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# Strengthening the resilience of urban retailers towards flood risks - A case study in the riverbank region of Kaohsiung City

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ABSTRACT

The urban environment is a complex system composed of the human-environment interactions within the physical-environmental system. It is constantly at the risk of the recurrent and prevalent flooding events in densely populated low land neighborhoods. Resilience is crucial to mitigating climate risks; this study ascertained the retail sector as the basic industry in Meinung with the Location Quotient (LQ) analysis; the interactive visualization tools supported and affirmed the retailers' concentration in the area most prone to flood risk. By conducting the semi-structured interviews for 15 key retailers, the study focused on the driver, pressure, state, impact, and response (DPSIR) framework to assess the knowledge, skills, and network capacity attained from climate change scenarios and flooding. The measurement of the level of resilience showed that retailers' focus on strategic identification of potential weather-related risks and implementation of adaptation plans for each business's provision of services conformed to place-specificity criteria.

The results indicated that (1) mal-adaptation of mitigation measures focus only on short-term objectives and overlook long-term and the overall resilience potential; (2) the appropriate tools for resilience strengthening assessment ascertained the perceived vulnerability; the mitigation relies on knowledge, skill and network capacity attained from previous experiences; (3) interactive visual tools provided an accurate mean, evaluation, and implementation of an integrative interface to guide and enhance the process of resilience strengthening; (4) resilience adaptability from local retailers built an effective way to mitigate flood risks. Finally, further research issues are identified with an effective resilience strengthening method against climate change.

## 1. Introduction

Recent studies on global disaster incidents indicated that more people are being affected by flood than any other type of disaster [58]; further assessment has estimated between 1996 and 2015, more than 528,000 people died worldwide and losses of US$ 3.08 trillion (in PPP) were incurred as a direct result of almost 11,000 extreme weather events [8,32,49,54,98,105,106]. These risks have urged communities to strive to adapt to the impacts of floods and reduce their vulnerability through mitigation measures such as physical barriers, retention basins, and early warning systems [1,3,108]. Other measures such as ways to enhance the flood mapping techniques and improve understanding of the global flood hazard [33,87], exposure [43], and vulnerability [50,92] to achieve process-based modeling of river flood risk at a global scale under present and future are used to strengthen the flood resilience in urban system.

Multiple concepts are attached to resilience. As a component of the process of mitigation in climate change, resilience is more inclined towards the realm of sustainability [74]. The emphasis is placed on the scope and the performance of the subjects, objects, and systems under changing boundary conditions [89] restricted to the urban constraints. Previous research primarily focused on changes in epistemic beliefs as people accepted climate change as a physical reality [77] in the context of resilience strengthening. Resilience is built on the perception that incorporates a vast range of contemporary risks [25]. Consequently, the concept has a long and multidisciplinary history [111]; it assumes that the ability of a system, community, or society is present to pursue its social, ecological, and economic development. On the contrary, its growth objectives are met while its disaster risk of time is met in a mutually reinforcing way [57,59].

No consensus exists now on how to measure resilience [11,26,42,45,75]. Experiences of an extreme weather event might make climate risk more cognitively available or salient in peoples 'minds. A number of indicators were developed for assessing the regional disaster resilience [28,109]. The impacts of climate change are experienced locally [18,48]. The United Nations Framework Convention on Climate

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Change (UNFCCC) Resilience Capacity Index (2017) [98] considers the community connectivity capacity as a key issue to measure resilience. Since resilience is a site-specific and locally adapted practice, the community's location or the "place" is closely linked to the residents' perception and local geographical character; while the people are linked to the local culture and demeanor, and is often closely tied to places that represent social or cultural values to people. The experience of a hazard is closely related to risk perception, but it can lead to the behavioral outcome because it is often mediated by other contextual factors [60]. Close analysis of the human–environment interaction indicates that climate impact is the result of cumulative social interactions in each place and practice. Stakeholders need to have the necessary information on the risk and the capacity to withstand and recover from a flooding event before it occurs [57,59]. This capacity could be acquired through the process of strengthening the resilience capacity.

Climate change would increase the risk of floods in terms of social amplification of risk, industry concentration areas, and effect on the region under flood scenarios of both extreme precipitation and sea level rise. Further, in the absence of adaptation techniques, water level rise would significantly increase the flood risks and would cause a permanent change in the urban fabric, particularly the urban industries which must advance adaptation approaches to moderate potential damages. It is argued here that to fully explore the human-environment approach, an interdisciplinary approach is necessary to bridge the gap between the natural environment and society at large, mainly in the resilience perception and actions toward flooding events. Countries and organizations began to put emphasis on non-structural mitigation such as U.K.'s measure of 'Making Space for Water', World Meteorological Organization (WMO) promotion of the concept of 'Water Adaptation' and 'Living with Water' in Netherland are just some examples. It is noted that damages to the retail sector greatly affect communities: on jobs, essential goods, and services [22]. The actions and behavior of the expected most affected sectors, i.e., retail and commodity-based small businesses, can be integrated to better understand and improve the decision-making on the environmental risks within complex systems in the riverbank region of Kaohsiung. The preparation for resilience derives from the local culture that may generate useful strategies for coping with environmental change, and it can help communities mitigate drivers and pressures in a timely and dynamic way, which contributes toward the stability and the social resilience of neighborhood. The ability of small businesses to become more resilient to accept the "new normal" is enhanced by recognizing the existence of an ongoing flood risk [97] and applying adaptation approaches to the existing systems, infrastructure, resource allocations, and work practices [73]. By examining social vulnerability with regard to people, it is crucial to assess the vulnerability and resilience of a particular area, particularly the sectoral composition because it evaluates the direct environmental impact on people, i.e. and it is most directly reflected in the adaptive capacity of the residents [40,66,95].

