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# A sustainable post-disaster housing development framework for an indigenous Hao-Cha community in Taiwan: Considering culture and livelihood in housing extensions

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## Abstract

**Purpose:** Several post-disaster housing extension and modification studies have indicated that owner-driven modification behavior relates to socio-economic and livelihood factors. This study clarifies housing extension patterns and examines the relationships among spatial characteristics, sociocultural factors, livelihood factors, and housing extensions. This research also highlights the implications of post-disaster housing design for indigenous communities.

**Design/methodology/approach:** An indigenous community case study was conducted using a literature review. Moreover, interview surveys and housing measurements were implemented based on purposive sampling to diversify interviewees' backgrounds and the extent of housing extensions.

**Findings:** This study confirms that housing extensions are closely related to the number of household members and their associated functions and cultural and livelihood factors that were ignored during the design stage. Furthermore, the housing extension process was confirmed to match households' economic recovery. A post-disaster housing implementation framework for the indigenous population is proposed.

**Practical implications and research limitations:** The study's proposed resilience post-disaster housing framework can be used to develop post-disaster housing design guidelines, which can benefit policymaking. The proposed participatory concept can be further adopted in future disaster risk-reduction programs. However, this research only targeted one indigenous community with a limited number of interviewees and samples due to the connection with households.

**Originality/value:** This study uniquely focuses on the pre- and post-disaster housing layout and the livelihood of an indigenous community. It offers valuable insights for post-disaster reconstruction planners and practitioners.

**Keywords** Indigenous community, housing extension, Typhoon Morakot, post-disaster reconstruction, socio-economic factors, livelihood

**Paper type** Research paper

## 1. Research background

In recent decades, the intensity and frequency of natural disasters have increased. Accordingly, there has been an increase in international concern about large-scale

catastrophic disasters (Arefian, 2018). Disaster risk reduction (DRR) measurement, a compound with the resilience concept, was introduced and widely applied in pre-and post-disaster projects (UNISDR, 2009). Especially in post-disaster situations, the resilience concept has been increasingly used to conceptualize the ideal characteristics of the built environment that can resist natural hazards and the impact of climate change (Johnson and Blackburn, 2014). Given the complexity of post-disaster reconstruction (PDR), the project encompasses multiple aspects, from a physical perspective, such as housing, site selection, and land use planning issues (Tucker et al., 2013; Tauber, 2015), and social perspectives, such as vulnerability and livelihood recovery (Chen et al., 2017; Naithani and Saha, 2020). However, some gaps remain in the literature regarding post-disaster social issues from spatial elements.

Typhoon Morakot struck Taiwan on August 8, 2009. The typhoon severely battered the central, southern, and eastern parts of the country. The unprecedented 2,854 mm of rainfall within three days drove large-scale landslides in the mountains. Typhoons damaged 1,764 houses, causing 699 people to die (Chen, 2010). Moreover, the indigenous population accounted for 73% of the total disaster victims (Hsieh, 2012), which caused post-disaster reconstruction to mainly target indigenous communities. After the disaster, the disaster-affected households were eventually relocated to the 44 permanent housing settlements scattered in disaster-affected counties. However, the reckless of disaster recovery programs, which lack of indigenous livelihoods and culture during the reconstruction process undermined the solidarity of indigenous communities (Hsu, 2015; Lin and Lin, 2016).

Due to the unsuitable permanent housing design, most indigenous permanent housing households have altered their living environments. Housing modification can be defined as the capacity of community resilience for residents to adjust to the new livelihood. The Hao-Cha tribal community, a Rukai ethnic group, which relocated to the largest indigenous permanent housing settlement in Pingtung County, had modified their permanent housing the most given the distinct environmental and livelihood changes. Due to the gap regarding the integration of physical and social perspective research and the scarcity of literature based on the indigenous context, given that housing extension behavior can be considered an important accommodation behavior to the new environment and change of livelihood, this research: 1) retrospectively traced the indigenous population's livelihood, culture, and spatial characteristics before a disaster; 2) clarified the relevant PDR background and post-disaster permanent housing spatial characteristics, analyzed in organized patterns, the housing modification that occurred in the indigenous people's relocated settlement, and sorted out the

modification incentives into pre-and post-disaster driven ones; and finally, 3) developed a resilience PDR framework for the indigenous population based on the existing literature and the results of this study.

