Risk Perception and Adaptation of Climate Change: An Assessment of Community Resilience in Rural Taiwan

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Abstract: Over the last five decades, there has been a decline of rural communities in Taiwan due to urbanization expansion. In the past 10 years, the central government has implemented the Rural Regeneration Project (RRP) aimed at revitalization and sustainable development in rural Taiwan. During the project’s implementation, communities have faced several disasters as a result of climate change-induced extreme rainfall events. Perceptions and adaptation practices of climate change-induced extreme events are critical to community sustainability and resilience. The gap between perceived and actual risks that communities experience creates challenges for policy-makers in achieving sustainability goals. This study aims to evaluate the perceived climate change-induced flooding hazard perceptions compared to the scientific projection and actual hazard events in 287 rural communities implementing the RRP. This study revealed consistency in risk perception, in that communities facing high potential exposure to extreme rainfall showed higher awareness of various impacts of climate change. However, when comparing climate actions, communities exposed to low-potential hazard areas had a relatively higher degree of recognition of the benefits of adaptation to climate change. Moreover, 59 rural communities with low awareness and exposed to high potentials of extreme events were widely distributed among hills of western, southern, and northern Taiwan, where compound disasters such as mudslides can occur. This research suggests that there is a need to integrate climate change planning and work with communities to bridge the gap between perceived and actual climate risks. In particular, capacity training, counseling services, and implementation of adaptation practices should be integrated into institutional planning and management for providing assistance in disaster prevention, relief, and post-event restoration; also, encouraging climate actions can directly improve community resilience toward climate change. While investing in the sustainable development of rural communities is largely based on revitalizing economic development, this study revealed the link to ensure resilience and social-ecological sustainability in rural communities under climate change impacts.

Keywords: climate risk perception; climate actions; rural community resilience; rural sustainable development; disaster risk reduction

1. Introduction

Climate change has caused diverse and significant impacts around the world. Based on the United Nations’ (UN) [1] review of the Sustainable Development Goals implementation, more than 95 million people were affected by climate-related disasters in 2017, contributing to the highest record in economic losses (greater than $330 billion USD) in the world history of disaster events. In addition, more than 40% of those disasters occurred...
in Asia, accounting for 58% of the total death toll and 70% of the total people affected. A report published by the UN International Strategy for Disaster Reduction [2] found that the population exposed to flooding in Asia Pacific regions has doubled from 1980 to 2010; the extent and magnitude of increased exposure are even greater in Southeast and South Asia [3]. Socially vulnerable populations (e.g., children, the elderly, single female households, minorities, those with lower education attainment, the disabled, those with low-income, migrants) [4,5] are often the victims that suffer the most from the climate change impacts, implying climate justice concerns in local communities [6,7]. Exposure to hazards combined with sensitivity and adaptive capacity to disastrous events has been employed for examining social vulnerability to natural disasters and risk assessment [4,8]. In addition to the social dimension, the interconnectedness and interactions among social, ecological, and technological systems have been applied as the social-ecological-technological Systems (SETs) framework [9] to flooding vulnerability and climate justice assessment [7].

Risk and vulnerability to disasters is a function of exposure, sensitivity, and resilience to hazards. Lowrance [10] defined risk as that which presents a measurable extent of the probability and severity of adverse effects, such as ozone hole development, heavy mental pollution, and contamination of water. Haimes [11] interpreted this definition in two aspects, i.e., as the probability of occurrence of adverse effects and of the severity of adverse effects if they occurred. Vulnerability represents the inherent states of a system, such as physical, technical, organizational, and cultural conditions, that are prone to being exploited by hazards and the resulting adverse effects [12]. Resilience refers to the adaptive capacity of a system to hazards, which represents “the ability of the system to withstand a major disruption within acceptable degradation parameters and to recover within an acceptable cost and time [13]”. Abebe et al. [14] analyzed the flood risk in urban areas by the likelihood and intensity of flood hazard, exposure to the hazard, and vulnerability and adaptive ability of the areas. Andersson-Sköld et al. [15] assessed the climate-related risks of heat waves, flooding, and air pollution and the adaptation alternatives by examining the risks of these hazards, the vulnerability of the study area, and the effectiveness of adaptive measurements. In their study, Andersson-Sköld et al. [15] found that risk perception of the public was one of the key factors to determine favorable adaptation measurements.

Risk perceptions to disasters at various institutional scales—countries, regions, communities, or individuals—are known to affect decisions of climate change adaptation practices [16,17]. However, a gap between perceived risks and measured risks does exist, indicating the potential mismatch of climate justice hotspots and priorities for climate actions [18]. Therefore, understanding risk perception and then pinpointing the gap is quite critical in terms of enhancing adaptive capability and community resilience [17,19]. Public perception regarding different impacts of climate change can be divided into objective viewpoints on ecological and environmental degradation and the public’s subjective opinions [17,20–22]. These factors influence the public’s willingness to support climate actions. For example, Nnko et al. [22] indicated that 94.4%, 88.2%, and 91.2% of 1375 pastoralists held perceptions of rising temperature, insufficient rainfall and frequent drought in the Maasai Steppe, respectively. Impacts of these changes included decrease of livestock productivity (85.7%) and increase of livestock mortality rate (11.9%). Nnko et al. [22] recommended that promotion and facilitation of livelihood assets among social, economic, and financial aspects may strengthen positive perceptions on climate change and, consequently, improve adaptive capacity. Bollettino at al. [23] conducted a survey of 5184 adults in the Philippines. Results showed that those who believed they had been directly affected by climate-related hazards were also more likely to prepare for disasters, set future plans, and even start substantive actions to prevent potential collateral damages. These findings imply that policies and programs would arguably benefit from a more unified intervention framework that links climate change adaptation and disaster preparedness. Wei et al. [17] surveyed 314 health professionals of the Centre for Disease Control and Prevention in China. More than two-thirds of the respondents agreed that climate change has occurred at both global and local levels, leading to adverse impacts to human beings. Although
respondents understood strategies and measures were key components to addressing climate-related issues, they were also concerned about economic development, energy security, and local environmental protection. The results provide useful information for policy makers in mitigating the impact of climate change on public health and improving public health preparedness. Furthermore, Bradford et al. [21] pointed out that risk management plans must take into account not only the physical nature of the risk but social factors; moreover, public risk perception should be at the core. Incorporating public perceptions into risk management plans is useful in preparing risk communication strategies and increasing resilience in at-risk communities.

