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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

Fig. 1. Meinung District and Tai-An Village Location Map showing 1904 contour map overlayed.
Source: Academia Sinica Map, drawn by this study

Kaohsiung area [63] and flooded the center of Meinung. Further, sea level is expected to raise 18 cm by 2030 [104], because storms with extreme precipitation are expected to occur to a higher frequency; disasters caused by climate change are much likely to take place in the area. It is very important to explore the flood resiliency in the area. In recent years, many plots of land designated for agricultural practices have been leased or sold to develop leisure homes and light industry factories; the low land prices and loose environmental regulations began affecting the population density. The construction of the river levees was completed in the beginning of 2010; however, the design did not consider the low capacity of the drainage system or the extreme rainfalls that often occur in the area. After the embankment pile construction built during 2006–2013, the government considered Meinung District to possess the capacity to cope with the flood risk; though from previous experience, flood defense relied mainly on blocking or containing rising waters [56], which included building embankments and dredging rivers, without much success.

Nevertheless, the main area in the Meinung was flooded with 2016 during Typhoon Meranti due to the inability to drain the excess rainwater accumulated in downtown; therefore, the central government planned to redesign the entire upper drainage system to reroute the mountain drain away from the Meinung District. A close examination of the environmental and socio-cultural perception of the residents made revealed that they considered the environmental risk to have increased compared to the past. Generally, people acquire knowledge about the impacts on environmental threats and the adaptation techniques to cope with them; the knowledge is based on risk awareness, i.e., people who experience related flood impacts exhibit more adaptability and knowledge compared to those who do not [93]. However, the residents of Meinung District are currently relying entirely on the infrastructure constructed for flood control. The young generation assumes that flood risks have been mostly eliminated from the influence of climate change; they have difficulty imagining flood situations and adopting response measures, which could increase the risks caused by climate change. Future risk frequency, then, could increase even further.

Without the appropriate adaptive measures, the flood risk caused by extreme climate and weather events could increase incrementally, which poses risks of both residents and infrastructure [53]. Local inhabitants always feel this risk [73]. Meinung District is currently under the risk of flooding, and other risks due to climate change are also expected. The risk remains despite the government efforts to upgrade the infrastructure for flood control because these added risks are not measurable or predictable. In late 2016, the Central Government decided to carry out a flood resilient redevelopment plan for the Meinung District, which was quickly supported by the community. The plan involves widening of the drainage system and rebuilding of the six bridges located along the river in addition to equipping the city with flood early warning system. The Environmental Protection Administration compiled several measures stressing the structural methods. Only a few non-structural measures were mentioned for the land use planning perspectives, such as the concept of new development to regulate the peak flow of run-off.

2.2. Key sectoral composition in Meinung

After identifying the flood risk exposure to downtown Meinung, we conducted Location Quotient (LQ) analysis to quantify the concentration of each industry or demographic group in the region. The analysis is conducted to compare to a larger reference region to determine the key industrial sectors of Meinung District. The LQ analysis focused on regional sectoral composition to identify the concentrations of cluster activity within one jurisdiction and local competitive advantage [4,10,12].

Different sectors were found to have significantly different susceptibility and exposed assets [73,109]. In addition, LQ analysis determines the highest concentration on sectoral composition in the study area; it takes a local measure of the geographical concentration of industries and compares the local share of jobs of a specific industry and

within the area compared with the larger region:

- An LQ greater than 1.0 indicates an area with a proportionately higher number of workers compared to the larger reference area for a specific industrial sector. This implies that this area produce more of the product or service that are consumed by its residents. This excess would be available for export outside the area.
- An LQ significantly less than 1.0 indicates that the numbers of workers compared to the larger reference area are proportionally less and that the industry is not significant in the area; this denotes a non-basic industry.
- As the underlying principle with the use of LQ is to allow the identification of basic and non-basic industries thru variance and magnitude. Variance detects the degree of specialization of employment to a specific industry across a number of places. Magnitude in the LQ for a specific industry and place indicates that the activity is residentiary (self-sufficient), exported, or imported depending whether the LQ is greater than less than, or equal to 1.0.

The LQ analysis was conducted by utilizing data onto the government census from 2006 to 2015. It helped to identify the employment concentration [30], considering the population employed in the manufacturing; electricity, gas and water; construction; retail; communication; finance and insurance; and services sectors. We employed the LQ analysis [7,10,100] to define the sector with the highest concentration on the area to define local measures of the geographical concentration of industries. The quotient is the local share of jobs of a specific industry and the total number of jobs of the city (Table 1).

Here is the LQ formula:

$$LQ = \frac{\left(\frac{Ei,r}{Ei}\right)}{\left(\frac{Er}{E}\right)}$$

Where:

Ei, r is the number of employed jobs in industry i region r,

Eris the number of employed jobs in region r.

Ei is the number of employed jobs in industry i,

E is the number of employed jobs in Meinung, Kaohsiung City.

We gathered data on the industry, commerce, and service census from the Directorate General of Budget, Accounting, and Statistics (DGBAS), Executive Yuan, conducted every five years. For the period of the analysis, the employment data extracted from the censusof 2006 and 2011 were used to estimate the employment data onto 2005, 2007–2010 and 2012–2015. The census divides the employment data onto two-digit sectoral divisions; therefore, eight sectoral division categories (mining; manufacturing, electricity, gas and water, construction, retail, transport and communication, financial and insurance and services) for Kaohsiung and Meinung District were used in accordance with the 2001 and 2006 data divisions. We focused on the flood sensitive Tai-An neighborhood in the Meinung District, where the main institutions and retailers are located. In addition, the growth ratio obtained from the annual population census from the Ministry of Interior is proportionally computed with the employed population by using the extrapolated employment in the industry, commerce, and services censuses of 2006 and 2011; the result is used to calculate the employed population for the other gap years between the two censuses. The sectoral employment of each neighborhood was computed proportionally to the total extrapolated employment in the Meinung District. After obtaining the extrapolated employment for the years 2005–2015, we conducted the LQ analysis (Table 2). Since mining industry has zero employment in Tai-An village, we subtracted the mining sector for the analysis. This approach enables the observation and analysis of the LQ change in the Tai-A neighborhood in Meinung District. In addition, it helps to understand the changes in the basic and non-basic industrial sectors in the area.

Table 2
The community vulnerability assessment index.

Community vulnerability	Environmental degradation (deterioration level)	+ Resident Resilience Capacity	= Flood Awareness
Indicator (value)	Building (−1) Environment (−1) Infrastructure (−1)	Skill (+1) Knowledge (+1) Support (+1)	
Level/state (value)	Low (−1= −1) Medium (−1–1 = −2) High (−1 −1 −1= −3)	Low (+1 = +1) Medium (+1 +1 = +2) High (+1 +1 +1 = +3)	Discouraged (−3 +1 = −2) Worried (−2 +1 = -−1) (−3 +2 = −1) No feeling (−1 + 1 =0) (−2 + 2 =0) (−3 + 3 =0) Acceptable(−1 + 2 = +1) (−2 +3 = +1) Resistant (−1 +3 = +2)

2.3. Resilience strengthening flow by DPSIR framework

It is noted that risk perceptions address the integrated knowledge performance, while awareness refers to information collection [76]. Based on Fig. 2, the study intended to affirm that the preparation for resilience is related to how the place reacts to the performance of resilience. The ability of a community to cope with and adapt to stresses, such as social and environmental change, underlines both the environmental sensitivity and human adaptability and consequently affecting the local place and people's input toward the practice of resilience. Factors, such as the over-dependence on the interconnected networked infrastructure, high population densities, large numbers of poor and elderly people, and concentrations of material and cultural assets, increase the chances of the cities to be particularly affected by climate change [29]. The study focused on the skill, network and knowledge as a positive input in the human-environment interaction in the flood event (Fig. 2). Since human's interaction in the environment creates a cause-effect condition within the system, the state presents a social amplification of risk [47,55] which modifies the perception of risk in terms of risk communication and its flow [6]. The Driver, Pressure, State, Impact and Response (also known as DPSIR) framework are used to determine the causal relationship between the natural environment and human activities [9,36,39,64,71]. The social structure and its functioning sub-system rely on human activities to gather the knowledge, skill and network build-up. The physical-environmental structures changes derived from the climate change driver as the

Table 1
LQ analysis for Meinung District, Kaohsiung.