This study is divided into six sections. First, the research background section introduces the context, rationale, and importance of conducting this research. Second, the literature review provided the concepts of resilience and PDR, culture and livelihood in an indigenous context, and housing extensions. Third, the criteria for case study selection and methodology are introduced. Fourth, the research results are presented. A resilience framework for indigenous permanent housing development is presented in Section Five, and Section Six presents the conclusions of the research.

## 2. Literature review

### 2.1. Resilience and post-disaster reconstruction (PDR)

The concept of resilience originated from ecology (Holling, 1973). It denotes the ability to cope with stress without changing the community's structure but enhances its ability to withstand future disaster impacts (Pelling, 2003). Given the increasing number of disasters, DRR concepts have also been introduced. For instance, the 1990s were known as the “decade for reducing disaster risks.” The Hyogo Framework for Action (HFA) 2005–2015 was marked as a paradigm shift to promote DRR actively (UNISDR, 2005). The Sendai Framework for Disaster Risk Reduction 2015–2030 further emphasized the interrelation of disaster and development from the DRR perspective, compounded with the concept of build back better (BBB), aiming to reconstruct the community to a more resilient status (UNISDR, 2015). After decades of development, Mannakkara et al. (2019) proposed a PDR framework comprising DRR, community recovery, and effective implementation. Jamshed et al. (2019) also provided a PDR framework that entails identifying beneficiaries, planning and design, economic revitalization, service delivery, and monitoring. The arrays of researchers were aware of the importance of encompassing physical and social perspectives when tackling PDR projects.

### 2.2 Culture and livelihood in an indigenous context

Culture has been defined as a complex whole that includes knowledge, belief, art, morals, law, custom, and any other capabilities and habits required as a member of society (Avruch, 1998). The resettlement authority should have a comprehensive understanding of disaster-affected people and communities (Siriwardhana et al., 2021).

The concept of livelihood was used to integrate social and economic disciplines, which have been widely adopted in development projects (Ayeb-Karlsson et al., 2016).

Régnier et al. (2008) argued that livelihood includes “means of living” and “a combination of resources used and the activities undertaken in order to live.” In the disaster-related context, DRR encompasses various activities, including livelihood, embracing pre-and post-disaster livelihood vulnerability (APEC, 2013). Livelihood resilience is also essential for livelihood recovery to achieve socio-economic self-sufficiency or self-reliance for a disaster-affected community (Weldegebriel and Amphune, 2017).

The United Nations stated that indigenous people have the right to define their indigeneity. These people grew up in a non-globalized culture and built their society accordingly (United Nations General Assembly, 2007), practicing culture-specific behavior and having their own cognitive styles. The worldview of indigenous people is rooted in human-land, human nature, and human relationships. Their culture’s indigenous livelihood and foundation closely interact with their land and natural resources (Kelman et al., 2012). However, in some scenarios, their culture and livelihoods may be threatened. This is particularly evident in the context of PDR. For example, in the Taiwanese indigenous context, Hsu (2015) argued that the post-colonial style PDR program and contemporary political dynamics further marginalized indigenous groups’ post-disaster livelihood. Lin and Lin (2016) argued that the cultural conflicts that arose during the reconstruction process, can undermine indigenous communities’ post-disaster recovery. Similarly, Taiban et al. (2020) stated that dynamic environmental changes and reckless reconstruction after the disaster forced indigenous populations to abandon their traditional agricultural livelihood.

### *2.3. Housing, culture, livelihood*

Regarding the relationship between housing, livelihood, and culture, Rapoport (1999) suggested that the housing environment, like all environments, should respond to human wants and needs. This means that the concept of housing is not just about the physical house but rather is interrelated with the family, household, and society. Moreover, housing embodies the culture, as reflected by its size, material, location, type, and other elements. As Rapoport (1983) reported, residents of developing countries usually apply a vernacular design to their housing. However, rapid cultural changes in developing countries have dramatically influenced and threatened local communities (Badura, 1986).