The 2018 UN Climate Risks Index ranked Taiwan as the 7th countries the most prone to climate risks [99]. A thorough analysis to understand the climate risks effect on the urban systems is important to mitigate the future risks. This study focused on the challenges that retailers face as they are a crucial part of communities, provide the community the needed supply and services. Their resilience building and mitigation toward flood risks in areas most prone to the climate change is thoroughly analyzed; specific attention is placed on small and medium businesses, as they account for 80% of all private sector businesses in Taiwan. It is noted that the differences in flood preparedness of businesses are based on their industrial sector, knowledge, the experience of floods, size, and on building ownership. Flooding may critically affect their ability to continue their operations uninterrupted, while for others, it may be considered insignificant to their ability to continue. High value is given to business-to-business learning, tied strongly to place; business owners' flood memories, are linked experiential flood knowledge [109,73], identifiable in an increase in the flood preparedness activities carried out by the businesses affected by flooding; these include jobs, essential goods, and services locally to the residents.

Since the retail sector is expected to be influenced the most by flooding [5,67], this study sought to explore fifteen key retailers' resilience thinking on how to adapt to floods in terms of risk communication with climate change. The Methods section discusses the following: the location quotient (LQ) analysis was used to find industrial areas at risk of flood from both extreme precipitation and sea level rise; the use of an interactive geographic information system (GIS) based visual tool to prove the adaptation simulation and impact informed by geographic contexts; and the resilience assessment process conducted through semi-structured interviews to explore perceptions of flood risk in a changing climate. In addition, the change after the flooding event was reviewed. In the Discussion section, we argue that the economic and environmental impacts of floods affect peoples' awareness, perceptions of future climate and adaptation adjustments; the focus is placed on their adaptive capacities to maintain and ensure a satisfactory environmental quality. Moreover, we noted that climate change would increase the risk of floods by analyzing the effects of flooding in the riverbank region, particularly in concentrated industrial areas. Furthermore, the current land use practices were analyzed, and suitable adaptation measures for the region were suggested. We also noted that actions are always initiated by risk perceptions [14,69,103]. It is important to recognize that multi-stakeholder understanding of small businesses knowledge system and how businesses 'learn for resilience' [73,109]; therefore, we underscored the social amplification of the flood risk as the core of the study.

## 2. Material and methods

### 2.1. Study site: the riverbank town of Meinung

Meinung District is a township in the suburbs of Kaohsiung City. It's in the region where the Meinung River runs cross-town through several drainage waterways until it meets the Cishan River. This district has a high sediment load and freshwater discharge. It mostly comprises agricultural settlements of the northern periphery of Kaohsiung City, as in 2010, the administrative division merged the county and the city proper. The area is a strong Hakka culture settlement, where the residents have lived for generations and many of them have ancestors of the early settlers in the late 1800s.

The contour map of Taiwan that was published in 1904 and the aerial photographs were taken in 2017 (Google Maps) demonstrate the geomorphic changes in the Meinung District (Fig. 1), and highlight its critical location in managing the water resources and flooding in southern Taiwan. The area is located at the tip of the alluvial fan area of the Kaping Delta. Water speed tends to decrease due to the change in the slope of the river contour. Meinung District, with about 41,000 residents, is designated as the upper section of the regional drainage system. Meinung River has undergone several embankment constructions since the 1990s. Since the water stream and direction impeded the waterway's smooth transition to the Cishan River, the flood water backup mostly concentrates on the center of the district. The study conducted by the government recommended elevating the levees higher, and construction along the Meinung River continued in the last decade. However, this measure did not decrease the occurrence of flooding, since floods in this area originated from multiple sources, e.g., in 2007, the center of the village was flooded seven times after completing the new river levee.

In 2009, Typhoon Morakot brought over three meters of heavy rainfall to the southern tip of Taiwan. Hundreds of people died in this disaster; mudslides and floods caused multiple damages and flooded the District of Meinung, and the overall economic loss for Kaohsiung exceeded five hundred million Euros [79]. Moreover, in 2010 Typhoon Fanapi brought record-high rainfall of 345.5 mm in three hours to the