Target Neighborhood in Meinung District	Industries division	Basic Industry (LQ > 1.0)	Non-basic Industry (LQ < 1.0)
Tai-An Village	Disaggregated into seven sectors: manufacturing, electricity, construction, retail, transport, finance, and services.	The industry is deemed basic if the LQ is above 1.	The industry is deemed non-basic for the area

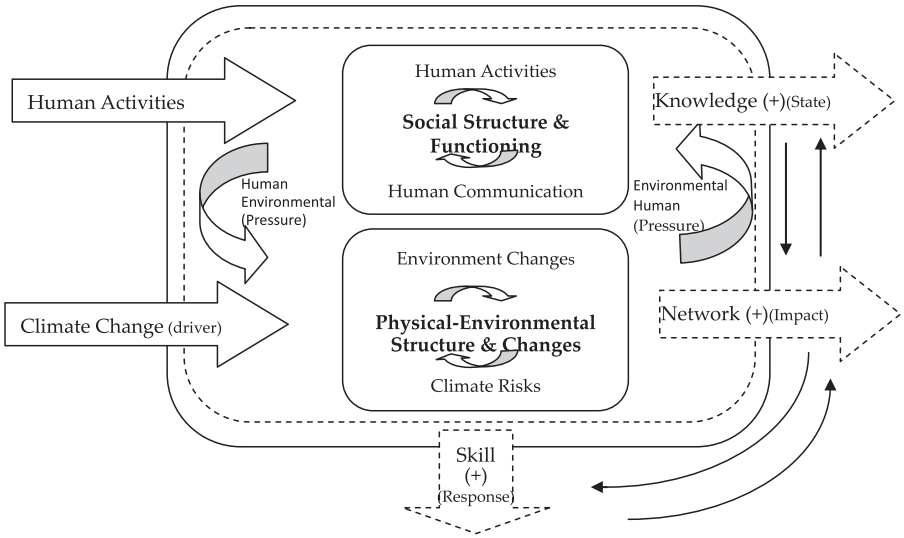

Fig. 2. A conceptual model indicating the linking and feedback between Human-Environment Dimension toward the Knowledge, Skill and Network capacity in a community.

pressure in environmental and human factors clearly bounded the conceptual model for resilience capacity building (Fig. 2).

Since the component of the system could be more resilient than the entire system, the key is to target the key components. Therefore, attention is paid to the relationships among what Bourdieu referred to as multiple forms of capital [15]. In Bourdieu's framework, the term "capital" refers to any resource or asset that social actors can use to further their goals. This study considers the skill, knowledge, and network as the capitals that residents as stakeholders utilize to meet resilience (Fig. 3).

The DPSIR (Drivers-Pressures-State-Impact-Response) approaches is used to assess the causes, consequences, and responses to change [9,31,46,82]. As an accepted, valuable and holistic structure framework, it has been applied to integrate and provide structure of the management of environmental systems [9,21,81]. The system was further developed from an 'Organization for Economic Co-operation and Development' (OECD) approach, to link anthropogenic Pressures with State changes and Impacts [80]. Further, this framework was often used, within an environmental context [9,21,34,37,44,94] to assess the response and changes incurred after each pressure. In this study, The DPSIR model is described as follows (Fig. 3):

- **Driver (D)**: Climate change affecting the urban system
- **Pressure (P)**: Extreme rainfall and flood as pressure to the environment
- **State (S)**: Communication in flood event challenges creates knowledge.
- **Impact (I)**: Community risk from flooding increases the impacts on the degradation of the local environment and residents' adaptability thru their risk perception build Network
- **Response (R)**: Actions taken to respond to Driver, Pressure, State and Impact build Skill.

2.4. The human-environment resilience and risk perception

The social–ecological paradigm encompasses, as part of its focus on the transaction, the ongoing exchanges of people and environments that occur at varying times and scales [96]. Therefore, the study must incorporate the temporal and spatial attributes since short-term stability or equilibrium within the given time frame but could render the resilience more fragile in the long term. Similarly, the defined parameter for the spatial scale of the system is critical to allotting the spatial attributes, making the approach a place-based method.

- Community Vulnerability The vulnerability or: resilience is measured in two folds, by the degradation of the environment (damages level (-)) and the residents' resilience (capacity level (+)). The capability to be adaptable is imperative to be able to function as the urban system. However, the risk perception of the community is given a numerical value to represent low, medium and high level with values from 1 to 3 [21]. The numerical values correspond to the human-environmental dimension in climate risk perception,

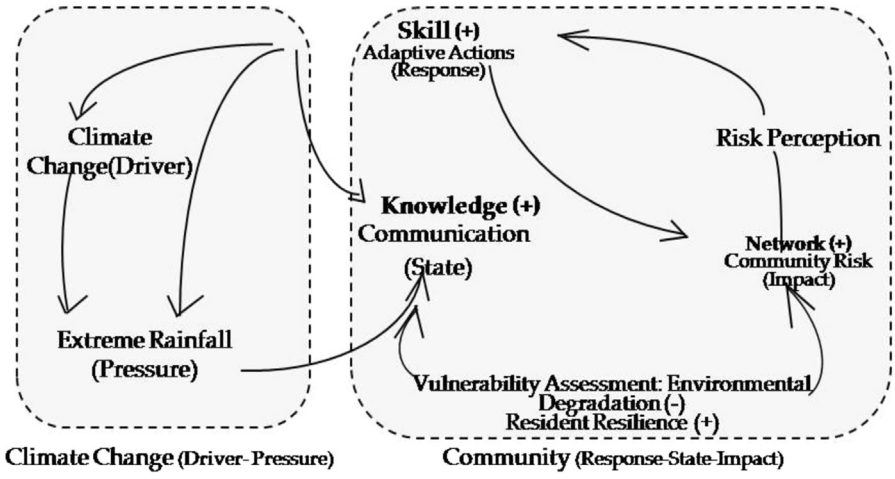

Fig. 3. The Driver-Pressure-State-Impact-Response (DPSIR) cause-effect model [36] was adapted as the human-environment assessment framework to explore the community resilience in climate change within the Physical-environmental structure and social structure functioning cycle.

reflecting the skill, network and knowledge level for an integrated resilience capacity. This study assigned 5 perception states [24]: Discouraged (−2), Worried (−1), Ambivalent (+0), Acceptable (+1) and Resilient (+2).
- The Environmental Degradation indicators comprised buildings, environment, and roads. These are given a numerical value of Building (−1), Environmental (−1), and Infrastructure (−1). The levels were assigned as Low (−1), Medium (−2), and High (−3).
- Resident Resilience: Previous studies [22] only indicated the skill, knowledge, and support from the risk perception perspective. However, this study included the community indicators of the Skill/ Response, Network/ Impact, and Knowledge/ Communication. Numerical values were assigned: Skill (+1), Knowledge (+1) and Network (+1). The levels are defined as Low (+1), Medium (+2), and High (+3).

