazard Characteristics	Previous Experiences: relative loss impact	3.7%
			Long Duration	3.7%
	Earthquake	Vulnerability	Household Characteristic	22.2%

Connection -Stage 2)		Health Condition (Mobility)	3.7%
	Hazard Characteristics	Fast Onset	66.7%

Through the assessment of an individual's self-efficacy in adaptation, the consideration of individual vulnerability and hazard characteristics has shown significant disparities across different disaster contexts. Compared to hazard characteristics, a broader range of individual vulnerability indicators has been incorporated in this section (Table 7). Initially, in the context of a pandemic, five pre-defined vulnerability indicators were considered: economic status and household characteristics, each mentioned in 22.2% (6/27) of the cases, 18.5% (5/27) considered their housing situation, 15% (4/27) considered the transportation situation, and the final case (3.7%) mentioned health condition. Only two indicators of hazard characteristics were considered: 11.1% (3/27) of the cases considered the duration of impact, and 3.7% (1/27) considered the speed of onset.

In the context of earthquakes, the consideration of individual vulnerability and hazard characteristics differed significantly from that in the pandemic context. Only three individual vulnerability indicators were deemed viable for assessing self-efficacy: 30% (8/27) of the cases considered household characteristics, 22.2% (6/27) considered transportation conditions, and 3.7% (1/27) considered health conditions. Regarding hazard characteristics, an individual's specific geographic location, being in a seismic zone, was a prominently discussed indicator in 81.5% (22/27) of the cases, and 26% (7/27) considered the speed of onset. Overall, in both

disaster contexts, a broader range of individual vulnerabilities as viable indicators were involved in self-efficacy assessments, but the nature of disasters still introduced noteworthy differences.

Table 7. Findings in Perceived Self-efficacy Sector.

Theme: Stages	**Disasters**	**Coding Items**	**Indicators**	**Percentage (*N* = 27）**
<u>Disaster Adaptation Appraisal</u> **Perceived Self-efficacy (Subjective & Indirect Connection-Stage 2)**	Pandemic (Covid-19)	Vulnerability	Health Condition	3.7%
			Household Characteristic	22.2%
			Transportation	15%
			Housing (Rent)	18.5%
			Economic Status	22.2%
		Hazard Characteristics	Slow Onset	3.7%
			Long Duration	11.1%
	Earthquake	Vulnerability	Household Characteristic	30%
			Health Condition	3.7%
			Transportation	22.2%
		Hazard Characteristics	Geographic Location: Seismic Zone	81.5%

			Fast Onset	26%

Similar to the assessment of self-efficacy, when evaluating the perceived cost for adaptation, a broader range of vulnerability indicators participate in the consideration compared to hazard characteristics (Table 8). When assessing the cost of adaptation in the context of a pandemic, four viable individual vulnerability indicators were identified: 33.3% (9/27) of the cases considered their transportation situation, 18.5% (5/27) considered economic status, 15% (4/27) considered household characteristics, and 7.4% (2/27) considered health conditions. In terms of hazard characteristics, two viable indicators were identified: 52% (14/27) of the cases considered the duration of impact, and 3.7% (1/27) considered the scope of impact.

Switching to the context of an earthquake, only two viable individual vulnerability indicators were identified: 15% (4/27) of the cases mentioned household characteristics and economic status. Regarding hazard characteristics, only one indicator was considered: the duration of impact, which was included in the consideration of one case (3.7%). Here, we can see that the included indicators still vary depending on the nature of the natural disaster.

Table 8. Findings in Perceived Adaptation Cost Sector.

Theme: Stages	**Disasters**	**Coding Items**	**Indicators**	***Percentage* (*N* = 27)**
Disaster Adaptation Appraisal	Pandemic (Covid-19)	Vulnerability	Household Characteristic	15%

Perceived Adaptation Cost (Subjective & Indirect Connection-Stage 2)	Earthquake	Hazard Characteristics	Transportation	33.3%
			Economic Status	18.5%
			Health Condition	7.4%
			Long Duration	52%
			Large Scope	3.7%
		Vulnerability	Household Characteristic:	15%
			Economic Status	15%
		Hazard Characteristics	Short Duration	3.7%

Lastly, we have applied the same coding system to discuss the direct involvement of individual vulnerability and hazard characteristics as viable indicators in the final adaptation decision stage (Table 9). Overall, for individual's proactive adaptation these two subjective aspects were not frequently considered as viable indicators in the consideration of whether to undertake adaptation measures. We found this phenomenon to be consistent across different disaster contexts. In the case of the pandemic: a total of three individual vulnerability indicators were discussed: 3.7% (1/27) of the cases considered economic status and health condition, while 18.5% (5/27) of the cases considered household characteristics. In terms of hazard characteristics, only the duration of impact was considered as a viable indicator by 18.5% (5/27) of the cases in the final

adaptation decision-making process. In the earthquake scenario, only a few objective indicators were directly considered: 11.1% (3/27) of the cases considered household characteristics, and 3.7% (1/27) considered health conditions. Finally, on the hazard characteristic side, 22.2% (6/27) of the cases discussed the speed of onset.

Table 9. Findings in Direct Adaptation Stage.

Theme: Stages	**Disasters**	**Coding Items**	**Indicators**	**Percentage (*N* = 27)**
<u>Adaptation</u> **(Subjective & Direct Connection-Stage 3)**	Pandemic (Covid-19)	Vulnerability	Economic Status	3.7%
			Health Condition	3.7%
			Household Characteristic	18.5%
		Hazard Characteristics	Long Duration	18.5%
	Earthquake	Vulnerability	Health Condition	3.7%
			Household Characteristic	11.1%

	Hazard Characteristics	Fast Onset	22.2%

2.5 Conclusion

In this paper, we compared 27 proactive individual adaptation cases collected through semi-structured interviews to empirically explore the validity of theoretical assumptions regarding the involvement of individual vulnerability and hazard characteristics as viable subjective indicators at different adaptation appraisal stages. Consequently, this study aims to advance the consideration and emphasis on social and ecological dimensions in the research of proactive individual adaptation by implementing a preliminary simple investigation with plausible probe.