### *2.4. Post-disaster housing modification*

GhaffarianHoseini et al. (2014) found that discrepancies in housing size and configuration can cause dissatisfaction among residents and push them to implement a

series of housing extensions and alteration activities. This phenomenon was observed by Arimah and Adeagbo (2000) in Lagos, Nigeria. Considerations of safety and income generation led residents to expand their public housing. Kardash (1999) reported that in Cairo, Egypt, residents defied the laws and regulations and expanded their public housing units, thereby introducing the concept of extensible core housing.

Recently, research on housing extensions has been widely conducted in PDR, such as in Hambantota New Town, Sri Lanka, which was affected by the 2004 Indian Ocean tsunami. The study found that residents spent their deposits extending and improving the layout of permanent housing based on rudimentary planning guidelines, thereby deteriorating the quality of life (Ahmed and McEvoy, 2014). Carrasco et al. (2016) noted that in 2011, a bottom-up housing alteration upgrade intensified a dispute between the government and a relocated household after Typhoon Washi hit the Philippines. The government stated that the unsafe and precarious extension structure violated the building code and safety conditions. The relationship between the reconstruction framework and housing extension was also underscored by Dikmen et al. (2016) concerning the relocation of disaster-affected households after the 2000 earthquake in Cankiri, Turkey. The Turkish government rolled out a typical design provided by the Ministry and custom designs, which were empowered under an owner-driven pattern. The study revealed that the residents disliked the typical design because the layout was inappropriate for the local climate and culture. Such a design eventually requires more spatial modifications than the custom design.

Considering the aforementioned literature, it is clear that housing is an inclusive and collective activity influenced by the residents' livelihood, culture, and family circumstances. As such, indigenous people face greater challenges when formulating a sustainable housing environment, especially in exceptional cases such as the aftermath of a disaster. Although existing literature discusses housing extension issues in the PDR context, there is no studies on post-disaster housing extensions for the indigenous population and the linkage between spatial elements and socio-economic aspects.

### **3. Methodology**

#### *3.1 Case selection*

Taiwan has been deemed a disaster-prone region, with typhoons comprising more than 80% of its natural disaster events (Daly, 2016). Typhoon Morakot, which hit the southern part of Taiwan, brought unprecedented precipitation in the southern mountain areas. Although the indigenous population only accounts for 2% of Taiwan's total population, due to the concentration of rainfall in the country's mountainous areas,

more than 73% of the disaster-affected population are indigenous people (Hsieh et al., 2012). Therefore, Typhoon Morakot is a suitable disaster event for this study, given the numerous indigenous affected households.

Among them, one disaster-affected indigenous community, the Hao-Cha, was chosen as the study object. There are several reasons for selecting this case study. First, the original settlement was eradicated due to Typhoon. The residents had no choice but to relocate to a remote permanent housing settlement. The residents faced drastic livelihoods and environmental changes. Second, the 177 households had moved to the Rinari permanent housing settlement, located in Pingtung County, after the typhoon, which was the largest indigenous community relocation project in Taiwan. Third, the Hao-Cha households had the most obvious housing extensions.

### *3.2 Research Method*

To understand how livelihood and culture influence housing extensions, this study adopted a case-study approach. Due to the wide range of explored aspects, a triangulation method (Mertens and Hesse-Biber 2012)—a combination of quantitative and qualitative methods—was used for data collection. The research methodology included 1) semi-structured interviews, 2) a housing measurement survey, and 3) secondary document reviews. First, a pilot field trip to the Hao-Cha Rinari community began in August 2017. Three households were interviewed to understand the major changes in livelihood and culture after the disaster. Based on the site observations, the housing extension patterns for five different situations were determined. After the pilot fieldwork, semi-structured interviews and housing measurements were conducted in February and August 2018, April, and August 2019. Among the 177 households, 28 households were selected for the interview and housing measurement. The interviewees were selected based on purposive sampling. The sampling considered the respondents' background and the variety of the extent of housing extension to diversify and unbiased the research results (Including two housekeepers, nine salaried employees, eight self-employed, three civil servant or community organization leader, and six retired interviewees). All residents were aged 30 to 80, who reside in the Rinari settlement. Given that their indigeneity might differ generationally, the diversity of age of interviewees was important. The interview abstract including their pre- and post-disaster livelihood culture, as well as the motivation of housing extension. Secondary document reviews included government publications and relative news.