As per previous research [21,22,24], we defined the three-main typological measure in the community vulnerability table as:

- **Environmental degradation**: The indicators include observable physical landscape such as buildings, environment and infrastructure. This study denotes the numerical value as Building (- 1), Environment (- 1), and Infrastructure (- 1). The level or state is given a sign value as Low (- 1), Medium (- 2), and High (- 3).
- **Resident Resilience Capacity**: The indicators include resident skill, knowledge and network, which is given a numerical value of Skill (+1), Knowledge (+ 1), and Network (+1). The level or state is given a sign value as: Low (+ 1), Medium (+ 2), and High (+ 3).
- **Flood awareness**: The flood awareness in this study is the president's behavior and action through the human-environment interaction. The state in which is communicable through the diverse signal. The aspiration for the learning tool was that it should be distinctive by being research-informed, narrative in orientation and draw on different evidence bases [73]. Social, economic, and political processes, such as poor governance structures or inadequate urban design, can also exacerbate climate change risks [35]. The assessment for the vulnerability is:

$$\boldsymbol{F}(\mathbf{x}, \mathbf{y}) = \mathbf{x} + \sum \mathbf{y}_{1,2,3} \quad (1)$$

Where:

x = environmental degradation (value) focused on the observable criteria of building, environment,

infrastructure rated from - 1 to – 3;

$y_{1, 2, 3}$ = adaptive capacity (value) about skill (Y_1), knowledge (Y_2) and network (Y_3), rated from +

1 to + 3;

f(x, y) = the flood awareness index.

The community vulnerability and flood awareness assessment framework are methodologically implemented with the data obtained from semi-structure interview to gain insight in understanding resident's resilience in climate change. The responses represent their perception on the environmental degradation and adaptability in the human-environment dimension [20–23].

2.5. Semi-structured interviews

Upon identifying the key industrial sector with LQ analysis and with the aid of interactive visualization model, the semi-structured interview was conducted with the local stakeholders. The multiple methodologies employed in this study require fewer persons during the process, like research that uses in-depth interviews with same numbers of respondents [23]. Supported by the aforementioned interactive visual tool (GIS platform), the semi-structured interviews were conducted to explore the respondents 'flood risk perceptions that are related to their flood resilience thinking under climate change. It addresses the reactive awareness of residents; their proactive actions in response to climate change; as well as their inextricable blend of the face and feeling, reason and gut reaction, and cognition and intuition [84]. The empirical research was carried out in April 2017, in which 15 stakeholders were interviewed, five of whom provided in-depth information based on the open-ended questions until the respondent repeated the same answers or was not able or willing to answer [23].

We underlined that risk event that occurs to a societal context and suggested that residents, as key stakeholders, can tell a "story" about environmental impacts and responses in collaboration with researchers [62]. It is noted that risks are communicated with different signals, such as images, which can amplify or attenuate the perception of risks and their manageability (Hagen, 2013) and the interview processes highlighted that the concept of social amplification of risk framework where people perceive, evaluate, and act toward climate change risks [22]. The DPSIR cause-effect framework was utilized to explore respondents' environmental degradation (deterioration level), their adaptability (tolerance level) through an open dialogue, which provided helpful information about the interaction between risk events and the psychological, social, and cultural processes in the area [22].

We selected residents with diverse backgrounds and interviewed them until no new relevant information could be obtained [85]. The researchers' guidance of the process aided the clarification of the risk perceptions of interviewees. The reliability of interview content is irrelevant to the samples size of the interviews [38,52]. The preferences, values, attitudes, behaviors, and decision models that the individuals' exhibit regarding environments differs based on subjective environmental images. These differences cannot be evaluated using physical geographical data. Therefore, we explored flood resilience in the retail sector based on human adaptability using three indices: knowledge (+1), skills (+1), and networks (+1). The adaptability index was calculated using positive points, because human adaptability positively influences individual responses to the climate change impacts. The study inquires the exposure, damage and recovery experience among the retailers. When conducting these semi-structured interviews with the residents, we avoided getting in contact with the local politicians, such as village heads and/or local representatives; we did not reveal our backgrounds or objectives.

3. Results

3.1. Adaptation of retail, as a key industrial sector to climate change

The LQ analysis was conducted for the period 2006–2015 (Table 3). The result reflects that retail sector is indeed the basic and residential (self-sufficient) industry with average LQs above 2, with small standard deviation affirming a long-term influence of one sector with respect to one another. The Village of Tai-An geographically exhibits the retail sector convergence. Of all the industries that exhibited an LQ > 1 in Meinung, which include retail and services, the study focused primarily on retail-related businesses, as retail in Meinung is the consistently being considered the basic industry. Evidently, local residents to rely on retail industry for their daily provisions and the resilience capacity among the retailers is crucial to sustaining residents' livelihood.

The study analysis indicated that (1) industry sectoral composition remain even in the past few years, having retail and services exhibiting an LQ > 1.0, with manufacturing showing an LQ above 1 only in 2006; (2) urban industries tend to be allocated within Meinung district in accord to that of Kaohsiung City, as the dominance of tertiary sector has taken the lead position in sectoral distribution; (3) tertiary industry distribution in Meinung is even throughout the area; (4) retail's LQ performs in accordance with the national trend, and the retail sector was identified being the basic industry for Meinung throughout the study period of 2006–2015.

As a result, the study indicated that (1) the retail sector LQ > 2.0 has been consistent throughout the time period of 2006–2015; (2)

Table 3
LQ analysis of the industrial sectors of the Tai-An neighborhood, Meinung District.

Year	Manufacturing	Electricity, gas, and water	Construction	Retail (wholesale)	Transport communication	Financial & insurance	Services
2015	0.202101	0.586093	0.738043	**2.440715**	0.571065	0.399609	**1.790839**
2014	0.203425	0.516851	0.699807	**2.432517**	0.589210	0.405668	**1.881184**
2013	0.203269	0.551617	0.751968	**2.323985**	0.610179	0.399609	**1.868701**
2012	0.197783	0.552240	0.806047	**2.421360**	0.586755	0.382666	**1.818114**
2011	0.199706	0.659981	0.762502	**2.449604**	0.569984	0.384989	**1.789385**
2010	0.183405	0.500253	0.552911	**2.580856**	0.781006	0.372859	**1.512505**
2009	0.188994	0.489646	0.552827	**2.502419**	0.764448	0.381543	**1.460432**
2008	0.189478	0.584013	0.496684	**2.470739**	0.779076	0.403571	**1.595905**
2007	0.186114	0.584013	0.496684	**2.515866**	0.768255	0.413179	**1.642844**
2006	0.191581	**1.553788**	0.489933	**2.646963**	0.832386	0.412967	**1.109848**

* The value in bold indicates the industrial sector with LQ greater than 1.0.

tertiary industry distribution in Meinung was quite dispersed within the urban structure; the distribution is in accordance spatially with the historic commercial core in Meinung, distributed mostly within Tai-An Village, along the artery road; and (3) the LQ for the retail sector has been consistent throughout the study period, propelling a better understanding of the suitability of current land use practice and building construction as well as defining the usable ground-floor line and height.