Our study builds upon the MPPACC framework and Protection Motivation Theory by identifying viable objective indicators of individual vulnerability and hazard characteristics associated with risk and adaptation appraisal (Grothmann & Patt, 2005; Rogers, 1975, 1983). These indicators represent linked social and ecological dimensions within any complex system in which disasters may arise. Meanwhile, previous studies have also identified subjective factors within such systems, including perceived severity and perceived probability for measuring risk appraisal, and perceived adaptation efficacy, perceived self-efficacy, and perceived adaptation cost for measuring adaptation appraisal.

The 27 cases assessed here were too few to merit conducting empirical (statistical) tests or making broad theoretical generalizations. However, these selected cases cover common conditions of individual vulnerability lists in SOVI (Cutter et al., 2003) while providing contrasts

in the disasters through contrastive hazard characteristics developed by Barton (1969) and Quarantelli (1993 & 1998). This allows us to explore the validity of hypotheses under different natural disasters and individual vulnerability conditions. Although we cannot verify causal relationships, we can identify and discuss the associations and patterns observed in the cases.

First, it is noteworthy that individual vulnerability and hazard characteristics are identified as viable indicators within the evaluation process of each subjective factor across risk and adaptation appraisal stages (Table 3). Although we did not explicitly observe this phenomenon in all the 27 included cases, variations in the results could stem from not integrating the internal and external baseline conditions of each case. However, overall, these 27 cases considered individual vulnerability and hazard characteristics at least once during the subjective appraisal stages. These insights confirm the observation that individual vulnerability and hazard characteristics participate as viable indicators in the cognitive process of individual proactive adaptation, aligning with Grothmann & Patt's (2005) recognition in the MPPACC framework of the importance of considering objective indicators in the subjective cognitive process.

In addition to identifying individual vulnerability and hazard characteristics considered in subjective appraisal stages, we also attempted to identify the direct participation of objective indicators in the final decision stage "adaptation" of the cognitive process. Compared to the number of cases that objective indicators directly participated in the final adaptation decision, more cases present that objective indicators are more often included in the adaptation cognitive process through participation in subjective appraisals. In cases where objective indicators directly participate in the final adaptation decision, the considered individual vulnerability or hazard characteristic typically has a strong decisive impact on the cognitive outcome. For

example, participants with previous health conditions or mobility issues often directly reject emergency evacuation and other rapid-action adaptation measures. However, while most current literature tends to consider the direct correlation of objective indicators on individual's proactive adaptation decision (Hoang-Thi et al., 2023; Hu et al., 2022; Li et al.; Mayer et al., 2020;), this study allows us to better identify at which stage of the cognitive process objective indicators have participated.

After confirming the plausibility of individual vulnerability and hazard characteristics as viable objective indicators participating in each subjective appraisal, we further explored the extent of their involvement in each subjective factor. In existing research on the adaptation cognition process, considerations of vulnerability and hazard characteristics tend to be general, typically focusing on the involvement of a single dimension in the risk appraisal or adaptation appraisal stage. However, more detailed analyses and comparisons of the involvement in each perception sector are lacking (Budhathoki et al., 2020; Pan, 2016; Zhao et al., 2022). Initially, in the risk appraisal stage, particularly regarding the perception of severity, the distribution of vulnerability and hazard characteristic indicators was average. Both dimensions were extensively considered, and the variation of indicators were evident in both vulnerability and hazard characteristic dimensions. However, when evaluating the perception of probability, a noticeable disparity occurred in the participation of vulnerability and hazard characteristic dimensions, with a more diverse range of hazard characteristics being incorporated as viable indicators compared to individual vulnerability. Overall, all cases demonstrated that hazard characteristics participated as objective indicators in both perception steps of the risk appraisal stage, whereas the participation rate of individual vulnerability was not as high as it.

In the adaptation appraisal stage, the evaluation of the three subjective factors showed a more diverse consideration of the vulnerability dimension compared to hazard characteristic. Particularly notable in the perception term of self-efficacy where the focus on vulnerability indicators was especially prominent. However, certain hazard characteristic indicators, such as geographic location in seismic zones and fast onset, were included in many cases. These insights confirm the observation that the two appraisal stages may place different emphases on individual vulnerability and hazard characteristic dimensions. Vulnerability and hazard characteristics do not equally participate in considering each subjective factor. During the risk appraisal stage, perceptions focus more on hazard characteristics, which are considered in every case. Conversely, the individual vulnerability dimension is the primary consideration in the perceptions of the adaptation appraisal stage, hence a more diverse range of vulnerability indicators are discussed.

As we mentioned previously, some specific indicators distinct from the general pattern we summarized. For example, in the adaptation appraisal stage, hazard characteristics such as geographic location in seismic zones and fast onset, and in the risk appraisal stage such as long duration, are exceptions. These three hazard characteristic indicators are considered in over 80% of the cases within their respective subjective factors, which is significantly higher compared to other indicators. Geographic location in seismic zones and fast speed of onset are hazard characteristics specific to earthquakes, representing the most significant and representative nature of earthquakes as disasters. Similarly, the long duration of impact is the most significant and representative hazard characteristic of pandemics. This identified phenomenon suggests that the potential impact of different natural disasters on the adaptation cognitive process can be more accurately measured and anticipated by identifying the involved hazard characteristic indicators.

In a previous systematic review (Li et al.), it was also pointed out that most current studies on individual disaster adaptation have included genotypical hazard characteristics as valuable indicators for adaptation assessment. However, the coverage of hazard characteristics in these studies is not comprehensive, with most existing research tending to include only the most obvious and representative characteristics.

Additionally, hazard characteristic indicators related to past experiences, such as relative loss impact, recurrence, and unfamiliarity, are notable special indicators. These indicators primarily appear in the perceptions of the risk appraisal stage, indicating a potential association with past disaster experiences and highlighting that the cognitive process of adaptation is not a one-time event but a cyclical process. Previous adaptation outcomes continuously influence future adaptations. This is also consistent with the cyclic nature of adaptation cognition emphasized by the CMIPAD model adopted in this study, where experiences influence an individual's future cognition (Li et al.).

