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Exploring community risk perceptions of climate change - A case study of a flood-prone urban area of Taiwan

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ABSTRACT

The regional phenomenon of heavy rainfall under global climate change is extremely likely to induce flash floods in flood-prone urban areas and endanger the lives and safety of residents. Due to its low-lying land and the overdevelopment of urban areas, Hsinchuang District in New Taipei City, situated in the Taliaokeng River basin, is subject to routine flooding on some of its streets after heavy rainfall in a changing climate. Faced with the challenge, this study provides insights into risk perceptions of flood-prone communities that should be factored in risk communication to foster adaptive actions in responding to climate change. It is underscored that community perception of climate change is a factor in increasing local awareness of climate risk. The study used Driver-Pressure-State-Impact-Response (DPSIR) cause-effect model as the information flow framework to assess community vulnerability and risk perceptions throughout semi-structured interview process. The focus was put on how the community risk perceptions were shaped in the context of social amplification of risk in responding to climate change. This methodological approach underscores community risk perceptions are an inherent part of the decision-making process, and helps to enhance adaptive actions of flood-prone communities. The study also underlined the risk communication in groups and social networks that contribute to the integration of structural and non-structural measures to advance understanding of community risk perceptions of future climate.

1. Introduction

Extreme weather and climate events (climate extremes) offer significant signals about climate risks and resilience in responding to changes that are already unavoidable (Huber & Gulledge, 2011; IPCC, 2012a, 2012b). The change in the probability of occurrence of climate extremes indicates that it occurred rarely over protracted periods but may occur more frequently in the future. It concerns the interaction of climatic, environmental, and human factors that can lead to impacts and disasters. It is noted that increasing intensity of extreme rainfall under climate change is of significant societal concern, with rainfall-derived floods being one of the most costly and dangerous natural hazards worldwide (Hallegatte, Green, Nicholls, & Corfee-Morlot, 2013; Westra et al., 2014). The Intergovernmental Panel on Climate Change (IPCC) has stated that floods will occur more frequently in South Asia and Southeast Asia in the future (IPCC, 2007). Taiwan may be the place on Earth most vulnerable to natural hazards, with 73% of its land and population exposed to three or more hazards (Dilley, Chen, Deichmann, Lerner-Lam, & Arnold, 2005; Ferry, 2016).

The frequency of rainfall shows a decreasing trend for lighter rain and an increasing trend for heavier rain in Taiwan (Tu & Chou, 2013). In Taipei, for example, total rainfall increased but the number of rainfall days decreased in 2011, indicating an increase in rainfall intensity in this area (Lu, Cho, Li, Li, & Lin, 2012). Rainfall levels have shown a significant increase in the typhoon period but a declining trend in the non-typhoon period, indicating greater extremes between typhoon rainfall and non-typhoon rainfall. Typhoon rainfall has affected Taiwan's rainfall levels for nearly 10 years (Tu & Chou, 2013). For example, Typhoon Morakot in 2009 caused large-scale flooding and loss. As an example of a severe disaster caused by climate change, Typhoon Morakot led to nearly 700 dead and missing, showing the impact of extreme rainfall. Disasters resulting from extreme rainfall have had considerable impacts, such as high casualties and economic losses. The level and scale of flooding vary with the temporal and spatial distributions of rainfall (CEPD, 2012). Being prone to natural disasters and with social changes occurring in Taiwan, the disasters caused by climate change in the greater environment have had considerable impacts indeed.

From the 1970s to the end of 2010, the number of weather-related events occurring every 10 days in Taiwan also showed an obvious increasing trend. According to the natural disaster statistics of the National Fire Agency of Taiwan (NFA), there were 32 weather-related

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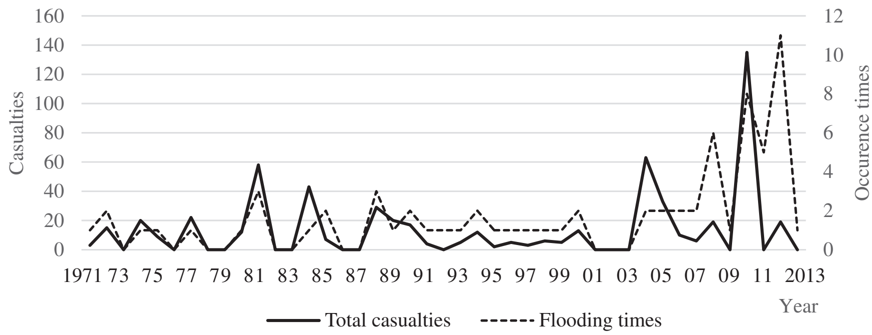

Fig. 1. Casualties and losses caused by floods in Taiwan on a bi-yearly basis (NFA, 2014).

disasters such as floods, wind disasters, heavy rain, and flash floods in the 1970s; but from 2001 to 2010, more than 79 such disasters occurred, resulting in as many as 1348 people dead and missing (Chen & Lin, 2011). Among these weather-related disasters, the number of floods in Taiwan rose the most obviously, with a year-by-year increasing trend being seen. Both casualties and losses caused by floods increased year by year (Fig. 1). In recent years, the severity of major floods and typhoons is attributed to the increasing occurrence of extreme rainfall. Fig. 1 shows that extreme climate conditions have a far-reaching impact on the environment, and will be even a great risk to human safety in the future (CEPD, 2012).