The results of the LQ analysis indicated that the performance of the retailers in Meinung is in accordance with the national trend. In addition, the retail sector is the basic industry for Tai-An, Meinung throughout the study period. The Tai-An neighborhood exhibited a unique LQ result, with the most robust LQ being exhibited by the retail industry during the analysis period. The focus on the retail-related businesses as the strongest basic industry in Meinung provides for the residents their daily needs; the adaptability of the businesses is crucial to support the life of the residents. Moreover, the results of the examination of the current neighborhood of Tai-An indicated that the concentration of the retailers along the main artery road allowed for direct connection to the highway back to the city of Kaohsiung; this encouraged all the retail service providers to congregate to the area. Hence, the neighborhood of Tai-An is chosen for conducting field visits and interviews (Fig. 4).

3.2. Adaptability of the respondents

The scheduled semi-structured interviews were conducted with the key retailers in the Tai-An neighborhood of Meinung, and the interviews took place in their stores. The 15 respondents were selected to represent age, gender, occupation, and leadership. The qualitative data were collected from the respondents' answers to the open-ended questions. In addition, the identities of the participants were coded from A to O, and the responses from the interviewees were collated for the questions (see Table 4). We also established the keywords afforded from the vulnerability indicators prior to the interview process in Tai-An village. We noted the retail store locations where respondents were interviewed, delineating the geographical relationship between the retail stores and the flooded zone. We focused on the environmental degradation (building, environment, and infrastructure) and resident resilience (skill, knowledge, and network). The assessment was scored and analyzed in Table 4.

Furthermore, all the interviews were recorded and transcribed. The interview questions were structured according to specific themes, such as exploring the participants' memories of flood events, their reactions and focusing on their awareness of the potential flood risk of the future climatic conditions. The semi-structured interviews process continued until no new relevant information could be obtained because they either repeated their answers or were not able or willing to answer. Significant information on the adaptability and resilience thinking of all the 15 respondents (symbolized as A, B, C….to O) in the retail sector was obtained using indices of knowledge (+1), skill (+1), and network (+1).

In terms of vulnerability and capacity, the responses from the interviewees were as follows (Table 4).

Table 4 indicated the characteristics and resilience of the respondents. It is noted that the interviewed retailers have a similar flooding experience, albeit with a time differential. They formed an informal network to aid each other during the flooding incidences, alerting and assisting the community. Though some of the retailers rent the business premises, they still work in a team effort in militating against the flood. Retailers corresponding to respondent B, E, and G have the highest resiliency; followed by J, verifying that the informal empowerment among the retailers regarding flood resilience is indeed happening to Meinung. We also noted their risk information communication capacity to understand how well the interactive simulation model performs as a communication tool. However, to fully understand the capacity characteristic of the retailers, we further analyzed the resilience build-up levels in terms of knowledge, network, and skill to denote the capacity value from the flooding experience. We then give a total sum as the total capacity and the risk information communication capacity for their reading of the information materials. The environmental degradation, retailers' capacity and flood awareness were taken singularly to observe the variation among the interviewees in the following Figs. 5–7.

In term of the environmental deterioration (Fig. 5)

- Interviewees exhibited high adaptability across the Tai-An village along the Chung-Cheng Road. Since the river and the drench affect them equally. The geographic proximity did not affect the retailers' perception since it depends on their own capacity rather than the proximity to the river or drench.
- The index score is highly dependable on the retailers' capability to adapt to the flood events and how they perceive the flood risk. For interviewee K's attitude to cope with the risks far exceed others due to the positive outlook.

In term of the retailers 'resilience capacity (Fig. 6)

- Interviewees exhibited high resilience across. The skill, network and knowledge level among the retailers in Meinung is quite high, only interviewee C, H, I and J measure only 2 in the capacity level. Interviewee L only measure 1 due to the environmental degradation perception and the interviewee's own capacity build-up level. Since capacity build-up requires the inter-cooperation among the skill, network, and knowledge, further analysis is studied in Fig. 8.
- The capacity index score is highly dependable on the retailers' capability. The capacity level, thus, should include their perceived risk and the actual event. Some retailers can adapt to the variation on perceiving and actual flood while others feel the pressure far more than the actual actions during the flood.

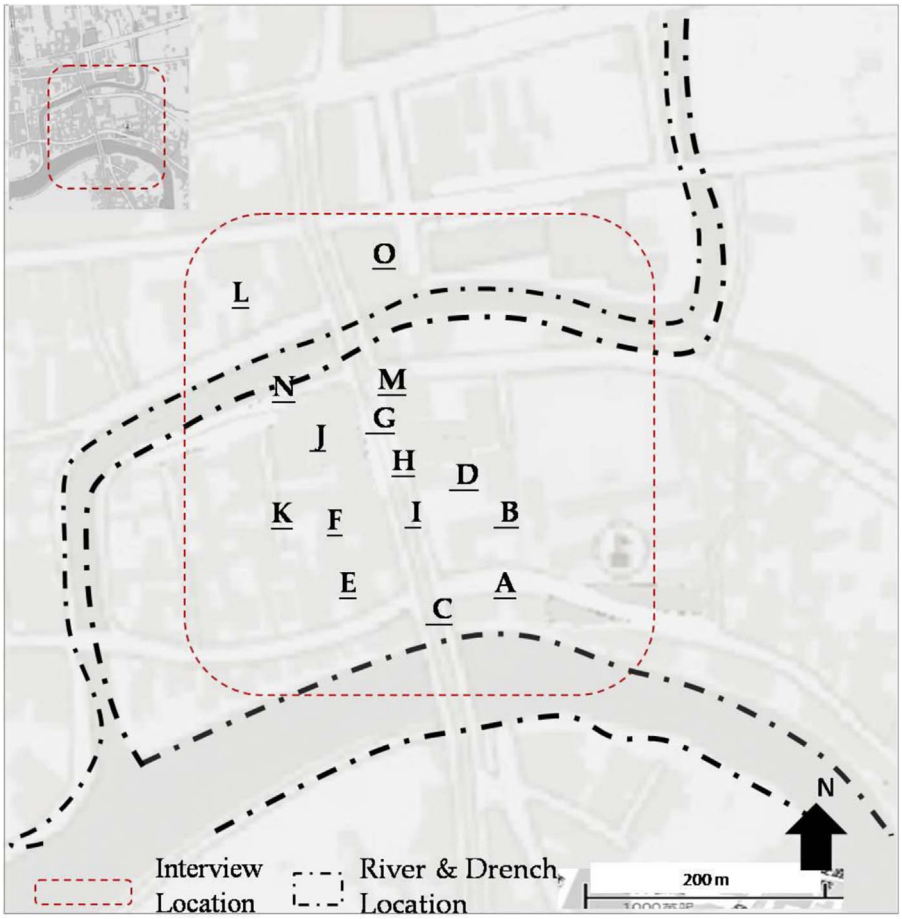

Fig. 4. Interviewees' (A-O) location in relation to the drench and Meinung River.

In term of the flood awareness (Fig. 7):

- Interviewees exhibited a static state as the perception of environmental degradation and the capacity even outs. Though the awareness state is zero, meaning there is no change per say. We could extrapolate that the capacity is far more positive about interviewee A, B, E, H, I, K, L, M, N, and O. Especially for interviewee K exhibited the highest flood awareness.
- The awareness index score is the function of perceived degradation and capacity from each interviewee; exhibiting the human-environment input in the resilience building to mitigate flood. Since the awareness stem from the retailers' own perception, the human activities and actions when facing the flood event are crucial in building the flood awareness.