Finally, we found that in almost every subjective factor, vulnerability indicators are considered more extensively in the context of pandemics compared to earthquakes. For instance, all five vulnerability conditions included in this study—household characteristic, housing situation, health condition, transportation situation, and economic status—have been considered at least once as viable indicators in the evaluation of subjective factors within the context of a pandemic. However, for earthquakes, the vulnerability indicator of housing situation is not mentioned at all in the appraisal stages. This reveals that the consideration of vulnerability indicators varies based on the natural disaster, and not all existing vulnerability indicators will be considered in the adaptation cognitive process. Furthermore, we can propose a new hypothesis that might be worth

testing in future studies: each Individual vulnerability, as the internal sensitivity of the social system, is more likely to be exposed in certain natural disasters, such as pandemics. In recent years, some empirical studies have also started to consider the combined impact of vulnerability and hazard characteristic indicators on adaptation cognition or perception determinants (Budhathoki et al., 2020; Gumasing & Sobrevilla, 2023; Kurata et al., 2022). Therefore, there could be potential interactions between the vulnerability and hazard characteristic dimensions. This also suggests that it is necessary for future research aiming to more accurately track and analyze the adaptation cognition process to understand the interaction between these two objective dimensions.

2.6 Limitations

As an exploratory study, this research contains theoretical, analytical, and methodological constraints and data collection challenges. We hope these limitations can provide some insights and reflections for future research.

Firstly, the theoretical limitations of this study are mainly associated with the scope of the theoretical framework. The CMIPAD model adopted in this study focuses only on adaptation cognition related to individual behavior. Due to limited resources and time, the study did not extend to more macro-level adaptive behaviors, such as government, social and institutional adaptation behaviors, etc. In SES thinking, SES is considered a mega system, where the cross-impact of more macro systems on their subordinate systems is emphasized (Berkes et al., 2003). Therefore, the CMIPAD model used in this study lacks consideration of macro factors that might affect individuals, which can be improved in future research.

Additionally, there are certain analytical limitations in this study. To have a clearer focus, individual vulnerability and hazard characteristics, as indicators representing social and ecological dimensions, were used in the CMIPAD model and analysis. As SES thinking emphasizes, the system and adaptation itself are very complex. While individual vulnerability and hazard characteristics might be the most representative and prominent indicators, other relevant indicators certainly exist and were not discussed in this study.

Methodologically, this study also has constraints, the most obvious being related to sampling. Due to accessibility and feasibility considerations, the sample in this study consisted entirely of individuals from a specific region (Dujiangyan, China), which may limit the generalizability of the findings to other regions. Therefore, future research should expand sampling to a broader range of regions, especially considering areas with different characteristics such as economic development, population structure, geographic location, culture, and government structure, etc. Moreover, the small sample size with only 27 cases limits the ability to generalize the findings to a broader population. Therefore, future research should not only diversify regions but also increase the sample size. This might encounter data collection challenges associated with language, connection, regulations, etc., so cross-regional cooperation should be encouraged.

THESIS CONCLUSION

The themes and findings identified in this thesis are foundational for advancing the understanding of individual proactive adaptation and for emphasizing the importance of objective indicators in the cognitive process. The study utilized individual vulnerability and characteristics of natural hazards as the two major objective indicators representing social-ecological dimensions, based on current literature and theory integrated with socio-ecological systems thinking. The two studies presented here provide extensive, structured insights into both subjective and objective indicators of individual proactive adaptation. Findings indicate that both subjective and objective indicators participate in the cognitive process of whether an individual decides to take proactive measures. Consistent with existing models of adaptation cognition and decision-making, subjective factors often serve as decisive elements that directly influence adaptation cognition and decision (Duval & Mulilis, 1999; Grothmann & Patt, 2005; Lindell & Perry, 2012; Najafi, 1999; Rogers, 1975, 1983). However, a review of the literature suggests that the involvement of objective indicators in the cognitive process may be greater than depicted in current theoretical models.

Study 1, through a systematic review, assessed how subjective factors and objective indicators were understood and applied in previous studies of individual adaptation. A key finding was that researchers previously considered both subjective factors derived from Protection Motivation Theory and objective factors tied to individual vulnerability and hazard characteristics as crucial components of individual proactive adaptation in numerous studies. However, most existing studies only simplistically consider the direct associations and interactions between subjective and objective factors with adaptation cognition. More specifically, few studies acknowledge or

incorporate the indirect pathways proposed in our newly developed cognitive model (MMPACC), which highlights ways that both objective and subjective indicators interact to influence adaptation cognition.

In view of these gaps, Study 2 conducted a plausibility probe to further explore assumptions around the participation of objective indicators in the new cognitive model proposed in Study 1. Findings confirmed the validity of the assumption that objective indicators, such as individual vulnerability and hazard characteristics, indeed serve as viable indicators that should be considered alongside subjective factors at each appraisal stage. Study 2 thus revealed that objective indicators are likely involved at all stages of the cognitive process of adaptation more than the literature reviewed in Study 1 might suggest. Therefore, it is meaningful and necessary to further test the complex interactions between objective and subjective indicators. These fundamental objective indicators can serve as primary entry points for designing measures to strengthen individual proactive adaptation. More specifically, measures targeting these direct-impact objective factors are more likely to achieve significant effectiveness in promoting and enhancing individual disaster adaptation capabilities.

In view of these gaps, Study 2 conducted a plausibility probe to further explore assumptions around the participation of objective indicators in the new cognitive model proposed in Study 1. Findings confirmed the validity of the assumption that objective indicators, such as individual vulnerability and hazard characteristics, indeed serve as viable indicators that should be considered alongside subjective factors at each appraisal stage. Study 2 thus revealed that objective indicators are likely involved at all stages of the cognitive process of adaptation more than the literature reviewed in Study 1 might suggest. Therefore, it is meaningful and necessary

to further test the complex interactions between objective and subjective indicators. These fundamental objective indicators can serve as primary entry points for designing measures to strengthen individual proactive adaptation. More specifically, measures targeting these direct-impact objective factors are more likely to achieve significant effectiveness in promoting and enhancing individual disaster adaptation capabilities.