Beyerl et al. [19] carried out a survey study in three Pacific small island states to investigate how the inhabitants perceived climate-related environmental change and the implemented and expected adaptation practices to disaster risk in those areas. The perceptions of the residents indicated that risks of floods are higher and cause more imminent dangers. Andersson-Sköld et al. [15] proposed an integrated approach to assess the climate-related risks and the adaptation alternatives in urban areas and found that perceptions of the public and vulnerability were two of the factors affecting favorable adaptation alternatives. In general, public perception of disaster risks can be affected by characteristics of disasters (e.g., type, scale, and frequency), prior exposure to similar events [22–26], and demographic and socioeconomic factors such as education, income, and age [26–30]. Disaster management or adaptation refers to the capability of people to mitigate or avoid possible costs by regulating existing physical, environmental, socioeconomic, or administrative components [24,28]. Decision making of particular practices could be directly shaped by people’s previous experience and motivated by what they are likely to expect in the near future. Therefore, the approach to enhance adaptive intention and ability needs to relate to the perceptions of change in current conditions, future expectations, and the adaptive strategies [19,30,31].

Understanding various disaster risks can facilitate future disaster management and enhance adaptation capabilities. Countries, regions, communities, or individuals of varying scales could choose different disaster adaptation practices in response to disaster impacts [16]. Kuo [32] indicated that disaster mitigation and adaptation plans should be initiated and participated in by locals or communities primarily because locals are privy to disaster characteristics and disaster conditions. Moreover, risks of disaster in different regions also exhibit cognitive differences. Therefore, local or community residents should be tasked with the implementation of disaster mitigation and adaptation plans because local support and effective promotion can be achieved only through local and community engagement [22,33,34]. The Rural Regeneration Act (RRA) is a policy aimed at nurturing rural communities in Taiwan with the capacity to establish their own RRP and self-management mechanisms for rural community development [35]. The RRA was enforced on 4 August 2010, providing 92-h training courses to empower communities and enhance self-development capabilities. After completing the required courses, communities will be qualified to formulate community RRPs, submit working proposals and request resource support from governments. Hence, those communities with previous exposure or potential risk to disasters will be able to incorporate adaptation and action strategies for climate change into rural regeneration development plans and acquire financial support from the Soil and Water Conservation Bureau to implement community disaster prevention works and raise communities’ awareness on disaster prevention. Briefly speaking, the RRP is a bottom-up strategic approach based on the RRA by law, and it authorizes the community a high degree of autonomy regarding climatic disaster prevention. However, many communities do not have adequate information to take actions, such as the level of potential hazards they are exposed to. With a lack of disaster risk awareness, communities fall behind implementing RRPs that were designed to enhance risk management: disaster preparation, emergency rescue, and post-disaster relief and recovery. Therefore, how to close up the gap between the assessment of potential disasters and disaster risk awareness is one of topics worthy of in-depth research.
Climate change has become a growing concern in rural Taiwan where communities are being exposed to greater risks of climate change-associated hazards. This study aimed to answer one central question: to what degree do communities who have been exposed to extreme precipitation events perceive higher climate change risks compared to measured risks? The results have implications for informing community members to strengthen their preparedness and recovery plans before, during, and after a disaster through implementing local adaptation policies and practices.

2. Research Study Design and Methods

This study focused on communities with high exposure to climate change-associated hazards and low perceived climate change risks, aiming to identify the number of communities and their spatial distribution. We calculated mean perception values corresponding to climate change adaptation attributes: individual adaptation, community adaptation, and government adaptation. We identified the climate change strategies within communities of the least awareness. This analysis disclosed the practices that communities should reinforce when facing challenges of climate change (Supplementary material Figure S1).

2.1. Sampling Method

Taiwan is a small island with an area of only 35,570 km² and altitudes ranging from 0 to 3952 m, which consists of a broad range of landscapes such as coasts, plains, hills, and mountains. It lies on the Tropic of Cancer, and the general climate is marine tropical. Northern and central Taiwan belong to the subtropical climate region, whereas southern Taiwan is located in the tropical region. The island’s mean annual temperature is 22–23 °C, and the average rainfall is up to 2600 mm (100 inches) per year, which is three times the global average precipitation. Climates in Taiwan have undergone significant changes. Lu et al. [36] indicated that the frequency of extremely heavy rain in the past three decades has increased considerably since 1970. Furthermore, 5.1 events of typhoons strike Taiwan every year, increasing at a rate of 0.66 every 10 years over the past three decades. Compound disasters such as typhoons and extremely heavy rains accompanied by flooding, mud and stone flows, and landslides have occurred more frequently [37,38]. In Taiwan, the climate has undergone significant changes that have led to higher risks of climate-related disasters. Specifically, climate change has caused more frequent and intense rainstorms, more frequent and prolonged droughts, major changes in precipitation during the dry and wet seasons, increasing amplitude of heat and cold waves, and more frequent disasters such as typhoons, heavy rainfall, and flooding accompanied by debris-flow disasters and landslides [2,22,39,40]. Therefore, Taiwan is one of the most suitable research areas when studying the impacts of climate change, gradually increasing amplitude of extreme rainfalls, exposure and disaster-related risk of people in different spatial regions, and what appropriate adaptation strategies should be chosen.