Approval for data collection was obtained from the interviewees. The interviews were recorded and analyzed. Although most of the interviewees had high proficiency in

Mandarin, interviews were conducted with two aged interviewees via the translation of local villagers. Hand measurements and drone video obtained the housing measurement data. The data were then drawn and presented using AutoCad to obtain the extension areas. The quantitative data were analyzed by R. All data screening and cleaning procedures were implemented, and no data were outliers or missed. A flowchart of the research methodology is provided in Figure 1.

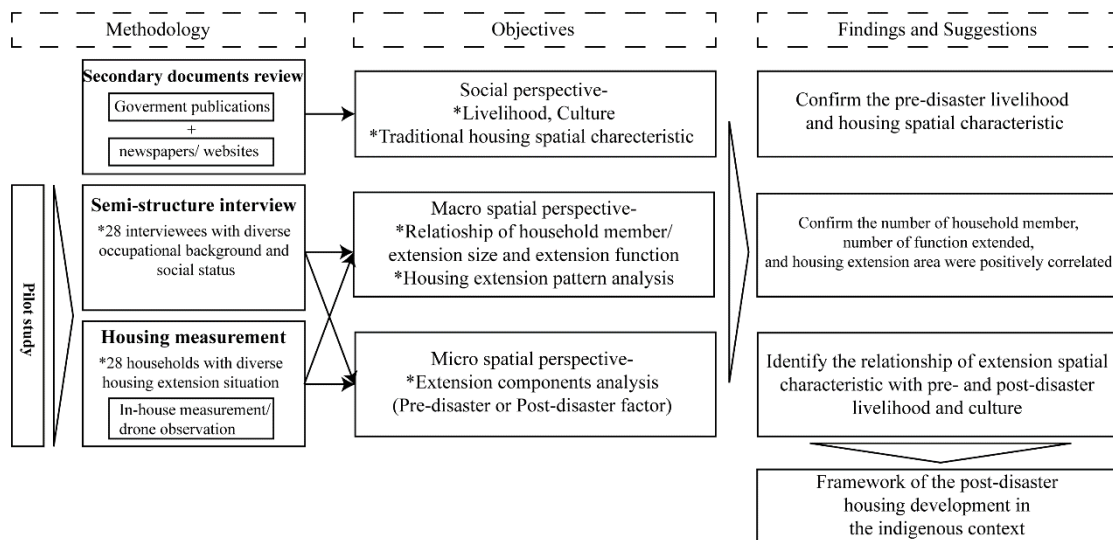


Figure 1. Research methodology flowchart

#### 4. Research findings

The Hao-Cha community belongs to the indigenous ethnic group called the “*Rukai*.” [1] The total population of the Rukai is 13,443 people, and the Hao-Cha community accounts for 3.7% of Rukai’s total population. The community was originally located at the North Dawu Mountain, Wutai Township, Pingtung County, 600 m away from the South Ai-Liao River [2] (National Council for Aborigines, 2019), which the villagers named the Old Hao-Cha settlement.

As the Old Hao-Cha settlement became isolated and without its electricity supply, the government relocated the Hao-Cha community (from 1975 to 1977) from the Old Hao-Cha to the South Ai-Liao River terrace, 200 m from the South Ai-Liao River (Taiban, 2016). This new site is called the New Hao-Cha settlement. However, the New Hao-Cha was not safe and was prone to typhoons and landslides.

On August 8, 2009, Typhoon Morakot brought a rainstorm that caused a landslide in the New Hao-Cha settlement. Eventually, the New Hao-Cha settlement was buried under the earth, and the government immediately evacuated its residents to emergency



shelters. The Hao-Cha community was asked to evacuate to the Ai-Liao military camp as a temporary shelter. Afterward, they concurred with the Pingtung County Government and moved to the Rinari settlement in 2010 (Figure 2).

Following the post-disaster reconstruction law, the disaster-affected people were relocated under the cooperative framework of the local government and large-scale non-governmental organizations (NGOs). To accelerate the construction process and save the budget, the government decided to skip the temporary housing stage and construct permanent housing directly and prioritized the relocation policy. However, given indigenous communities' strong attachment to their land, a great dispute occurred between the government and indigenous households, including the Hao-Cha community.