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APPENDICES

Appendix I: Search strategy

Database	Final Complete Search Design
PubMed (Medline)	("models, theoretical"[MeSH Terms] OR "Principal Component Analysis"[MeSH Terms] OR "Model"[Title/Abstract] OR "Pathway"[Title/Abstract] OR "Framework"[Title/Abstract]) AND "english"[Language] AND (("Vulnerable Populations"[MeSH Terms] OR "Vulnerability"[Title/Abstract] OR "Vulnerable"[Title/Abstract]) AND ("humans"[MeSH Terms] AND "english"[Language])) AND (("Natural Disasters"[MeSH Terms] OR "Earthquake"[Title/Abstract] OR "Pandemic"[Title/Abstract] OR "Drought"[Title/Abstract] OR "Volcano"[Title/Abstract] OR "Flood"[Title/Abstract] OR "Storm"[Title/Abstract] OR "Tornado"[Title/Abstract] OR "Tsunami"[Title/Abstract] OR "Landslide"[Title/Abstract] OR "Wildfire"[Title/Abstract] OR "extreme weather"[Title/Abstract]) AND ("humans"[MeSH Terms] AND "english"[Language])) AND (("Capacity Building"[MeSH Terms] OR "resilience, psychological"[MeSH Terms] OR "Risk Reduction Behavior"[MeSH Terms] OR "Disaster Planning"[MeSH Terms] OR "adaptation disaster"[Title/Abstract] OR "disaster adaptation"[Title/Abstract] OR "disaster adapted"[Title/Abstract] OR "disaster resilience"[Title/Abstract] OR "disaster resilient"[Title/Abstract] OR "hazard adapted"[Title/Abstract] OR "hazard resilience"[Title/Abstract] OR "hazard resilient"[Title/Abstract]) AND "english"[Language]
Web of Science	TS= (Model OR Pathway OR Framework) AND TS=(Adaptation disaster OR disaster adaptation OR disaster adapted OR disaster resilience OR disaster resilient OR hazard adapted OR hazard resilience OR hazard resilient) AND TS= (Earthquake OR Flood OR pandemic OR storm OR drought OR volcano OR tornado OR tsunami OR wildfire OR landslide OR extreme weather) AND TS=(vulnerability OR Vulnerable)
Academic Search Ultimate	(DE (“DISASTER resilience”) OR AB (adaptation OR adaptive behavior OR adapting OR adapted OR adaptability OR adapting) OR TI (adaptation OR adaptive behavior OR adapting OR adapted OR adaptability OR adapting)) AND (DE (“NATURAL disasters”) OR AB (Earthquake OR Flood OR pandemic OR storm OR drought OR volcano OR tornado OR tsunami OR wildfire OR landslide OR extreme weather)

	OR TI (Earthquake OR Flood OR pandemic OR storm OR drought OR volcano OR tornado OR tsunami OR wildfire OR landslide OR extreme weather)) AND (DE (“PSYCHOLOGICAL vulnerability” OR "Sociocultural Factors") OR AB (Vulnerability OR vulnerable) OR TI (Vulnerability OR vulnerable)) AND (AB (model OR pathway OR framework) OR TI (model OR pathway OR framework))
APA PsycInfo	(DE (“Coping Behavior”) OR AB (adaptation OR adaptive behavior OR adapting OR adapted OR adaptability OR adapting) OR TI (adaptation OR adaptive behavior OR adapting OR adapted OR adaptability OR adapting)) AND (AB (Earthquake OR Flood OR pandemic OR storm OR drought OR volcano OR tornado OR tsunami OR wildfire OR landslide OR extreme weather) OR TI (Earthquake OR Flood OR pandemic OR storm OR drought OR volcano OR tornado OR tsunami OR wildfire OR landslide OR extreme weather)) AND (DE ("Sociocultural Factors" OR “At Risk Populations”) OR AB (Vulnerability OR vulnerable) OR TI (Vulnerability OR vulnerable)) AND (AB (Model OR pathway OR framework) OR TI (Model OR pathway OR framework))

Appendix IIA: Informed Consent Form

Exploring Objective Indicators of Individual Proactive Adaptation to Disasters: A Plausibility Probe within a Cognitive Model

Informed Consent Form

Introduction: You are invited to participate in a research study conducted by Dr. David Knight and Yanxi Li, as part of Colorado State University, U.S. Before deciding whether to participate, it is important that you read and understand the following information about the study. Please ask any questions you may have before agreeing to participate. Your participation in this study is voluntary, and you have the right to withdraw at any time without penalty or loss of benefits.

Study Purpose: This study investigates the influence of hazard characteristics and vulnerability conditions on individual adaptation behaviors across disasters. The study applies a newly developed theory framework and utilizes mixed methods to assess Dujiangyan residents' perceptions and experiences tied to the two significant disasters they have experienced in the past 15 years (earthquake and Covid-19). By improving assessments and prediction s associated with individual post-disaster adaptation behavior, the methods and findings should support ongoing research into disasters as opportunities for cultivating more efficient adaptability and resilience in diverse vulnerability contexts.

Procedures: If you agree to participate, you will be asked to complete an online or in-person interview that includes questions about your basic demographic information, experiences and perception related to the earthquakes (either of 2017 Jiuzhaigou earthquake and 2008 Wenchuan Earthquake) and the COVID-19 pandemic, and your adaptive behaviors for these two disasters. (For interview participants) The Interview is estimated to take approximately 60 minutes to complete with 4 sections questions. (For survey participants).

Confidentiality: All information collected in this study will be kept strictly confidential. Your responses will be de-identified, for both interview and survey participants, your personally identifiable information will not be asked or stored such as name, address, contact formation, etc. As Only the research team will have access to the data, and the findings will be reported in aggregate form without identifying individual participants.

Voluntary Participation: Participation in this study is entirely voluntary and there will be no compensation for this study. You have the right to decline participation or withdraw from the

study at any time without providing a reason. Your decision to participate or not will not affect your current or future relationship with the researcher, the institution, or any associated parties.

Benefits and Risks: While there may not be any direct benefits to you personally, your participation will contribute to advancing knowledge and understanding of the experiences and impacts of natural disasters. Additionally, the information gathered may help inform future disaster response and recovery efforts. There are no known risks associated with participating in this study beyond the minimal risks typically associated with online surveys or interviews.

Data Use and Publication: The findings of this study may be published or presented at academic conferences. However, your identity will remain confidential, and any information shared will be in an aggregate form that does not identify individual participants.