We conducted a questionnaire survey in communities that have completed training courses in the community-based RRP between 2011 and 2014. Priority was given to communities that had completed the RRP for more than a year because these communities were experienced in implementing RRP. If two adjacent communities all met the first criterion, then the ones that had completed the RRP for a longer period of time were selected in order to avoid obtaining highly homogeneous communities. As a result, 300 out of 419 rural communities were selected in Taiwan (Figure 1).
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Figure 1. Location of 300 selected rural communities in Taiwan.

2.2. Questionnaire Design and Data Collection

The survey questionnaire was designed based on the dimensions and factors of disaster risk perception and disaster adaptation practices. A total of seven dimensions were identified: (1) climate change perception, (2) climate change experience, (3) climate change impact, (4) individual adaptation practices, (5) community adaptation practices, (6) government adaptation strategies, and (7) benefits of adaptation to climate change. All questions were ranked on a 5-point Likert scale [17] with 1 denoting strongly agree and 5 representing strongly disagree.

The survey questions involved factors of climate change perception to extreme precipitation events [28,36,40–45]. Climate change experience included questions relevant to previous experiences of heavy rain events [3,24,39,46–50], connecting 14 subjects such as the frequency of epidemics, the probability of contracting an illness, rural population loss, decline in life quality, degradation of air quality, increased disaster occurrence, increased post-disaster recovery costs, greater risks in pest outbreak, unfavorable conditions for industrial and commercial development, inadequate food supply to achieve self-sufficiency, reduction in biodiversity, degradation of forestry land, unstable water supply and quantities, and disappearance of traditional customs [36,37,50–52].

Individual adaptation practices included pre-disaster disaster-prevention efforts, emergency responses during disaster events, post-disaster relief and recovery, and post-disaster prevention preparedness in support of government initiatives [36,37,49,53,54]. Community adaptation practices comprised nine factors: disaster-prevention awareness campaigns and education, community-oriented environmental protection movements, environmental sanitation maintenance in community, increased infrastructure development for disaster prevention, spatial planning for disaster prevention, presence of early warning systems, implementation of eco-friendly farming practices, conservation of ecosystems and biology,
and willingness to join disaster relief taskforces [28,36,37,41,45,54]. Government adaptation strategies included whether the government should formulate corresponding policies, whether government’s disaster warning system is faster and more accurate, whether government’s disaster relief operation is faster during an event of disaster, and whether the post-disaster recovery is faster under the support from government [36,47,54,55]. There were eleven items for the benefits of adaptation to climate change: protecting human life, providing safer living environments, maintaining quality of life [54], having effective community-based organization, having food security, boosting economic development, enhancing both yield and quality of agricultural production, promoting innovative technological and industrial development, sustaining environments, preserving traditional heritage, and managing agriculture, forestry, fishery, and husbandry industries properly [37,54–59].

A pre-test through community interviews was performed to collect suggestions from residents on questionnaire contents and methods of questionnaire narratives in 12 rural communities between 28 June and 6 July 2015. These rural communities were located in central Taiwan which had suffered extreme precipitation events during 2010 to 2014. Then, the full survey was conducted between 1 August and 30 November 2015. Community contact information was provided by the Rural Regeneration in Taiwan website of the Soil and Water Conservation Bureau. Each community was contacted to arrange an interview appointment with the directors of community development associations. Then, questionnaires were sent to targeted stakeholders such as directors, director-generals, management staff, and community affair volunteers. In Taiwan, the community director is elected by residents who live in the particular community. Leaders have often lived in a community for 40 years or more and typically understand the developmental history of their area [60]. Moreover, community directors, director-generals, and management staff are key persons for practicing RRP in a community. Prior to filling out the survey, it took 20 min to explain the focal subject, contents, as well as the definitions of key terms used in this study. In each of the 287 communities, we performed three valid questionnaires with the community director, director-general, and management staff, a one-hour interview, and a one-hour site analysis. Investigators performed questionnaire validation in the community. If problems with the questionnaires were found, these were resolved right away. A total of 861 (n) valid questionnaire samples were generated to calculate the mean for further analysis.

2.3. Measured Climate Change-Induced Hazards

Rural communities exposed to extreme precipitation events were categorized based on previous research of measured potential impacts of climate change in different locations (e.g., coastal areas, plains, hills, and mountains) under various environmental conditions. According to Lu et al. [61], the meteorological index of precipitation extremes was classified into five levels: 1.00–1.61, 1.62–2.37, 2.38–3.14, 3.15–3.95, and 3.96–5.0. A higher level indicates a higher likelihood of experiencing a precipitation extreme disaster. In this study, rural communities located in areas with index values of 3.15–3.95 and 3.96–5.0 were defined as groups with exposure to potential extreme precipitation events and with higher risks of disasters (Figure 2).
Matrix analysis was applied to identify priority communities for climate change adaptation practices. Communities that were exposed to high potential risks with low perceived risks received high priority. Communities outside of the priority areas were classified as low priority communities. Communities that had perceived risks over the threshold value (i.e., mean value) were characterized as those with high awareness, whereas communities with a below-average value of perceived risks were considered as having...
low awareness. Results of the matrix analysis revealed four quadrants: high exposure–high awareness, high exposure–low awareness, low exposure–high awareness, and low exposure–low awareness.

3. Results

Four types of rural communities in Taiwan were categorized by high and low perceived risks and whether or not they were exposed to extreme precipitation hazards (Figure 3). Out of 287 communities, 111 (38.68%) were exposed to extreme precipitation hazards, while 176 (61.32%) communities were not potentially at risk. Table 1 shows that both exposure groups presented significant differences in their perceptions in respect to three aspects: climate change-induced hazards, climate change impacts, and benefits of adaptation.