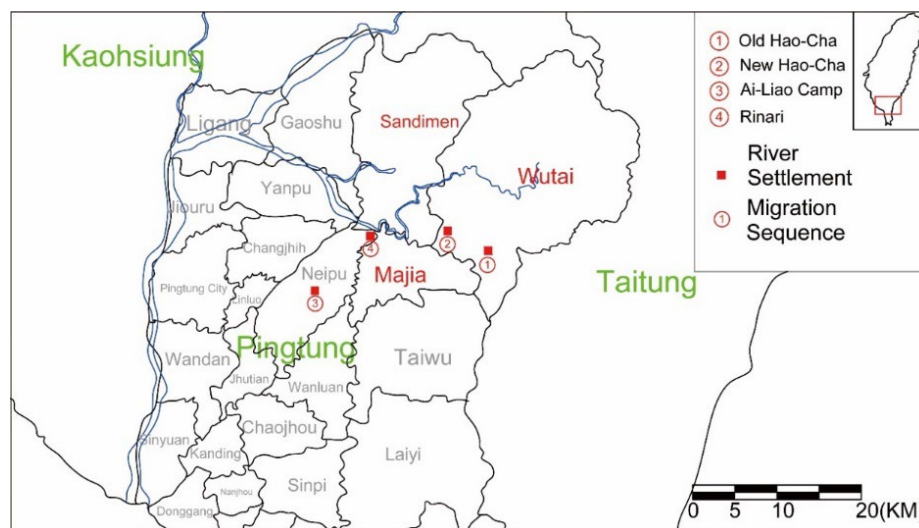


Figure 2. The locations of and distances between the three settlements

#### 4.1 The people's pre-disaster livelihood

In the Old Hao-Cha settlement site, housing was constructed using a slate, as this material was available in the nearby mountains. The residents stated that the slate material was strong against the elements and could last for generations. The structure is resilient to earthquakes and typhoons. Typically, the width of the slate wall was 25 cm, and the size of the slate houses was 8 m × 8 m.

Traditional slate houses can be divided into main spaces, subsidiary spaces, and front yards. The main and subsidiary spaces were interior areas, while the front yard was an external space. Regarding function, the family's dining and social activities took place in the main space. Meanwhile, the subsidiary space was located alongside the main space and was used to store crops, such as pig houses, toilets, and sleeping quarters.

Agriculture was the source of livelihood in the Old Hao-Cha settlement. Because of long-term disconnection to industrialization, traditional Hao-Cha residents practiced slash-and-burn cultivation in a self-sufficient manner. Crops such as millets, sweet potatoes, taro, and peanuts were alternately planted or mixed. Following the traditional tribal social hierarchy system, the Old Hao-Cha settlement was led by the chieftain, followed by the noble class, which consisted of the relatives of the chieftain and the civilian class .

Aside from self-sufficient agricultural activities, handcrafting and weaving were part of people's livelihoods. Such activities were usually conducted at the front yard. Hence, the front yard space was a significant spatial characteristic of the traditional Hao-Cha slate house. The pavement was decorated with slate furnitures, such as slate tables and chairs.

Given the isolated geographical conditions and the challenge of administering the Old Hao-Cha community, in keeping with the government's "modernization policy" for indigenous populations, the Hao-Cha residents were relocated to the New Hao-Cha settlement in 1977. However, this decision was not made in consultation with the residents but rather for the government's convenience. The policy called for a universally designed housing that in the 1970s was considered "fashionable and civilized". The universally designed housing was significantly distinct from the traditional slate housing. The new housing had a brick structure with a sloped tiled roof. The housing layout was approximately 4–4.5 m × 10 m, depending on the number of family members, and its layout was much smaller than that of traditional housing. Thirty years after the relocation, Lee (2012) found that most households extended their housing. The extension compensated for a small living space. An annex to the main housing unit served as storage for agricultural products, a legacy from the Old Hao-Cha period. Most households continued to practice self-sufficient agricultural activities. Despite the parapet surrounding the housing unit's construction lot, the front yard space with the slate table remained important in the spatial characteristics of the New Hao-Cha housing. As a legacy from Old Hao-Cha, residents continued to chat and perform collective activities in the front yard space.