This study observed a high level of adaptability among the property owners and retailers in the Tai-An village in Meinung district. Most retailers do own eateries, juice bars, or related businesses, while the age of business ranged from 2 to 25 years. Several respondents are employees; however, they also exhibited high resilience toward flood. We observed that skills in some retailer respondents are high, like E, while some others exhibited lower levels from 1 to 2 levels. Interestingly, the retailers with the highest resilience score correspond with self-owned property owners.

Perhaps due to the financial impact flooding have on the property, these retailers are more sensitive and aware of the risk at hand than other retailers that rent their premises. Retailer respondents with higher knowledge level like respondent B, G, and I could enable and share their knowledge with other retailers in the community. Certainly, several retailers responded to possess a high overall resilience capacity, as they gather experience thru each flood event and learn adaptive measures against the risk of the flood (Fig. 8). This study indicated that retailers have strategically identified potential weather-related risks and have implemented adaptation plans for each store function. This strengthens the resilience and helps the retailers to bounce back and able to provide needed goods after natural disasters. The statistic distributions of respondents' human adaptability on knowledge, skills, and networks in comparison to their risk information on buildings, roads, land use, and flooding can constitute an example of exploring key retailers' resilience-thinking on how to adapt to floods in terms of risk communication with climate change (Fig. 9).

3.3. Visual enhancement and risk communication

During the simulation of flood risks of extreme precipitation and sea level rise, the local condition of flood channels, embankments, housing settlement plans, fields, and roads are shown thru the visualization model, aiding the communication process and effectively transmitting the risks effect of resilience strengthening communication. The issues of resilience strengthening to include people, place, and policy; with the visualization tool, they can be effectively bounded into the decision-making process toward flood risks, essentially enhancing the improvement, implementation, and resolution toward miscommunication among the stakeholders in noting the changes for infrastructure such as road, building and vicinity neighborhood. The accurate and comprehensive information offers several benefits. Data that are conscientiously collected, rigorously analyzed, and correctly employed result from the efficient use of limited resources (Kellet et al., 2013). Controlling these factors can affect the local flood resilience and establish a system that can face the threats and still retain the same controls on function and structure while maintaining options of future development. Further, [19, pp. 258] argued that "in a post-disaster

Table 4
Flood awareness Index.

Retailer (age, gender, business type)	Environment deterioration (-) (building, environment, infrastructure)	+ Resilience capacity (+) (skill, knowledge, network)	= Flood awarenessperception (-, 0, +)
A (50+), male owner Breakfast bar; self-owned property. 10 years in business	Deterioration level: - 3 The building will be devalued (building −1); government is responsible for the road or bridge if it is flooded over (Infrastructure −1). The cleanup is quite messy and takes longer than normal (Environment −1).	Capacity level: + 2 We alert each other once we see the drench's water change (Network +1). We raised the ground up (Skill + 1).	Perception state: - 1 Worried in the face of the current situation. Flood experience: 5 times.
B (40+), female owner Juice bar; self-owned property. 5 years in business	Deterioration level: −2 The streets were flooded each time before the improvement work (Infrastructure −1). The flooding usually remains overnight bringing sludge and garbage from upstream. (Environment −1).	Capacity level: + 3 I always runback to alert the elders living near bye (Network +1). I store the materials up above on shelf (Skill + 1). We just watched the water flow speed (Knowledge + 1)	Perception state: +1 Acceptable in the face of the current situation. Flood experience: 4 times
C (60+), female owner Grocery store; rental property. 20 years in business	Deterioration level: - 2 The problem is that when it gets flooded we have no access since that is our only way to the store (Infrastructure −1). The town's cleanup must be done faster because it is dirty after the flood (Environment −1).	Capacity level: + 2 I know to store everything upward above (Knowledge +1). I observe the drench water flow (Skill + 1).	Perception state: +0 No change in the face of the current situation. Flood experience: 10 times.
D (40+), female owner Drinks store; rental property. 10 years in business	Deterioration level: - 3 Our store always gets flooded (building - 1); government's improvement only lasts a few years and then the flood is back (Infrastructure −1). Garbage collection service stops during the flood and it really stinks (Environment −1).	Capacity level: + 3 Neighbor alerts me each time and I tell others nearby (Network +1). I move the food supply into cabinet and fridge (Skill + 1). I judge the TV report on the rainfall (Knowledge + 1)	Perception state: +0 No change in the face of the current situation. Flood experience: 8 times
E (40+), male employee Restaurant; owner self-owned property. 25 years in business	Deterioration level: - 2 Government is responsible for the road or bridge if it is flooded over (Infrastructure −1). The cleanup is quite messy and takes longer than normal (Environment −1).	Tolerance level: + 3 The bar owner calls us on the flood risk (Network +1). We stop business to store things upward, cleanup first and install flood stopper planks (Skill + 1). Rainfall on upstream is what I judge first (Knowledge +1)	Perception state: +1 Acceptable in the face of the current situation. Flood experience: 10 times.
F (50+), male Owner Beauty Salon; owner self-owned property. 8 years in business	Deterioration level: - 3 Our store always gets flooded (building - 1); government's improvement only lasted a few years and then the flood is back (Infrastructure −1). Garbage collection service stops during the flood and it really stinks (Environment −1).	Tolerance level: + 3 The one closer to the drench would alert others (Network +1). I improved the building structure and raised the ground up (Skill + 1). All the previous flooding taught us what to expect (Knowledge +1)	Perception state: +0 No change in the face of the current situation. Flood experience: 5 times.
G (50+), female Owner Restaurant; owner self-owned property. 25 years in business	Deterioration level: - 3 Flooding occurred this year again into the building (building - 1); the drench work only lasted for 4 years of dry season (Infrastructure −1).	Tolerance level: + 3 I rely on the alert by the neighbor (Network +1). We just stop operating (Skill + 1). I watch the TV to see forecast, ask friends around the area and check with neighbors (Knowledge +1)	Perception state: +0 No change in the face of the current situation. Flood experience: 5 times.
H (40+), female Owner Restaurant; Owner self-owned property. 25 years in business	Deterioration level: - 1 City government needs add the drench wall (Infrastructure −1).	Tolerance level: + 2 I also help alerting Others (Network +1). Usually I see how others prepare for flood and I do It too. It minimizes the damage.(Skill + 1).	Perception state: +1 Acceptable in the face of the current situation. Flood experience: 10 times.
I (50+), female Owner Restaurant; owner self-owned property. 25 years in business	Deterioration level: - 1 I worried more about garbage floating after the floods (Environment −1).	Tolerance level: + 2 Beside the drench's water change, I tend to observe the river too (Knowledge +1). I wait for the neighbors' alert and tell them my thought too (Network + 1).	Perception state: +1 Acceptable in the face of the current situation. Flood experience: 2 times.
J (30+) Owner Diner; owner self-owned property. 10 years in business	Deterioration level: - 2 Flooding up to 40 cm (building - 1); no electricity for a day (Infrastructure −1).	Tolerance level: + 2 I learned from my parents when we lived upstairs from the shop (Knowledge +1). The neighborhood alerts each other (Network + 1).	Perception state: +0 No change in the face of the current situation. Flood experience: 5 times.
K (30+) Employee Convenience store; rental property. 2 years in business.	Deterioration level: - 1 Drench should be relocated (Infrastructure −1).	Tolerance level: + 3 We alert each other no matter what and I tell my customers to prepare (Network +1). We install the flood prevention plank (Skill + 1). The headquarter has a SOP for such event (Knowledge + 1).	Perception state: +2 Acceptable in the face of the current situation. Flood experience: 2 times.
L (20+) Employee Convenience store; rental property. 2 years in business.	Deterioration level: - 2 Flood stopper plank did not work (building - 1); cleanup took forever (Environment −1).	Tolerance level: + 1 The headquarter has a SOP for such event (Knowledge + 1).	Perception state: −1 Worried in the face of the current situation. Flood experience: 2 times.