Communities exposed to potential disaster risks appeared to have significantly higher awareness of frequency of cold waves, frequency of epidemics, degraded air quality, and inability to achieve food security (Table 1). On the other hand, communities that were not potentially at risk exhibited considerably higher levels of awareness of the following: quality of life could be maintained, community-based organization operated effectively, food safety was ensured, economic development was boosted, relevant technological and industrial development was encouraged, and traditional customs could be preserved.

Table 1. One-way ANOVA analysis of perceived risks between communities.

| Factors                      | Items                                      | Exposure Group 1 | Mean 2 | Stdev. | F     | Sig. |
|------------------------------|--------------------------------------------|------------------|--------|--------|-------|------|
| Climate change perception    | Frequency of cold waves                    | A                | 2.330  | 1.329  | 6.535 | 0.011|
|                              |                                            | B                | 1.964  | 0.894  |       |      |
|                              | Frequency of epidemics                     | A                | 2.034  | 1.553  | 7.010 | 0.009|
|                              |                                            | B                | 1.595  | 1.012  |       |      |
|                              | Degradation of air quality                 | A                | 2.438  | 1.351  | 9.350 | 0.002|
|                              |                                            | B                | 1.928  | 1.412  |       |      |
|                              | Inadequate food supply to achieve self-sufficiency | A         | 2.148  | 2.014  | 3.860 | 0.050|
|                              |                                            | B                | 1.703  | 1.610  |       |      |
|                              | Maintaining quality of life                | A                | 1.500  | 0.614  | 6.347 | 0.012|
|                              |                                            | B                | 1.676  | 0.507  |       |      |
| Benefits of adaptation to climate change | Having effective community-based organization | A                | 1.432  | 0.655  | 4.243 | 0.040|
|                              |                                            | B                | 1.586  | 0.547  |       |      |
|                              | Having food security                        | A                | 1.290  | 0.734  | 9.257 | 0.003|
|                              |                                            | B                | 1.541  | 0.584  |       |      |
|                              | Boosting economic development              | A                | 1.250  | 0.697  | 7.453 | 0.007|
|                              |                                            | B                | 1.477  | 0.672  |       |      |
|                              | Promoting innovative technological and industrial development | A         | 1.335  | 0.647  | 4.260 | 0.040|
|                              |                                            | B                | 1.495  | 0.631  |       |      |
|                              | Preserving traditional heritage             | A                | 1.369  | 0.680  | 4.096 | 0.044|
|                              |                                            | B                | 1.532  | 0.630  |       |      |

1 A were not exposed to extreme precipitation events, and B were exposed to extreme precipitation events. 2 Lower mean values represent higher perceived risks.
Figure 3. Four types of rural communities in Taiwan categorized by high and low perceived risks and whether or not they were exposed to extreme precipitation hazards.

Among 287 samples in four quadrants of the matrix analysis, 52 (18.12%) were classified as high exposure–high awareness; 59 (20.57%) as high exposure–low awareness; 98 (34.15%) as low exposure–high awareness; 78 (27.18%) as low exposure–low awareness (Table 2). In particular, communities with high exposure but lacking knowledge were
considered at high risk. Most of them were located in Taitung County (n = 9), Tainan City (n = 8), and Miaoli County (n = 8).

Table 2. Matrix analysis of four quadrants of communities with exposure and awareness to extreme precipitation hazards.

| Rural Communities in Taiwan (n = 287) | Precipitation Extremes |
|--------------------------------------|------------------------|
|                                      | High Exposure | Low Exposure |
| Perceived Risks                      |              |             |
| High Awareness                       | n = 52       | (18.12%)    |
|                                      | n = 98       | (34.15%)    |
| Low Awareness                        | n = 59       | (20.57%)    |
|                                      | n = 78       | (27.18%)    |

Climate change adaptation practices relating to individual adaptation practices, community adaptation practices, and government adaptation strategies were further analyzed by comparing community groups with low awareness (Table 3). The results revealed that respondents had less awareness on post-disaster prevention preparedness under the individual level and community willingness to join disaster relief taskforces on the community level. In addition, those communities also related significantly on government adaptation strategies. These findings imply that focal training courses or counseling services should be provided to these rural communities to improve their awareness and their own coping capacity for climate change adaptation and managing disaster risks.

Table 3. Perceived climate change adaptation practices in rural communities.

| Adaptation                        | Attributes                                           | Level of Awareness ¹ |
|-----------------------------------|------------------------------------------------------|----------------------|
| Individual adaptation practices   | Pre-disaster prevention efforts                      | 1.38                 |
|                                   | Emergency response during disaster events            | 1.42                 |
|                                   | Post-disaster relief and recovery                    | 1.46                 |
|                                   | Post-disaster prevention preparedness                | 1.52                 |
| Community adaptation practices    | Disaster-prevention awareness campaign and education | 1.60                 |
|                                   | Community-oriented environmental protection movement | 1.67                 |
|                                   | Environmental sanitation maintenance in community     | 1.60                 |
|                                   | Increased infrastructure development for disaster prevention | 1.52     |
|                                   | Spatial planning for disaster prevention              | 1.42                 |
|                                   | Set-up of disaster watching and warning system       | 1.31                 |
|                                   | Implementation of eco-friendly farming practices      | 1.38                 |
|                                   | Conservation of ecosystems and biology                | 1.48                 |
|                                   | Community willingness to join disaster relief taskforces | 1.58     |
| Government adaptation strategies  | Government should formulate corresponding policies  | 1.63                 |
|                                   | Government’s disaster warning system is faster and more accurate | 1.71     |
|                                   | Government’s disaster relief operation is faster during an event of disaster | 1.69     |
|                                   | Post-disaster recovery is faster in support of government | 1.65     |

¹ Lower mean values represent higher community perception, and the bold values indicate mean values higher than 1.5.