#### *4.2 The design and construction of post-disaster housing*

After Typhoon Morakot, Hao-Cha households were relocated to the Rinari settlement. The Rinari settlement also accommodated two other indigenous disaster-stricken communities (the Da-She and Ma-Ja communities). With 483 households aggregated together in the Rinari settlement, it became the largest post-disaster settlement in Pingtung County, in which the Hao-Cha accounted for 177 households. Despite easy

access to cities, the Hao-Cha residents found themselves distanced from their homes.

An architectural studio experienced in PDR-related projects and had previously worked with NGO-A assisted in the design and planning of the Rinari settlement. The construction team believed that it was challenging to build a spotless “home” for the indigenous population to satisfy every cultural and livelihood requirement. Hence, the team invited residents to participate in the workshop. Initially, the residents proposed using the traditional slate as the construction material. However, because of budgetary constraints and technical issues, the proposal was rejected. Eventually, the residents accepted light steel for the structure and wooden stick material as the housing envelope. The advantages of such a structure lie in its simplicity, quick construction, and low cost. Generally speaking, housing material and design differed from traditional slate housing in the Old Hao-Cha period due to several constraints. Given this situation, a 3,333 USD subsidy entitled the “indigenous housing façade renovation budget” was dispensed to each household to decorate the housing. However, the residents stated that the money was inadequate. It is fair to say that although the government relocated the Hao-Cha community to the Rinari settlement, thereby ensuring their living security, the ignorance of indigenous culture and the hash PDR schedule depressed the chance of community participation.

For the design of permanent houses, there are two alternatives: single or duplex. After the residents discussed their preferences with the team, the team planned the settlement according to the number of each type of permanent house. Regardless of the number of family members, the post-disaster housing units were uniform at 105.6 m<sup>2</sup> or used a square-shaped layout of 7.32 m x 7.32 m with two floors. Therefore, the duplex type had a floor area of 211.2 m<sup>2</sup>. The housing layout was slightly larger than that of other post-disaster settlements. One housing unit consisted of a kitchen, living room, bathroom, and bedroom on the first floor, while the second floor had a bathroom and three bedrooms.

#### *4.3 Basic housing extension attributes of the Hao-Cha community in Rinari*

Housing measurements and household interviews were conducted to understand the housing extension pattern. Information on the gender, occupation, extension functions, number of family members, and extension floor area are listed in Table I. All 28 surveyed and measured households extended their houses. First, Spearman’s correlation was used to understand the relationship between the housing extension floor area and the number of household members and extended functions. The results showed a significant positive correlation between the number of household members and the

extension floor area ( $\rho = 0.44$ ), indicating that the larger the number of family members, the larger the extension area. Additionally, the results revealed a significant positive correlation between the number of functions extended and the extension floor area ( $\rho = 0.87$ ). Thus, the extended floor areas were positively correlated with the number of households and the number of functions. More specifically, the extension of the houses was partly driven by household size and the desire to diversify housing functions. In addition to the quantitative data, this research also plotted the 28 measured Hao-Cha households in Figure 3, which shows the housing plot, extension area, and functions in different colors. The 28 households can be categorized into five distinct extension prototypes: 1) front yard extension; 2) front yard and back yard extension; 3) front yard, left side, right side, and back yard extension; 4) front yard, left side, right side, back yard extension, and 5) multiple floor extension.

As shown in Figure 3, all surveyed households expanded their front yard spaces. The interviewees stated that the original front yard was too narrow to accommodate neighbors for daily gathering, which was an essential practice back in the Old Hao-Cha and the New Hao-Cha settlements; thus, the front yard extension was needed. Another reason for altering the front yard space was that the government reimbursed residents from the “indigenous housing façade renovation budget” to renovate their housing (pattern one). Households that needed more living space spent their budgets to expand the backyard space. The back yard space usually served as the kitchen and dining area, as the original layout for the kitchen was placed on the back of the housing unit. Nine households belonged to this category (pattern two). Meanwhile, left- and right-side extensions were built by ten households, wherein a working space, studio, garage, and storage were added to diversify the housing function (pattern three). Two other households renovated their original kitchen space into a working space, as the new kitchen had been placed in the back yard to extend it further and diversify the living floor area and function (pattern four). Finally, three households that had a restaurant, shop, and hostel business extended their housing units with additional floor(s) for family use and business purposes. Two households added a second floor, and one extended to a third floor (pattern five).