Contact Information: If you have any questions or concerns about the study, you can contact Dr. David Knight (the PI of the study) at email: dkespecial79@gmail.com or David.Knight@colostate.edu or phone: 3038192769 (U.S.) Yanxi Li (the Co-PI of the study) at email: liyanx19@colostate.edu or phone: 15982036270 (China) and 4699009039 (U.S). If you have any concerns about your rights as a research participant, you can contact the Colorado State University's Research Ethics Board by email: CSU_IRB@colostate.edu.

Consent: By proceeding with the interview or survey, you indicate that you have read the above information, understood the nature of the study, and voluntarily agree to participate.

Sincerely,

David & Yanxi

Contact information for the PI Dr. David Knight

3038192769 (U.S.)

David.Knight@colostate.edu

Contact information for the Co-PI Yanxi

4699009039 (U.S.)

15982036270 (China)

liyanx19@rams.colostate.edu

Appendix IIB: Informed Consent Form (Chinese Translated)

新冠疫情和地震影响下的主动适应行为：中国都江堰地区研究

知情同意书

介绍：您被邀请参与由李彦兮作为美国科罗拉多州立大学研究生进行的一项研究。在决定是否参与之前，请您阅读并理解以下关于该研究的信息。如有任何问题，请在同意参与前提出。本研究是自愿参与，您有权在任何时候无需承担任何后果或损失的情况下退出。

研究目的：本研究旨在调查灾害特征和个体脆弱性条件对个体适应行为的影响。研究应用了新开发的理论框架，并通过访谈评估都江堰居民在过去 15 年中经历的两场重大灾害（地震和新冠疫情）的感知和体验，以及他们的适应行为。通过改进对个体灾后适应行为的评估和预测，方法和发现 lai 支持未来的研究和灾害风险缓解策略。本研究将灾害视为在不同个体脆弱性背景下培养更高效适应性和韧性的机会。

程序：如果您同意参与，您将被邀请完成一次在线或面对面的访谈，包括关于您的基本人口统计信息、与地震（2017 年九寨沟地震或 2008 年汶川地震）和新冠疫情相关的经历和感知，以及这两场灾害的适应行为的问题。访谈预计需要约 45 分钟，共有 5 个部分的问题。

保密性：本研究中收集的所有信息将严格保密。您的回答将保持匿名，对于访谈和调查参与者，不会要求或存储您的任何可识别个人信息，例如姓名、地址、联系方式等。只有研究团队能够访问数据，且研究结果将以汇总形式报告，不会识别个别参与者。

自愿参与：参与本研究完全是自愿的，并且无筹金支付。您有权拒绝参与或随时退出研究，而无需提供原因。您是否参与或不参与的决定不会影响您与研究人员、机构或任何相关方的当前或未来关系。

利益和风险：虽然您个人可能没有直接的利益，但您的参与将有助于推进对自然灾害经验和影响的了解。收集的信息可能有助于未来的灾害应对和恢复工作。此外，本研究将对您的信息进行编码，以确保没有风险暴露您的个人信息。严格的数据管理控制将防止研究团队以外的任何人未经许可访问研究数据，从而最小化数据泄露的风险。

数据使用和发布：本研究的发现可能会在学术会议上发表或展示。然而，数据将仅用于此项研究，您的访谈数据将保持保密，原始数据集不会向公众公开。

联系信息：如果您对研究有任何疑问或担忧，可以通过电子邮件 dkespecial79@gmail.com

或 David.Knight@colostate.edu 或电话 3038192769 (美国）联系项目负责人 David Knight 博士；同时也可通过电子邮件 liyanx19@colostate.edu 或电话 15982036270（中国）和 4699009039（美国）联系研究共同负责人李彦兮。如果您对作为研究参与者的权利有任何担忧，可以通过电子邮件 CSU_IRB@colostate.edu 联系科罗拉多州立大学的研究伦理委员会。

同意：继续进行访谈表示您已阅读或口头了解上述信息，理解研究的性质，并自愿同意参与。请注意，您有权拒绝参与访谈，并可随时终止访谈。同样，您有权拒绝研究团队在访谈后将您的访谈信息作为研究数据使用。

此致，

李彦兮

项目负责人 David Knight 博士联系信息

3038192769 （美国）

David.Knight@colostate.edu

项目负责人李彦兮联系信息

4699009039（美国）

15982036270（中国）

liyanx19@rams.colostate.edu

Appendix III: Participants recruitment flyer (Chinese Translated)

受访者招募

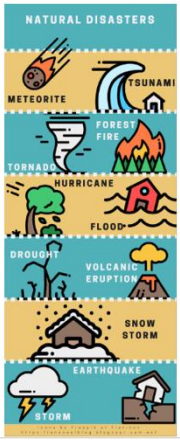
研究什么：都江堰居民的个体脆弱性以及自然危害的特征对于个人主动适应决定的影响

为什么研究：理解具有不同特征的个体如何适应不同的自然灾害，这可以帮助在随后的灾害适应和韧性建设研究及策略中更多地关注脆弱群体。

我们在寻找谁：都江堰区居民；成年人，曾经历过2017年九寨沟地震或2008年汶川地震✔，并曾在新冠疫情检测呈阳性✔；

需要做什么：半结构化访谈，约45分钟，包括5个问题部分：
- 个人人口统计信息：脆弱性主题（5分钟）
- 灾害：确认两种灾害及其特征（5分钟）
- 两种灾害的感知可能性和严重性（5分钟）
- 受访者感知的每场灾害的适应效能、自我效能和适应成本（7-10分钟）
- 两场灾害中发展的生计适应行为及其与自然灾害和脆弱性的感知联系/途径（20-25分钟）

本研究收集的所有信息都将严格保密！参与是自愿并无偿的，可以随时终止！
我们不提供任何酬金，但我们衷心感谢您的参与！



研究员李彦兮的联系方式
4699009039 (美国)
15982036270 (中国)
liyanx19@rams.colostate.edu （电子邮件）

Appendix IVA: Screening Procedure

Individual's Disaster Experience

1. Have you stayed in the Dujiangyan district during either the 2008 Wenchuan earthquake or the 2017 Jiuzhaigou earthquake?