4. Discussion

The public awareness of climate change has become a rising trend in the world. Dunlap et al. [62] conducted a survey of public awareness of climate change on a global scale. They found that respondents in more than 50% of the surveyed countries considered climate change to be a serious threat. Brechin [63] investigated concern levels of American
citizens on climate risks and revealed that in 2003, 40% of respondents were extremely worried compared with 24% in 1989. MORI [64] indicated that 62% of British people considered climate change an undeniable and critical problem. Taylor Nelson Sofres (TNS) Opinion and Social [65] also identified that the perception of E.U. citizens increased from 45% in 2004 to 57% in 2007. Interestingly, results of this study revealed that only 16.4% of residents in rural communities in Taiwan realized the increase of extreme rainfall frequency. It suggested that rural communities exhibited low perceptions of climate change disaster, particularly on the subject of the magnitude and occurrence rates of typhoons and heavy rain. Since these two types of disasters [63,64] occur so often in Taiwan that citizens have become accustomed to them [38,65], people could pay less attention to any significant changes. Precipitation extremes in Taiwan can cause flooding, debris flow, and village destruction [66]. Because disasters due to precipitation extremes are serious, communities within the area of influence have higher levels of perception of precipitation extremes and their influences. Precipitation extremes result in disasters of considerable scale which are often irrecoverable because they exert a wide range and broad scope of influence and take longer to recover from. Therefore, communities within the area of influence demonstrate lower perception regarding the benefits of various adaptation strategies.

Raising risk awareness can encourage people’s positive adaptation practices in reducing disaster risks, e.g., adopting environmentally friendly behaviors [22,26,30]. Liu and Chen [59] drew several conclusions based on their observations of previous significant natural disasters. First, disaster-induced loss of life and properties are attributed to a low level of risk perception and inability to respond to a disaster independently. By contrast, crisis awareness of disaster prevention and responsiveness to a disaster facilitate avoiding or mitigating the disaster’s impact. Second, past experiences show that communities and people in a disaster are the most important factors for reducing disaster risks, losses, and casualties. Therefore, developing and fostering disaster prevention capabilities in the general public and communities are crucial issues in disaster prevention and disaster relief. Buylova et al. [33] found that respondents who were aware that they are located in the natural disaster inundation zone (earthquakes and tsunamis) and those who have already been involved in a number of physical preparedness actions (e.g., self-learning of disaster prevention knowledge, the creation of an emergency plan, and the preparation of an emergency supply kit) were more likely to enhance their adaptation practices (e.g., immediate evacuation intentions) when the event actually occurred. Numerous cases of empirical research have demonstrated the connection between disaster risk awareness and adaptation practices, e.g., mitigation actions [52], evacuation or relocation behavior [65], emergency warning systems [22,30], and incentives, funding, or supportive policy provided by governmental agencies [27,30,67]. Thus, given its behavioral implications, examining the public perception of climate-induced disaster risk can not only provide us with insights on the measurement of personal precautions, but can also pinpoint current insufficient knowledge of disasters themselves and suitable adaptation practices.

In modern society, extreme weather due to climate change often causes disasters. Since this situation is unavoidable, the best strategy is to keep alert and precautionary. It is evident that residents’ awareness and risk reduction behavior show a positive relationship. Furthermore, people will be affected by their own experience. The more the public understands the level of exposure to hazards they are facing, the more they are willing to support related adaptation practices [30,68]. This study identified communities with high risk to climate change-associated hazards. These communities were mostly located on hill lands that were also prone to compound disasters (e.g., landslides, mudslides, soil loss, and others). To strengthen communities’ adaptation capabilities, we suggest increasing infrastructure development for disaster prevention, establishing community-oriented disaster prevention plans in advance, and incorporating communities into current national disaster response systems. Awareness campaigns in response to precipitation extremes and education on post-disaster actions should be provided to avoid resulting in environmental health problems.
The reinforcement of government’s adaptation strategies should be led by a competent authority for landslide disaster management, the Soil and Water Conservation Bureau, which mainly promotes related policy (e.g., RRA), provides funding, and implements training for the community. Therefore, the communities will be well-informed of existing pre-warning systems established for precipitation extremes, understand pre-warning operation mechanisms and disaster response procedures, and learn how government adaptation strategies are actually linked with individual actions and community operations. In addition, collaborative efforts involving multiple-disciplinary stakeholders, including the government, the private sector, non-governmental organizations, and the common public, from information provision to protecting vulnerable groups, can enhance pre-disaster preparedness, during-disaster response, and post-disaster restoration [69–71]. Individuals have increasingly and specifically been identified as a key dimension to progress in disaster management, given their contributions to risk information management and adaptation measures. The effectiveness of participatory risk management depends on identifying public perceptions of risks and integrating them with good practices.

Previous researchers have failed to consider both environmental backgrounds of disaster-susceptible locations in relation to disaster types caused by climate change and residents’ perception of disaster risks together. They have often concentrated on either disaster awareness or adaptive strategy only at a specified region or on data analysis of surveys directly without considering influences of existing spatial heterogeneity in nature. In this study, we attempted to fill the paucity by linking spatial characteristics and community dimensions of disaster perception. First, we classified the degree of precipitation extreme disaster potential, selected communities located in different regions to explore disaster awareness and adaptation, and then performed a cross matrix analysis. Based on that, we were able to define four different community types responding to disasters (high exposure–high awareness, high exposure–low awareness, low exposure–high awareness, and low exposure–low awareness). We further targeted the level of awareness of adaptation behaviors in residents in the four types of communities. Consequently, planning individual, community, and government adaptation plans in different regions and different community types is an adaptive strategy-planning method suitable for local extreme climate disasters and local residents.