Regarding the distribution and number of extended functions, 20 (15) households chose to extend their storage (kitchen). This indicates that storage, kitchen, and dining functions are fundamental requirements for most households.

An analysis of these five patterns of housing extensions reveals that housing extensions were done gradually and continuously. Consistent with the economic recovery process,

each household made gradual improvements to the functions and living areas of the post-disaster housing units because the associated costs were a tremendous burden on these households. The functions were also gradually extended to enhance housing conditions. For example, a household generally extended its kitchen and storage to fulfill this fundamental need and then made further extensions to satisfy income generation requirements.

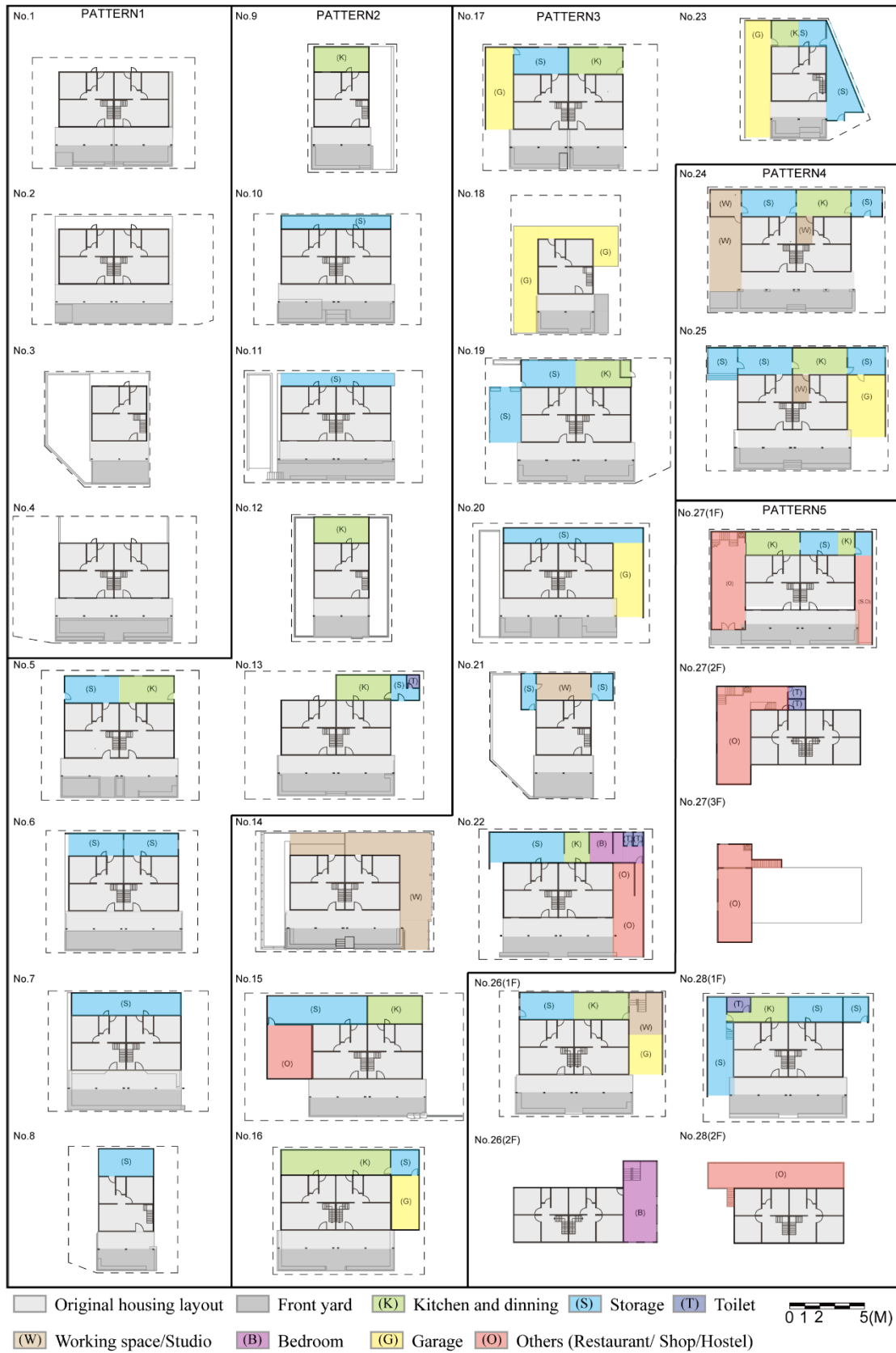


Figure 3. The floor plans of 28 Hao-Cha households

#### 4.4 How the housing extension relates to the residents' culture and livelihood

Besides providing an overall understanding of the housing extension patterns, plotting the four typical examples of housing extensions reveals the spatial characteristics related to the culture and livelihood of the residents.

##### (1) Traditional culture and livelihoods.

It was confirmed that some of the housing extension characteristics were related to the traditional culture and livelihood in the Old Hao-Cha and New Hao-Cha settlements. First, 15 households were motivated by the traditional Hao-Cha food culture to extend their kitchens. According to the residents, during important ceremonies such as weddings, harvest festivals, and formal community gatherings, traditional food like the “*chinavu*” and “*abai*” must be available on the dining table. Both dishes are made using the traditional crop millet and are bound by the leaf of the shell ginger before being placed into steam cases for cooking. Therefore, a large kitchen space with a sizeable steam case is essential for the Hao-Cha residents. Nonetheless, the originally provided kitchen space was too small for the steam case. Hence, the residents constructed additional kitchen spaces at the back of the housing unit (Figures 4a and Plate 1a). Since some of the households consisted of relatives who resided in the same permanent duplex housing unit, they decided to merge the two housing units by combining the kitchen space in the backyard (Figure 4b). Meanwhile, the initially provided kitchen space was used for other purposes (e.g., food storage without cooking activities; Plate 1b).