A.Yes

B.No

2. Have you tested positive for COVID-19 at least once during the pandemic and undergone strict isolation measures for two weeks or longer?

A.Yes

B.No

3. (for interview only) Are your employees of tourism industry from Dujiangyan District?

A.Yes

B.No

4. (for survey only) Are you residents of Dujiangyan District?

A.Yes

B.No

Individual's Vulnerability Themes

Socioeconomic Status:

1. What is your monthly income?

A.Less than 5000 RMB/month

B.Equal to or higher than 5000 RMB/month

Ethnicity and Minority:

1. What is your ethnicity?

A.Han (majority ethnicity in China)

B. Minority group

Housing and Transportation Type:

1. Do you own a private vehicle?

A. Yes

B. No

2. What is your housing status?

A. Ownership of property

B. Renting a house

Household Characteristics:

1. How old are you?

A. 65 years and older

B. Below 65 years

2. Do you have any disability?

A. Yes

B. No

Appendix IVB: Screening Procedure (Chinese Translated)

个人灾难经历

1. 您是否在 2008 年汶川地震或 2017 年九寨沟地震期间留在都江堰区？

A.是

B.否

2. 您是否在疫情期间至少一次新冠病毒检测呈阳性?

A.是

B.否

3. 您是否 ga 感知到地震对您的生活或工作产生了明显的影响

A.是

B.否

4. 您是否是都江堰区的居民？

A.是

B.否

个人脆弱性主题

社会经济状况：

1. 您的月收入是多少？

A.小于 5000 元/月

B.等于或高于 5000 元/月

种族和少数民族：

2. 您的民族是什么？

A.汉族（中国主体民族）

B.少数民族

住房和交通类型：

3. 您是否拥有私人交通工具？

A.是

B.否

4. 您的住房状况是什么？

A.拥有产权

B.租房

家庭特征：

1. 您多大年纪？

A.65 岁及以上

B.65 岁以下

2. 您是否有任何残疾？

A.是

B.否

Appendix IIVA: Semi-Structured Interview Protocol

Semi-Structured Interview Protocol

(~60 minutes, five sections)

Hi. My name is Yanxi Li. I'm a master's student from Chengdu studying how people respond to big natural disasters like COVID-19 and earthquakes. I hope my research helps businesses,

government, researchers, and residents better understand and respond to these kinds of events.

I'd like to interview people like you for about 45 minutes. Questions are divided into five parts. Your responses will be used for my graduate research only and will not be made public. All your identifiable personal information will be made anonymous, and your contact details will be destroyed at the study's conclusion.

Your participation is completely voluntary and greatly appreciated.

1. Individual demographic information: Vulnerability themes (5 mins)

First, I'd like to ask you several questions about your basic information personal income, household situation, daily transportation, etc.

1. May I ask if your monthly income exceeds 5000 RMB? (Socio-economic Status)
2. Can you speak Mandarin or only the local dialect? (Ethnicity and Minority-Language)
3. Can you understand Mandarin? (Ethnicity and Minority-Language)
4. Do you rent or live in your own house? (Housing and Transportation Type)
5. Do you use public transportation for your daily routine? Why? (Housing and Transportation Type)
6. Are you or any of your household members aged 65 or above? (Household Characteristics)

7. Do you or any of your household members have any pre-existing physical conditions that have affected your life during the COVID-19 pandemic and/or earthquakes (Household Characteristics)

2. Disasters: confirmed with two hazards and their hazard characteristics with interviewees (5 mins)

Second, I'd like to know whether you experienced COVID-19 and either of the recent earthquakes in Sichuan Province. And do you agree with the following characteristics identified for the COVID_19 and Earthquake.

1. COVID-19 has a long duration of impact. (Yes/No)
2. COVID-19 has a slow speed of onset. (Yes/No)
3. COVID19 has a large (global) scope of impact. (Yes/No)
4. Earthquake has a short duration of impact. (Yes/No)
5. Earthquake has a fast speed of onset. (Yes/No)
6. Earthquake has a small (regional) scope of impact. (Yes/No)

3. Perceived probability and severity of two disasters (8 mins)

Third, I'd like to ask you about how disasters like COVID-19 and earthquakes affect you personally, and how often you think disasters like this happen…

- Do you think the impact of the COVID-19 pandemic on you personally was positive or negative? You can answer with a number — 10 for extremely positive, -10 for extremely negative.
- Do you think the impact of the 2017 or 2008 earthquake on you personally was positive or negative? You can answer with a number — 10 for extremely positive, -10 for extremely negative
- In your opinion, how likely is it that another pandemic similar to COVID-19 will occur? You can respond with a number – 10 being extremely likely, and 1 being not at all likely.
- In your opinion, how likely is it that another earthquake similar to 2008 or 2017 will occur? You can respond with a number – 10 being extremely likely, and 1 being not at all likely.
- How often do you believe another pandemic or earthquake might occur?
    - For pandemics like COVID-19, will it be: every 5 years or less, every 5-10 years, every 10-20 years, every 20-30 years, or every 30 years or more?
    - For earthquakes like 2008 or 2017, will it be: every 5 years or less, every 5-10 years, every 10-20 years, every 20-30 years, or every 30 years or more?
- How badly do you think another pandemic like COVID-19 would impact you in the future? 10 for extremely bad, -10 for extremely positive
- How badly do you think another earthquake like 2008 or 2017 would impact you in the future? 10 for extremely bad, -10 for extremely positive

<u>4. Interviewee's perceived adaptation efficacy, self-efficacy and adaptation cost for each disaster. (7-10 mins)</u>

Fourth, I'd like to ask how well you think you dealt with COVID-19 and the earthquakes, and how costly those changes were for you.

- How well do you think you responded or adapted to COVID-19? Please explain in terms of any specific behaviors or changes.
- How well do you think you responded or adapted to the earthquake(s)? Please explain in terms of any specific behaviors or changes.
- What was the costliest change you made when COVID-19 hit? Please explain in terms of time and financial expenses.
- What was the costliest change you made when the earthquake(s) hit? Please explain in terms of time and financial expenses.
- On a scale of 1 to 10, with 10 being perfectly confident and 1 being not at all confident, please rate your confidence in your ability to respond to:
    - a future pandemic like COVID-19?
    - a future earthquake like 2008 or 2017?