5. Conclusions

This study identified high-priority rural communities for enhancing their awareness of climate change-associated hazards and implementing climate change adaptation practices in order to strengthen community resilience. These results mirror the fourth assessment report of the IPCC, which revealed that Taiwan is at a high risk for multiple types of disasters and that those communities in coastal areas, plain areas, and highlands are at a high risk of sea level rise, drought, and precipitation extreme and debris flow disasters, respectively. The findings imply that investing efforts in disaster risk management is valuable and could increase resilience of vulnerable communities. Finally, enhancing public perception and ensuring the effectiveness of related adaptation practices is critical to mitigate potential losses in the future.

Supplementary Materials: The following are available online at https://www.mdpi.com/2071-1050/13/7/3651/s1, Figure S1: Flowchart of the study.

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References

1. United Nations. The Sustainable Development Goals Report; United Nations Publications: New York, NY, USA, 2018.
2. United Nations International Strategy for Disaster Reduction. Reducing Vulnerability and Exposure to Disasters: The Asia-Pacific Disaster Report 2012; United Nations International Strategy for Disaster Reduction: Bangkok, Thailand, 2012.
3. Cheng, D.C. The Characteristics of Flood and Resident Adaptation—A Case Study on Yunlin County. Master’s Thesis, National Cheng Kung University, Tainan City, Taiwan, 2017.
4. Cutter, S.L.; Boruff, B.J.; Shirley, W.L. Social vulnerability to environmental hazards. Soc. Sci. Q. 2003, 84, 242–261. [CrossRef]
5. Flanagan, B.E.; Gregory, E.W.; Hallisey, E.J.; Heitgerd, J.L.; Lewis, B. A social vulnerability index for disaster management. J. Homel. Secur. Emerg. Manag. 2011, 8, 3. [CrossRef]
6. Cheng, C. Spatial climate justice and green infrastructure assessment: A case for the Huron River watershed, Michigan, USA. GI_Forum 2016, 1, 179–190. [CrossRef]
7. Cheng, C. Climate justescape and implications for urban resilience in American cities. In The Routledge Handbook of Urban Resilience; Burayidi, M., Twigg, J., Allen, A., Wamlester, C., Eds.; Routledge, Taylor & Francis Books: New York, NY, USA, 2019.
8. Polsky, C.; Neff, R.; Yarnal, B. Building comparable global change vulnerability assessments: The vulnerability scoping diagram. Global Environ. Chang. 2007, 17, 472–485. [CrossRef]
9. Grimm, N.B.; Pickett, S.T.A.; Hale, R.L.; Cadenasso, M.L. Does the Ecological Concept of Disturbance Have Utility in Urban Social–ecological–technological Systems? Ecosyst. Health Sustain. 2017, 3, E01255. [CrossRef]
10. Lowrance, W.W. Of Acceptable Risk; William Kaufmann: Los Altos, CA, USA, 1976.
11. Haines, Y.Y. On the Complex Definition of Risk: A Systems-Based Approach. Risk Anal. 2009, 29, 1647–1654. [CrossRef]
12. Haines, Y.Y. On the definition of vulnerabilities in measuring risks to infrastructures. Risk Anal. 2006, 26, 293–296. [CrossRef] [PubMed]
13. Lee, Y.J.; Tung, C.M.; Lin, S.C. Attitudes to climate change, perceptions of disaster risk, and mitigation and adaptation behavior in Yunlin County, Taiwan. Environ. Sci. Pollut. Res. 2019, 26, 30603–30613. [CrossRef] [PubMed]
14. Abebe, Y.; Kabir, G.; Tesfamariam, S. Assessing urban areas vulnerability to pluvial flooding using GIS applications and Bayesian Belief Network model. J. Clean. Prod. 2018, 174, 1629–1641. [CrossRef]
15. Andersson-Sköld, Y.; Thorsson, S.; Rayner, D.; Lindberg, F.; Janhäll, S.; Jonsson, F.; Moback, U.; Bergman, R.; Granberg, M. An integrated method for assessing climate-related risks and adaptation alternatives in urban areas. Clim. Risk Manag. 2015, 7, 31–50. [CrossRef]
16. Adger, W.N. Scales of governance and environmental justice for adaptation and mitigation of climate change. J. Int. Dev. 2001, 13, 921–931. [CrossRef]
17. Wei, J.; Hansen, A.; Zhang, Y.; Li, H.; Liu, Q.; Sun, Y.; Bi, P. Perception, attitude and behavior in relation to climate change: A survey among CDC health professionals in Shanxi province, China. Environ. Res. 2014, 134, 301–308. [CrossRef] [PubMed]
18. Cheng, C.; Tsai, J.Y.; Yang, E.Y.C.; Esselman, R.; Kalcic, M.; Mohai, P.; Xu, X. Risk communication and climate justice planning: A case for Michigan’s Huron River watershed. Urban Plann. J. 2017, 2, 34–50. [CrossRef]
19. Beyerl, K.; Mieg, H.A.; Weber, E. Comparing perceived effects of climate-related environmental change and adaptation strategies for the Pacific small island states of Tuvalu, Samoa, and Tonga. Isl. Stud. J. 2018, 13, 25–44. [CrossRef]
20. Weber, E.U. What shapes perceptions of climate change? Wiley Interdiscip. Rev. Clim. Chang. 2010, 1, 332–342. [CrossRef]
21. Bradford, R.A.; O’Sullivan, J.J.; van der Craats, I.M.; Krywkow, J.; Rotko, P.; Aaltoinen, J.; Bonaiuto, M.; De Dominicis, S.; Waylen, K.; Schelfaut, K. Risk perception—Issues for flood management in Europe. Nat. Hazards Earth Syst. Sci. 2012, 12, 2299–2309. [CrossRef]
22. Hsu, H.C.; Lin, P.S.S. Impact of broadcast equipment of disaster warning system and disaster experience on residents’ adaptation behavior: Case of Shuangchi Village, Taichung City. J. Disaster Manag. 2018, 7, 113–134.
23. Nnko, H.J.; Gwakisa, P.S.; Ngonyoka, A.; Estes, A. Climate change and variablity perceptions and adaptations of pastoralists’ communities in the Maasai Steppe, Tanzania. J. Arid Environ. 2021, 185, 104337. [CrossRef]
24. Bollettino, V.; Alcayna-Stevens, T.; Sharma, M.; Dy, P.; Pham, P.; Vinck, P. Public perception of climate change and disaster preparedness: Evidence from the Philippines. *Clim. Risk Manag.* 2020, 30, 100250. [CrossRef]