(*continued on next page*)

Table 4 (*continued*)

Retailer (age, gender, business type)	Environment deterioration (-) (building, environment, infrastructure)	+ Resilience capacity (+) (skill, knowledge, network)	= Flood awarenessperception (-, 0, +)
M (20+) Employee Convenience store; rental property. 2 years in business.	Deterioration level: - 1 All that drenches destroyed the town and it does not work, there is always overflow (Environment −1).	Tolerance level: + 2 We alert each other once we see the drench's water change (Network +1). We Used the flood stopper plank (Skill + 1).	Perception state: +1 Acceptable in the face of the current situation. Flood experience:2 times.
N (60+) Owner Stationary store; rental property. 20 years in business.	Deterioration level: - 1 Flooding on the street no matter what the government does (infrastructure - 1);	Tolerance level: + 2 We alert each other once we see the drench's water change (Network +1). We raised the ground up (Skill + 1).	Perception state: +1 Acceptable in the face of the current situation. Flood experience: 10 times.
O (60+) Owner Stationary store; rental property. 20 years in business	Deterioration level: - 3 Our store gets flooded (building - 1); town's improvement is not up to standard (Infrastructure −1). The walls make the town ugly (Environment −1).	Tolerance level: + 2 I know when to put all the stationary up (Knowledge +1). I also use the flood stopper plank (Skill + 1).	Perception state: −1 Worried in the face of the current situation. Flood experience: 10 times.

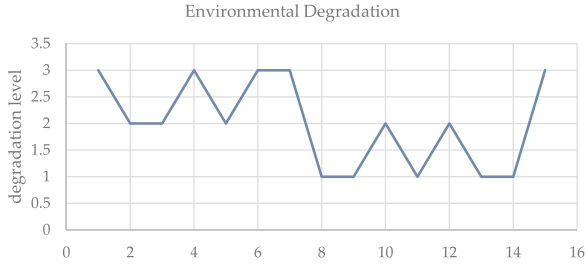

Fig. 5. Retailers environmental degradation.

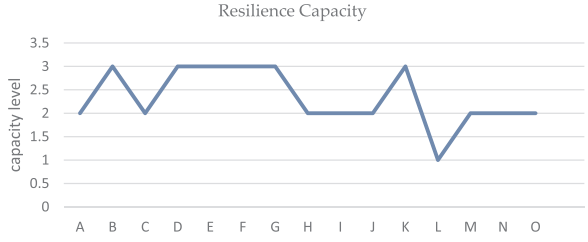

Fig. 6. Retailers resilience capacity.

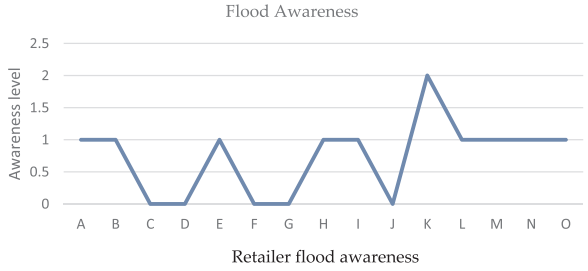

Fig. 7. Retailer flood awareness.

context, the expectations that people have about the behavior of their neighbors and their governments can profoundly affect the recovery strategies that they adopt "and consequently influence their responses to flood risks in terms of both mitigation [16] and adaptation methods [23]. To help the residents in understanding and responding to the risks of climate change, this study used interactive visual tools to combine the adaptation approaches to the retail sector (proposed according to impact simulations informed by geographic contexts) with the responses from the residents throughout the interview process. Therefore, we used the governmental GIS information platform to visualize the flood scenario and explore the potential flood risks of climate change (Fig. 8).

The higher are the exposure to risk, the higher the resilience becomes due to the available resources to respond [107]. Allowing residents to comprehend the risk at hand, this study employed flood risk maps thru diverse scenarios simulated on an interactive visualized modeling to enhance the communication with flood risks to the residents. The geodesign techniques address the methodological process of the design and planning proposals; most importantly, the simulation within the geographic context visually [41]. The systematic structure of the interactive geographical data application aided the decision-making and collaboration methods of the residents and related stakeholders during the planning and design process. It is noted that the three-dimensional modeling software program designed by Esri City Engine is applied to producing the interactive visualization model with a procedural modeling approach and a strong online model-sharing service for smoother communication and interaction with stakeholders, like the residents and policy-makers [21,23].

4. Discussion

4.1. Retailers' adaptability and living with maladaptation practices

In a flood-prone area, resilience is demonstrated for the preparations before the occurrence of flooding; this includes actions taken by the residents, and flood-control systems, such as drainage system fortification, rapid response units, rescue services, damage repairs, and future improvements that administration often establishes in the vulnerable areas. However, policy-makers may overlook the multidisciplinary and complex nature of the subject and use the term without sufficient information or with a limited understanding [51]. Maladaptation often occurs when the adaptation measures merely focus on the short-term objectives and overlook the long-term and overall considerations [23]. The increasing focus on the "local" is changing the roles of the community groups of the community-lead adaptation planning [73,109].

The case of Meinung District reflects a planning and common problem in Taiwan: that the focus on Kaohsiung City Government is concentrated on strengthening the flood-control constructions, like embankments and pumping stations. However, the government did not take the notion of a comprehensive planning strategy until typhoon Morakot hit in 2009. The planning units did not meet the local expectations; therefore, the adaptation measures could not fulfill the needs of urban resilience in the area. When risks arose, the planning units that were supposed to continually enhance the infrastructure