<u>5. Developed adaptation behaviors for two disasters with perceived connections/pathways to natural hazards and vulnerability. (30-35 mins)</u>

Now for section five - the final set of questions! I'd like to ask you how your responses to COVID-19 and the earthquakes were influenced by other factors we discussed in the above sections.

- What are some changes in behavior you observed that people surrounding you have taken due to the COVID-19 pandemic that you think are very ineffective? Please explain in terms of any specific behaviors or changes you think are beneficial.
    - Have you adopted those changes?
    - Why? (Prompt with existing vulnerability conditions? Hazard characteristics of COVID-19? the severity or probability of COVID-19 we discussed above? Or is it hard/easy to implement? Is the perceived effectiveness high or low? Is the perceived cost of adopting the behavior high or low?)
- What are some changes in behavior you observed that people surrounding you have taken due to the COVID-19 pandemic that you think are very ineffective? Please explain in terms of any specific behaviors or changes that you think are not beneficial or are counterproductive.
    - Have you adopted those changes?
    - Why? (Prompt with their existing vulnerability conditions? Hazard characteristics of COVID-19? the severity or probability of COVID-19 we discussed above? Or is it hard/easy to implement? Is the perceived effectiveness high or low? Is the perceived cost of adopting the behavior high or low?)
- Have you changed or adjusted any other behaviors not mentioned so far in response to COVID-19?
    - Why? (Prompt with existing vulnerability conditions? Hazard characteristics of COVID-19? the severity or probability of COVID-19 we discussed above? Or is it hard/easy to implement? Is the perceived effectiveness high or low? Is the perceived cost of adopting the behavior high or low?)

- What are some changes in behavior you observed that people surrounding you have taken due to earthquakes that you think are very effective? Please explain in terms of any specific behaviors or changes that you find helpful in such situations."
    - Have you adopted those changes?
    - Why? (Prompt with existing vulnerability conditions? Hazard characteristics of earthquake? the severity or probability of earthquake we discussed above? Or is it hard/easy to implement? Is the perceived effectiveness high or low? Is the perceived cost of adopting the behavior high or low?)
- What are some changes in behavior you observed that people surrounding you have taken due to earthquakes that you think are very ineffective? Please explain in terms of any specific behaviors or changes that you think are unhelpful or may exacerbate the situation.
    - Have you adopted those changes?
    - Why? (Prompt with existing vulnerability conditions? Hazard characteristics of earthquake? the severity or probability of earthquake we discussed above? Or is it hard/easy to implement? Is the perceived effectiveness high or low? Is the perceived cost of adopting the behavior high or low?)
- Have you changed or adjusted any other behaviors not mentioned so far in response to earthquake?
    - Why? (Prompt with existing vulnerability conditions? Hazard characteristics of earthquake? the severity or probability of earthquake we discussed above? Or is it hard/easy to implement? Is the perceived effectiveness high or low? Is the perceived cost of adopting the behavior high or low?)

Appendix IIVB: Semi-Structured Interview Protocol (Chinese Translated)

半结构化访谈程序

（约 45 分钟，五个部分）

您好。我叫李彦熙，是成都的一名硕士研究生，研究自然灾害频发地区，例如中国中部的四川省都江堰区，人们如何应对大型自然灾害，例如 COVID-19 和 2017 年的四川地震。我希望我的研究能帮助企业、政府和其他研究者更好地了解如何增强不同灾害和脆弱条件下个体的适应能力和抗灾能力。

我们将通过与参与者进行开放性面试来收集研究数据，每次面试约为 45 分钟。面试将分为五个部分。在这些面试中收集的信息将仅用于我的研究生论文研究，不会公开。您的可识别个人信息将被编码和匿名化处理，研究结束后将销毁您的联系方式。

部分一：个人基本信息：脆弱性主题（5 分钟）

首先，我想问您一些关于您的基础信息的问题，如个人收入、家庭情况、日常交通等。详细列表：

1. 请问您的月收入是否超过 5000 人民币？（社会经济地位）
2. 您是否会说普通话，还是只会说当地方言？（民族和少数民族语言）
3. 您是否能听懂普通话？（民族和少数民族语言）
4. 您是租房还是住自己的房子？（住房和交通方式）
5. 您是否在日常生活中使用公共交通工具？为什么？（住房和交通方式）

6. 您或您家里是否有 65 岁或以上的人？（家庭特征）
7. 您或您家庭成员是否有任何既往的身体状况，需要在 COVID-19 大流行和/或地震期间有规律就医或者影响了您的生活？（家庭特征）

部分二：确认两种灾害及其特征（5 分钟）

我想知道您是否经历过 COVID-19 和四川省近期的任何一次地震。

其次，我们想要确认您是否认可我们研究为为 COVID-19 和地震确定的灾害特征？

1. COVID-19 的影响持续时间较长。 (是/否) (1-10: 1 低，10 长）
2. COVID-19 的爆发速度较慢。 (是/否)
3. COVID-19 的影响范围较大（全球性）。 (是/否)
4. 地震的影响持续时间较短。 (是/否) (1-10: 1 低，10 长）
5. 地震的爆发速度较快。 (是/否)
6. 地震的即时影响范围较小（地区性）。 (是/否)