25. Shao, W.; Barry, D.; Keim, B.D.; Siyuan Xian, S.; O’Connor, R. Flood hazards and perceptions—A comparative study of two cities in Alabama. *J. Hydrol.* 2019, 569, 546–555. [CrossRef]

26. Grothmann, T.; Reusswig, F. People at risk of flooding: Why some residents take precautionary action while others do not. *Nat. Hazards* 2006, 38, 101–120. [CrossRef]

27. Ho, M.C.; Shaw, D.; Lin, S.; Chiu, Y.C. How do disaster characteristics influence risk perception? *Risk Anal. Int. J.* 2008, 28, 635–643. [CrossRef]

28. Al Qahtany, A.M.; Abubakar, I.R. Public perception and attitudes to disaster risks in a coastal metropolis of Saudi Arabia. *Int. J. Disaster Risk Reduct.* 2020, 44, 101422. [CrossRef]

29. Sado-Inamura, Y.; Fukushima, K. Empirical analysis of flood risk perception using historical data in Tokyo. *Land Use Policy* 2019, 82, 13–29. [CrossRef]

30. Alshehri, S.A.; Rezgui, Y.; Li, H. Public perception of the risk of disasters in a developing economy: The case of Saudi Arabia. *Nat. Hazards* 2013, 65, 1813–1830. [CrossRef]

31. Chu, C.; Wu, C.Y. Climate change and health promotion. *Formosan J. Med.* 2012, 16, 503–509.

32. Al-Namr, F.; Alzaghah, M. Towards local disaster risk reduction in developing countries: Challenges from Jordan. *Int. J. Disaster Risk Reduct.* 2015, 12, 34–41. [CrossRef]

33. Buylova, A.; Chen, C.; Cramer, L.A.; Wang, H.; Cox, D.T. Household risk perceptions and evacuation intentions in earthquake and tsunami in a Cascadia Subduction Zone. *Int. J. Disaster Risk Reduct.* 2020, 44, 101442. [CrossRef]

34. Chakraborty, R.; Daloz, A.S.; Kumar, M.; Dimri, A.P. Does Awareness of Climate Change Lead to Worry? Exploring community perceptions through parallel analysis in rural Himalaya. *Mount. Res. Dev.* 2019, 39, R35–R54. [CrossRef]

35. Kuo, M.Z. The Hazard Perception and Adaptation Behavior of Residents in Flood-Prone Area under the Influence of Extreme Weather—A case study of Wenzij, Jiadong Township, Pingtung County. Master’s Thesis, National Kaohsiung Normal University, Kaohsiung City, Taiwan, 2013.

36. Lu, M.M.; Cho, Y.M.; Lee, S.Y.; Lee, C.T.; Lin, Y.C. Climate Variations in Taiwan During 1911–2009. In *Proc. of the 1st East Asia Regional Conf. on Atmosphere and Climate Change, Taipei, Taiwan, 30 October 2009.*

37. Shih, Y.J.; Yang, W.S. Climate change, public awareness and pro-environmental behaviors: An empirical test of the Giddens’s Paradox. *Surv. Res. Meth. Appl.* 2012, 28, 47–77.

38. Wang, J.H. Association among climate disaster, area capital and agricultural production of indigenous peoples. *J. Taiwan Agric. Res.* 2016, 65, 286–295.

39. Lin, S.H.; Chen, Y.C.; Lin, W.S.; Liu, C.M. Climate change projection for Taiwan based on statistical downscaling on daily temperature and precipitation. In *Proceedings of the 15th International Joint Seminar on the Regional Deposition Processes in the Atmosphere and Climate Change, Taipei, Taiwan, 30 October 2009.*

40. Chen, Y.Y. A Study of Flood Disaster Risk Communication and Adaptive Behavior for Household. Master’s Thesis, National Chengchi University, Taipei, Taiwan, 2016.

41. Kuo, F.Y. Adapting land use policy in the face of climate change: The case of coastal area in Taiwan. *J. City Plann.* 2010, 37, 47–69.

42. Ku, C.Y.; Chen, C.J.; Chang, I.W.; Hsu, S.M.; Chen, N.C.; Wen, H.Y. Study on the assessment of regional rainfall-induced landslide hazards under extreme climate conditions. *J. Chin. Soil Water Conserv.* 2012, 43, 75–84.

43. Lai, C.H. Assessing Perceptions and Adaptation Practices of Climate Change Disasters in Rural Communities. Ph.D. Thesis, National Chung Hsing University, Taichung City, Taiwan, 2018.

44. Olanrewaju, R.M.; Tilakasiri, S.L.; Bello, F.B. Community perception of deforestation and climate change in Ibadan, Nigeria. *J. Univ. Ruhuna* 2018, 6, 26–36. [CrossRef]

45. Intergovernmental Panel on Climate Change (IPCC). *Climate Change 2014-Impacts, Adaptation and Vulnerability: Regional Aspects*; Cambridge University Press: New York, NY, USA, 2014.