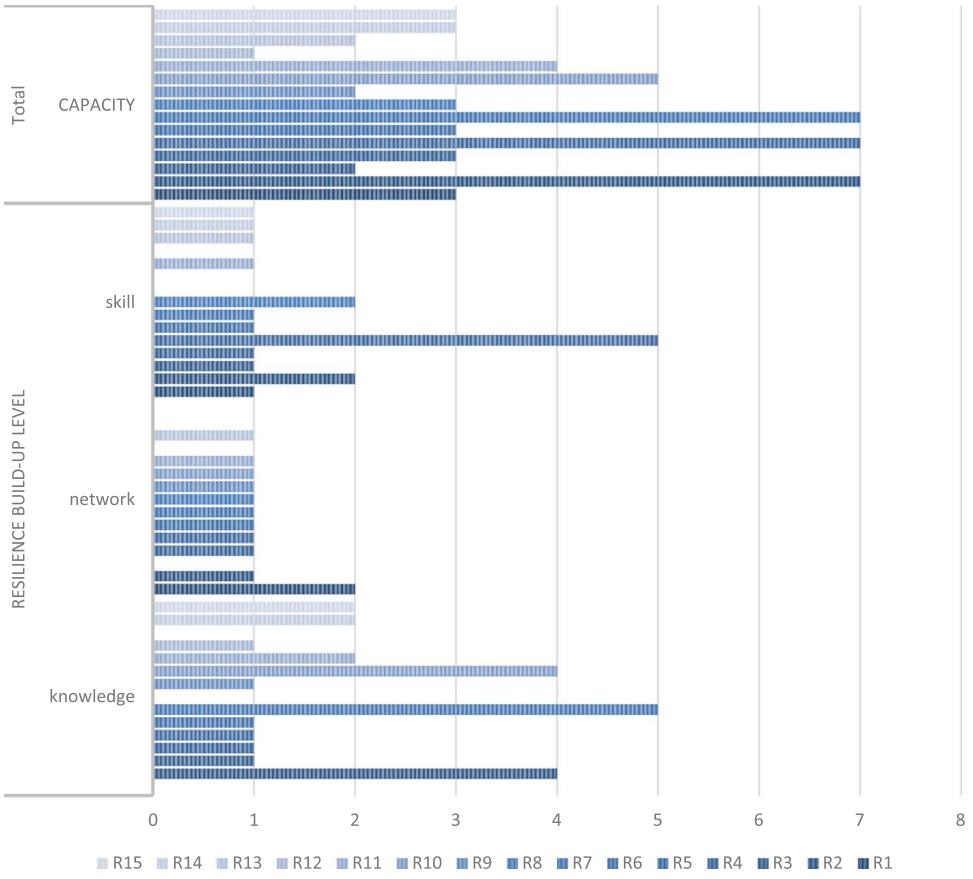

Fig. 8. Retailers' community resilience capacity.

failed to adopt strategies suitable for the local needs. In addition, the public lacked related knowledge, which results in a delay in appropriate development plans and obstructed the improvement on the local resilience. More collaborative strategies were developed through the collaboration between the government and the local nongovernmental organizations after the hit of Typhoon Morakot in 2009. These strategies fairly decreased the chances of maladaptation. However, the results of the interview showed the knowledge asymmetry was rendering the residents as well as the governmental planning units unable to identify the appropriate development mechanisms. The adaptive capacity influences the risk perceptions and the perceived risk determines the responses to the residents [86,101], i.e., the human risk perceptions and behaviors are parts of the human–environment system.

The adaptability and information understanding the inherent risks are present but mismatched toward the locally acceptable practices and responses mechanisms. While the governmental approach may be maladaptive regarding the climate change risks, the residents exhibited a notable capacity of their knowledge of impacts and adaptation to the flood risks. They showed a strong network and skills toward facing this threat. However, the planning units continue to develop certain

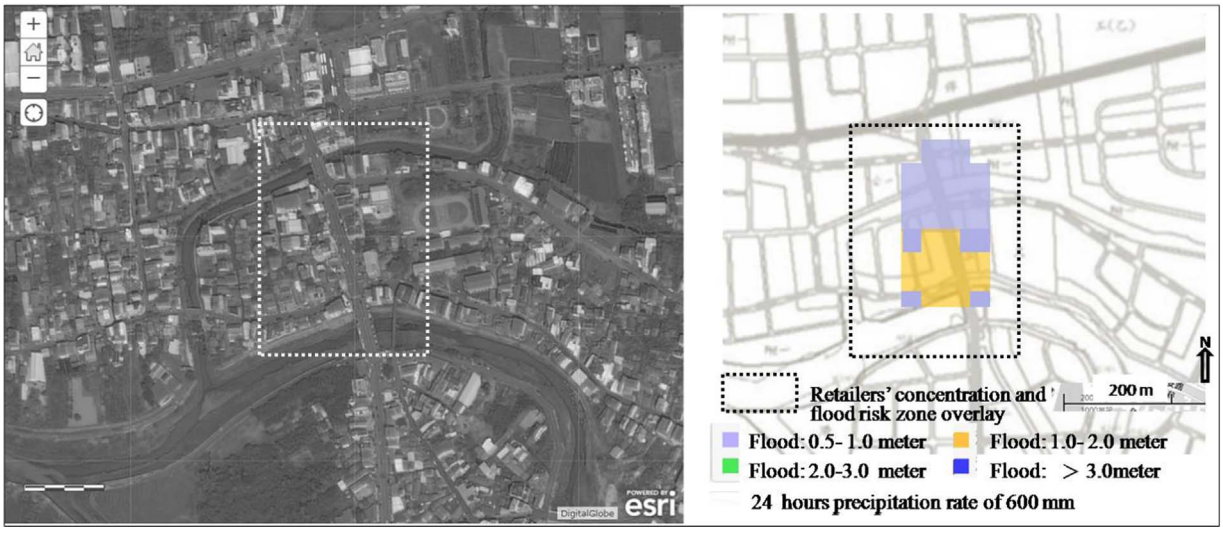

Fig. 9. Flooding simulation in Meinung District; based map generated with Esri City Engine.
Source: NCDR, 2017; drawn by this study

maladaptation strategies that could not match nor reflect the needs of the residents, and thus failing to properly address and respond to the impacts of flooding. Therefore, adaptation strategies should mainly focus on filling the gaps between the local needs and implementation strategies to solve the problem of the knowledge asymmetry towards the challenges to climate change. Thus, we highlight that resilience and adaptation strategies should consider all options, investigate all practices, and take all the possible adverse effects into account.

4.2. The proper visualization tool's enhancement toward flood resilience

It is expected that awareness and perceptions of climate change as a serious threat would increase worldwide. This knowledge and skills would help to reduce vulnerability towards climate change and managing its risks, and thus help in achieving sustainability [78]. The study used an effective communication and decision-making tool, the Geodesign approach, which relies on the joined design output of impact simulations in the geographic domain [23]. This is a base of important references to the exchange of information and mutual consensus among the residents. We proceeded with the aid of interactive visualization model during the interview process; we utilized the GIS tool as a medium for an effective communication with the impact and understanding of climate change effect and flood risks. The scenarios simulation presented through the three-dimensional model greatly assisted the respondents' conceptual gathering of information and sharpened their responses and awareness of the effect of flood risks during the process of the interview.

The communication with flood risks is indeed evidence-based, and its effective way for information exchange should be carefully processed to fully inform people about the potential hazard and impact on their livelihood and community at large. In the interactive simulation model, valuable input can be contributed by incorporating the scenarios of the environmental evidence-based data, toward the formulation of proper design criteria and the decision-making process. The progressive adaptive approaches and actions can be documented and contributed to the understanding of climate impact as well as facilitating the visualization of the changes and the space adaptation in a real-time simulation [23].

4.3. Community connectivity capacity through retailers' actions and responses

Resilience thinking offers a promising framework of mitigating flood risks since they could increase due to the frequent climate impacts. Implementing adaptive capacities enables people to lead meaningful and dignified live under the risks posed by climate change [2,86]. The local knowledge can be articulated in various ways, such as lay, traditional, and indigenous knowledge that exist within the notions of common wisdom and can be redistributed among communities [65]. Their practice of observing the rise of the water table in the trench drain near their stores is an example of a place specific practice. In addition, the residents in this community have known each other for a long time, which improves their ability to cope in unison and creates a deep understanding of the place.