Overall, climate change leads to changes in global hydrological systems, resulting in changes in rainfall intensity and distribution. The consequent regional heavy rainfall results in river flow changes, which will probably exacerbate flooding in flood-prone urban areas. In the future, however, the intensity of extreme rainfall under climate change will exceed the capacity of the regional drainage system or the embankment protection standards, thereby increasing the risk of flooding. In particular, the current frequency of flooding in areas with high flooding potential may increase. Therefore, climate change adaptation measures must be carried out as early as possible to reduce community vulnerability, and flood management systems for flood-prone areas should be explored to support decision-making in the face of climate change (CEPD, 2012). In other words, in regarding the irreversible impacts of and uncertainties about climate change, people should be concerned with their own or group vulnerability covering both environmental degradation and human adaptability (adaptive capacity) (Biesbroek, Termeer, Klostermann, & Kabat, 2014; Eriksen, Nightingale, & Eakin, 2015; van Buuren, Keessen, van Leeuwen, Eshuis, & Ellen, 2015).

Faced with climate impacts, this study takes the flood-prone communities in Hsinchuang District, New Taipei City, situated in the Taliaokeng River basin, as an example for exploring community risk perceptions of climate change, which should be factored in risk communication (Ndamani & Watanabe, 2007). Risk perception is defined in this study as people's knowledge performance through information flow in the context of social amplification of risk (Kasperson et al., 1988; Mase, Cho, & Prokopy, 2015), which helps to foster adaptive actions in responding to the cause and consequences of climate change. The focus was put on how the community risk perceptions were shaped on both environmental degradation and resident adaptability. This methodological approach underscores community risk perceptions are an inherent part of the decision-making process (Klein & Cerully, 2007; Williams & Noyes, 2007), and helps to enhance adaptive actions of flood-prone communities as they manage floods as a group, and can serve as a reference for the development of climate resilient communities.

In order to understand and simplify the complex climate-community interactions, the Driver-Force-Pressure-State-Impact-Response (DPSIR) cause-effect model was used as the information flow framework to explore the community vulnerability and risk perceptions of climate change in the context of social amplification of risk and throughout the semi-structured interview process. It is noted that climate change impacts are closely related to each individual and their risk perceptions are the major cause of unequal adaptive actions. It is also noted that knowledge gap leads to vulnerability and maladaptation and indicates the importance of including human adaptability in responding to climate change (Giddens, 2009; Granberg & Glover, 2014; IPCC, 2014; Lahsen, 2010; Newsham & Thomas, 2011).

2. Methods

2.1. Study site

The study site is flood-prone communities in the lower reaches of the Taliaokeng River in New Taipei City. Due to the low-lying land and change in land use of the urban areas, runoffs have increased and some areas have experienced routine flooding after rainfall, threatening local residents' safety. In 2012, Typhoon Sura struck the city with heavy rain. Due to the high water level of the Dahan River, the water control gate of the Taliaokeng River was closed, and the floodwater could not be immediately drained by the pumping station alone. As a result, rainwater in urban areas could not be discharged to the Taliaokeng River, leading to ponding water in low-lying sections of the Qionglin Road near the water control gate. In view of the flood issue in these areas, the government invested in the construction of the Zhonggang Main Drainage scheme and promoted the Taliaokeng drainage system improvement project in order to resolve a local flooding issue that had existed for years. Therefore, the government built the No. 2 pumping station for the Taliaokeng River, a major flood control project in the Regulation Project of Flood-prone Areas.

The pumping station equipment quickly drains internal waters when typhoon floods occur and is usually set near the water control gate. When the river water level rises to a level at which the internal water cannot be discharged, the pump in the pumping station needs to be used to pump the water to the main river beyond the dyke to protect the living environment from flooding, thereby preventing casualties and losses to residents (NTCG, 2016). As part of this project, it is planned to build five pumping units in total and increase the number of drainage gates from four to six. In this case, water will be rapidly discharged into the river, reducing the flooding risk in Hsinchuang District.

Using Hsinchuang's flooding potential map (precipitation: 600 mm) (NCDR, 2017), we first conducted preliminary interviews with the residents in the flood-prone area of the Taliaokeng River basin. It was found that the heavily flooded areas were mainly distributed in the lower reaches of the Taliaokeng River. The upstream flood-prone area has not been flooded since a renovation project was completed 10 years ago. Therefore, the scope of the study site was narrowed from seventeen communities located around the river basin, which had been delineated according to the flooding potential map of Hsinchuang, down to seven communities of C1, C2, C3, C4, C5, C6, C7 (that is, Haishan, Fengtai, Qionglin, Quanan, Fengnian, Wenheng, and Guotai) located in the flood-prone sections in Hsinchuang District for in-depth interviews (Fig. 2).