46. Fan, J.C.; Yang, C.H.; Chang, S.C.; Huang, H.T.; Guo, J.J. Effects of climate change on the potential of the landslides in the basin of Kaoping Stream. *J. Chin. Soil Water Conserv.* 2013, 44, 335–350.

47. Kim, D.; Kang, J.E. Integrating climate change adaptation into community planning using a participatory process: The case of Saebat Maeul community in Busan, Korea. *Environ. Plann.* 2018, 45, 669–690. [CrossRef]

48. Rahim, M.A.; Siddiqua, A.; Nur, M.N.B.; Zaman, A.K.M.M. Community perception on adverse effects of natural hazards. *Atmos. Sci.* 2012, 40, 297–321.

49. Harries, T. The anticipated emotional consequences of adaptive behavior-impacts on the take-up of household flood-protection measures. *Environ. Plann. A* 2012, 44, 649–668. [CrossRef]

50. Wachinger, G.; Renn, O.; Begg, C.; Kuhlicke, C. The risk perception paradox—implications for governance and communication of natural hazards. *Risk Anal.* 2013, 33, 1049–1065. [CrossRef] [PubMed]

51. Wang, J.H. Agricultural adaptation to climate change among highland indigenous tribes. *J. Agric. Assoc.* 2013, 14, 491–505.

52. Hung, H.C.; Lu, Y.T. Adaptation to climate change and typhoon-flood hazards in coastal areas. *J. City Plann.* 2015, 42, 87–108.

53. Ford, J.D.; Sherman, M.; Berrang-Ford, L.; Llanos, A.; Carcamo, C.; Harper, S.; Lwasa, S.; Namanya, D.; Marcello, T.; Maillet, M.; et al. Preparing for the health impacts of climate change in Indigenous communities: The role of community-based adaptation. *Glob. Environ. Chang.* 2018, 49, 129–139. [CrossRef]
54. Epstein, P.R. Climate change and emerging infectious diseases. *Microbes Infect.* 2001, 3, 747–754. [CrossRef]

55. Bernard, S.M.; Samet, J.M.; Grambsch, A.; Ebi, K.L.; Romieu, I. The potential impacts of climate variability and change on air pollution-related health effects in the United States. *Environ. Health Perspect.* 2001, 109, 199–209. [PubMed]

56. Sharma, U.; Patwardhan, A.; Parthasarathy, D. Assessing adaptive capacity to tropical cyclones in the east coast of India: A pilot study of public response to cyclone warning information. *Clim. Chang.* 2009, 94, 189–209. [CrossRef]

57. Council for Economic Planning and Development. *Adaptation Strategy to Climate Change in Taiwan*; Council for Economic Planning and Development: Taipei, Taiwan, 2012.

58. Lin, S.W.; Liao, S.C. Retailers’ hazard perception and adjustment behaviors for flooding disasters occurring in the Sijih City. *J. Chin. Soil Water Conserv.* 2005, 36, 413–427.

59. Liu, Y.C.; Chen, L.C. Community-based disaster risk management: Retrospect and issues. *J. Disaster Manag.* 2015, 4, 59–81.

60. Wu, C.F.; Lin, Y.P.; Chiang, L.C.; Huang, T. Assessing highway’s impacts on landscape patterns and ecosystem services: A case study in Puli Township, Taiwan. *Landscape Urban Plan.* 2014, 128, 60–71. [CrossRef]

61. Lu, K.Y. The Study of the Residents’ Hazard Perceptions and Adjustments about the Flood in Sijih City. Master’s Thesis, National Dong Hwa University, Hualien County, Taiwan, 2005.

62. Dunlap, R.E.; Gallup, G.; Gallup, A. *Health of the Planet: Results of a 1992 International Environmental Opinion Survey of Citizens in 24 Countries*; George, H. Gallup International Institute Press: Princeton, NJ, USA, 1993.

63. Brechin, S.R. Comparative public opinion and knowledge on global climatic change and the Kyoto Protocol: The US versus the World? *Int. J. Sociol. Soc. Policy* 2003, 23, 106–134. [CrossRef]

64. MORI Science in Society: *Findings from Qualitative and Quantitative Research*; Office of Science and Technology, Department of Trade and Industry and MORI Social Research Institute: London, UK, 2005.

65. TNS Opinion and Social. *Attitudes of European Citizens towards the Environment*; Directorate-General for the Environment, European Commission: Brussels, Belgium, 2008.

66. Fu, H.S.; Shih, H.R.; Chang, C.H. A review of major global natural disasters in 2018. *NCDR NewsL.* 2019, 165, 1–16.

67. Sun, Y.; Han, Z. Climate change risk perception in Taiwan: Correlation with individual and societal factors. *Int. J. Environ. Res. Public Health* 2018, 15, 91. [CrossRef]

68. Ge, Y.; Peacock, W.G.; Lindell, M.K. Florida households’ expected responses to hurricane hazard mitigation incentives. *Risk Anal.* 2011, 31, 1676–1691. [CrossRef] [PubMed]

69. Huang, S.K.; Lindell, M.K.; Prater, C.S.; Wu, H.C.; Siebeneck, L.K. Household evacuation decision making in response to Hurricane Ike. *Nat. Hazards Rev.* 2012, 13, 283–296. [CrossRef]

70. Shao, W.; Xian, S.; Lin, N.; Small, M. A sequential model relating risk exposure, perception and public support for coastal flood adaptation measures. *Water Res.* 2017, 122, 216–225. [CrossRef] [PubMed]

71. Chen, Y.S. Research on the residents’ experience and behavior under the influence of extreme weather-A case study of Linbian and Jiadong Township in Pingtung County after August 8 flood. *Environ. Worlds* 2014, 28–29, 25–53.