Encouraging people to remember and pass down their knowledge, which they may be already doing in private settings, is a key part of the resilience process. Creating opportunities for communities to remember their experiences helps develop memories. Therefore, establishing the sites and frames for sharing sustainable flood memory is crucial [73]. To reduce flood losses and help communities improve flood resilience, we focus on mitigating risks and preparing for floods, rather than simply dealing with the consequences after a flood occurs [61]. Human adaptation ability reflects the influence of various impacts on individuals and is strongly related to individual knowledge and skills, socioeconomic structures and institutional policies [23]. Other studies focused on the role of "network influence" and the frequency with which people has conversations or are influenced by close friends and family climate change [17]. Although this type of research is still limited, studies have indicated that social network variables, like homophiles, network size, and centrality have a significant influence on the awareness of global warming [68,102]. We must forge network connections with rapidly changing communities of decision-makers and researchers to foster the social learning necessary for effective adaptation to climate risks [13]. The experiential learning is established through emotional responses. This illustrates the importance of the experience and its subsequent influence on attitudes to risk [109] because it is easier to remember the affect-laden events. The network system fosters a sustainable flood memory, which the community focuses, in addition to integrating individual/personal and collective/community experiences as well as involving inter and intra-generational communication and strategies for its future (McEwen, 2016).

Disaster resilience underlies the measurement framework as the ability of a system, community, or society to pursue its social, ecological, and economic development and growth objectives while managing its disaster risk of time for a mutually reinforcing way [57,59]. Resilience is only visible, or "revealed," after the occurrence of a disaster [91]. Locally embedded knowledge arises from continuous experimentation, innovation, and adaptation, absorbing the knowledge systems to solve local problems related to climate risks. The adaptive innovations, techniques, methods, and processes of the residents are based on their own knowledge and skills. To decrease or prevent devastating climate change impacts is location specific and community-specific [83]. Constas et al. [27] identified resilience as a "multi-dimensional capacity, "because business communities prefer learning from other businesses rather than from governmental agencies [73]. We observed a close relationship between several respondents, as they would alert each other of an approaching flood and teach each other practices to mitigate the risks. The retailers in Meinung can communicate prior to the flooding event because they consider themselves critical stakeholders in collaboration with mitigating the risk of flood. Their communication mostly consists of informal narration and visual approaches, particularly self-authored digital narratives, aiding their mitigation toward recovery. Further, these learning resources were the most powerful when they were strongly linked to the local flooding experience. We concluded that thru the network, skill and knowledge build-up, the retailers can strengthen their resiliency contributing to the adaptability.

5. Conclusion

The Meinung delta region is a historical Hakka settlement ofself-sustaining local industries spanning from agricultural to the retail sector. In this study, we focused on flood adaptive practices of retailers, which allowed them to adapt to the threat from floods; the focus is placed on the capacities and practices that residents adapted and practiced, along with how they define and perceive the risks and actions taken to enhance and strengthen their resilience. The concept of "living with risk" rather than simply trying to prevent the occurrence of hazards is highly emphasized on the finding of this study. This alternative approach advocate for resilience, which is the capacity of a system to absorb hazard disturbances, learn from mistakes in past responses, reorganize after disturbance events and prepare for possible future shocks and anticipated impacts [70]. The retailers in Meinung practice the concept of "living with flood" and apply set of routine actions before, throughout, and after the flood. The adaptability is responsible for the risk perceptions of the surroundings and differs from individuals depending on upbringing, perceptual experience, and epistemological systems, from which subjective environmental images reconstructed [23]. Resilient communities have an improved capacity for the disaster risk management cycle due to their awareness and knowledge of the risk [90], and they experience fewer disaster impacts and a lower degree of fluctuation compared to less resilient

communities [72]. Climate and environmental change will further elevate the overall environmental risks; necessitating residents to familiarize themselves with the strategies carried out by their government and learns to respond to such risks. Being adaptive to the risks at hand is a divergent capacity for individuals, induced by the residents' actions and responses toward the environmental impacts.

The management and implementation of policies on the area focused mainly on the hardware reinforcement and could be considered maladaptive. The local government's focus relies on the reinforcement of the hardware to defend against the risks, such as dikes, embankments, and drench channels. The measures weathered thru several seasons, but negligence could bring further impacts from future flooding risks. The awareness of the limitations of the implemented technical measures should be increased, e.g., in the case of the dike on the Meinung River; many participants perceived the dike as an ultimate solution to the problem and have become dependent on such hardware measure. The future urban planning according to the local and overall considerations is recommended to avoid maladaptation, rather than merely inclining on a certain method. In addition, new adaptation strategies should be carried out to strengthen and fill the gaps between the local resilience. Moreover, the results indicated that the adaptation measures carried out by the local community are related to their perceptions and practice methods. Therefore, we conclude the local adaptation is place specific, related to the local practices, and initiated by risk perceptions. The local resilience capacity should be considered during the planning to minimize future maladaptation.

Flooding is still considered a major challenge, despite the development of the engineering techniques towards mitigating flood impacts over the last twenty years [88,110]. This study analyzed the risk perceptions and practices the retailers considered during the exposure to floods, to the local conditions, culture and living habits. We employed the semi-structured interview to comprehend their adaptive capacity thru risk perception. Each respondent would profess his/her options and attitudes toward the changes observed and felt within the environment. The adaptability assessment was applied for semi-structured interviews to analyze the risk perceptions of the local retailers and document their adaptive capacity [70]. We argue that perceptions influence the opinions and attitudes of the residents to environmental changes. The results of this study indicated the residents in Meinung were considered to be within a resilient system. They are able to absorb the impacts on the hazard without changing their fundamental functions, and able to renew, reorganize, and adapt to significant impacts on disasters [70]. We compared the risk perceptions of the retailers exposed to the climate risk and found that their response to every aspect of climate change is mediated by local culture and living style. Therefore, the retailers' in Meinung was regarded as part of a resilient community because they can adapt to an uncertain and changing place. This reflects their ability to adapt to the changing conditions. Concerned, informed, and active citizens are being supported and encouraged to become a part of the resilience planning process, which provides local information that can be integrated into wider "expert" knowledge systems. The experiences are connected to memories of past flood events and the emotional responses to them (McEwen, 2016). The ability to adapt to the actions a system undertakes to better cope with, adjust to or hazard is achieved by attaining social memory that accumulates from previous experiences, accumulated hazard knowledge, and reorganization of past disturbance events, which could include outside assistance.

The flood resilience among small businesses reflects the positive thinking and the advanced preparation carried out by the urban industries to mitigate the impacts on flood risks. This thinking facilitates the process of resilient practices, or faces the consequences of this detrimental event. The actions of retailers and their application of all types of knowledge learned from previous floods verify the effective process of social learning; the participants share, think, and act together according to their knowledge and skills to enhance their adaptive capacity. In addition, the retailers identified the knowledge necessary for adaptation, which includes the characteristic of the hazard, effective strategies to mitigate the impacts and methods for proper management of the situation. They could bridge and share experiences and identify gaps between the information obtained, even if the policies implemented are considered maladaptive. The local residents exhibited capacity superior to what is assumed by the public sector. Since the population of Meinung remains stable, it is necessary for the public sector to initiate further resilience practice that would include interactive visualization tools to guide urban industries toward a more effective adaptive procedure. The storytelling and sharing were a major enhancement of the community resilience. To further to enhance their flood resilience, we recommend that the Meinung community should focus on further proliferation on their knowledge of floods, raising the awareness of the flood management options available for the local community and collaborations with the local flood emergency and authorities. We also recommend integrating adaptive interventions in the long-term urban planning as a part of a comprehensive strategy to manage the impacts of climate change. Finally, we highlight the adaptive capacity influences the risk perceptions; the perceived risk determines the responses from the residents, specifically in their indigenous risk perceptions and behaviors, as in the case of Meinung's retailers, which are parts of the place-specific human-environment system.

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