部分三：两种灾害的感知可能性和严重性 (15 分钟）

我将与您讨论关于像新冠疫情和地震这样的自然灾害对您个人的影响，以及您认为这类灾害在将来发生的频率是什么。

- （严重性）您认为新冠疫情对您个人产生的影响是积极还是消极的？您可以用数字回答 （10 表示非常积极，-10 表示非常消极。）
- （严重性）您认为 2017 或 2008 地震对您个人产生的影响是积极还是消极的？您可以用数字回答 （10 表示非常积极，-10 表示非常消极）
- （可能性）您认为类似新冠疫情的另一场大流行再次发生的可能性有多大？您可以用数字回答 （10 表示极有可能，1 表示根本不可能）
- （可能性）您认为类似 2008 年或 2017 年的另一次地震再次发生的可能性有多大？您可以用数字回答 （10 表示极有可能，1 表示根本不可能）
- (可能性）对于类似新冠疫情的大流行，发再次生的频率会是：每 5 年或更短时间一次，每 5-10 年一次，每 10-20 年一次，每 20-30 年一次，还是每 30 年或更长时间一次？
- （可能性）对于类似 2008 年或 2017 年的地震，发再次生的频率会是：每 5 年或更短时间一次，每 5-10 年一次，每 10-20 年一次，每 20-30 年一次，还是每 30 年或更长时间一次？
- （严重性）您认为像新冠疫情这样的另一次大流行在将来再次发生会对您产生多大的影响？10 表示非常积极，-10 表示非常消极。
- (严重性）您认为像 2008 年或 2017 年那样的另一次地震在将来再次发生会对您产生多大的影响？10 表示非常积极，-10 表示非常消极。人的脆弱性条件是否有影响到您的感受？

部分四：两场灾害中发展的适应行为及其与自然灾害和脆弱性的感知联系/途径（20-25 分钟）

现在进入第五部分 - 最后一组问题！我想了解您对新冠疫情和地震的反应是如何受到我们在上面部分讨论的其他因素的影响的。

4.1（有效性）您认为对于新冠疫情最有效的应对措施是什么（不论您是否采纳）？请根据您认为有益的具体行为或变化进行解释。

- 您是否采纳了这些应对措施？
- （可行性：适应成本） 您认为实施这个应对措施的时间，资源，人力及经济成本总体来说对于您来是高或者低呢？（1 是非常低-10 是非常高）哪一个高/哪一个低？
- （可行性： 自我效能）您认为对于您来说这是否是容易进行/实现的措施？（1-10， 1 非常容易，10 是非常不容易）
- （感知途径）为什么？（提示：现有的脆弱性条件？新冠疫情的灾害特征？我们之前讨论的新冠疫情的严重性或可能性？或者我们之前讨论的自我效能、适应效能或适应成本？）
- 个人的脆弱性条件是否有影响到您的感受？

（有效性）您认为对于新冠疫情最无效的应对措施是什么？请根据您认为不有益或适得其反的具体行为或变化进行解释。

- 您是否采纳了这些变化/措施？
- （可行性：适应成本） 您认为实施这个应对措施的时间，资源，人力及经济成本总体来说对于您来是高或者低呢？ （1 是非常低-10 是非常高）哪一个高/哪一个低？
- （可行性： 自我效能）您认为对于您来说这是否是容易进行/实现的措施？ （1-10， 1 非常容易，10 是非常不容易
- （感知途径）为什么？（提示：现有的脆弱性条件？新冠疫情的灾害特征？我们之前讨论的新冠疫情的严重性或可能性？或者我们之前讨论的自我效能、适应效能或适应成本？）
- 个人的脆弱性条件是否有影响到您的感受？

您在新冠疫情期间是否还采取了其他的应对措施？

- （有效性）您认为它分别而言是否有效？（1 完全无效-10 非常有效）请根据具体采取的行动进说明。
- （可行性：适应成本）您认为实施这个应对措施的时间，资源，人力及经济成本总体来说对于您来是高或者低呢？
- （可行性： 自我效能）您认为对于您来说这是否是容易进行/实现的措施？ （1-10， 1 非常容易，10 是非常不容易）

- （感知途径）为什么？（提示：现有的脆弱性条件？新冠疫情的灾害特征？我们之前讨论的新冠疫情的严重性或可能性？或者我们之前讨论的自我效能、适应效能或适应成本？）
- 个人的脆弱性条件是否有影响到您的感受？

（自我效能）您认为当未来与新冠疫情相似的自然灾难来临时，您是否有自信应对（1 到 10 的范围内，其中 10 表示完全自信，1 表示完全不自信）

4.2（有效性）您认为对于地震最有效的应对措施是什么（不论您是否采纳）？请根据您认为有益的具体行为或变化进行解释。

- 您是否采纳了这些应对措施？
- （可行性：适应成本）您认为实施这个应对措施的时间，资源，人力及经济成本总体来说对于您来是高或者低呢？（1 是非常低-10 是非常高）哪一个高/哪一个低？
- （可行性： 自我效能）您认为对于您来说这是否是容易进行/实现的措施？（1-10， 1 非常容易，10 是非常不容易）
- （感知途径）为什么？（提示：现有的脆弱性条件？地震的灾害特征？我们之前讨论的地震的严重性或可能性？或者我们之前讨论的自我效能、适应效能或适应成本？）
- 个人的脆弱性条件是否有影响到您的感受？

（有效性）您认为对于地震最无效的应对措施是什么？请根据您认为不有益或适得其反的具体行为或变化进行解释。

- 您是否采纳了这些变化/措施？
- （可行性：适应成本）您认为实施这个应对措施的时间，资源，人力及经济成本总体来说对于您来是高或者低呢？（1 是非常低-10 是非常高）哪一个高/哪一个低？
- （可行性： 自我效能）您认为对于您来说这是否是容易进行/实现的措施？（1-10， 1 非常容易，10 是非常不容易）
- （感知途径）为什么？（提示：现有的脆弱性条件？地震的灾害特征？我们之前讨论的地震的严重性或可能性？或者我们之前讨论的自我效能、适应效能或适应成本？）
- 个人的脆弱性条件是否有影响到您的感受？

您在地震期间是否还采取了其他的应对措施？（有效性）您认为它分别而言是否有效？（1 完全无效-10 非常有效）请根据具体采取的行动进说明。

- （可行性：适应成本）您认为实施这个应对措施的时间，资源，人力及经济成本总体来说对于您来是高或者低呢？
- （可行性： 自我效能）您认为对于您来说这是否是容易进行/实现的措施？（1-

10， 1 非常容易，10 是非常不容易）

- （感知途径）为什么？（提示：现有的脆弱性条件？地震的灾害特征？我们之前讨论的地震的严重性或可能性？或者我们之前讨论的自我效能、适应效能或适应成本？）
- 个人的脆弱性条件是否有影响到您的感受？

（自我效能）您认为当未来与 08/17 地震相似的自然灾难来临时，您是否有自信应对（1 到 10 的范围内，其中 10 表示完全自信，1 表示完全不自信）