Second, although most of the Hao-Cha residents lost their arable land after the relocation, some households borrowed arable land from the private sector to revive their agricultural livelihood. Accordingly, some residents put the barn for the millet behind the kitchen to preserve the millet (Figure 4c and Plate 1c). Moreover, some storage extensions were used as cabinets for farming tools. These findings indicate a profound relationship between agricultural activities and housing spatial characteristics, which can be interpreted as an inheritance from the Old Hao-Cha period.

Third, as previously mentioned, the Hao-Cha people used the front yard space as a semi-public area for gathering with other villagers. This habit continued in the Rinari settlement. Noticeably, all residents applied the slate material as an essential component of the front yard decoration. As shown in Figures 4a, 4b, and 4c and Plate 1d, the slate material was used on the pavement of the front yard and for the chairs and tables. Plate 1g, 1h, and 1i indicates that some households portrayed their family stories on the parapet of the extended front yard to express their cultural identity (Plate 1g and 1h

were the duplex type of housing, while Plate 1i was the single type of housing). Additionally, some families belonging to the noble class had an exhibition area in the house's interior that proudly showed their cultural identity and indigeneity (Plate 1e).

(2) Post-disaster livelihood

The disaster had a significant economic impact on most households. Hence, aside from cultural and self-sufficiency purposes, some households established restaurants and hosted family businesses to earn extra income. As shown in Figure 4c and Plate 1f, the housing units were extended to include a modern kitchen and a restaurant for serving customers with indigenous dishes. Moreover, as shown in Figure 4d, the first floor was extended to serve as an indigenous handicraft studio and additional rooms to host guests on the second floor. Some households proactively participated in the revitalization initiative and further extended their houses. However, other households encountered financial challenges in expanding their houses for business purposes. Accordingly, the financial discrepancy among households might widen because of housing extension behavior. Furthermore, the government deemed these housing extensions unlawful because they did not go through the legal procedure before construction and lacked supervision by professionals. Disputes regarding some extensions were amplified ten years after the disaster (CNA, 2020).

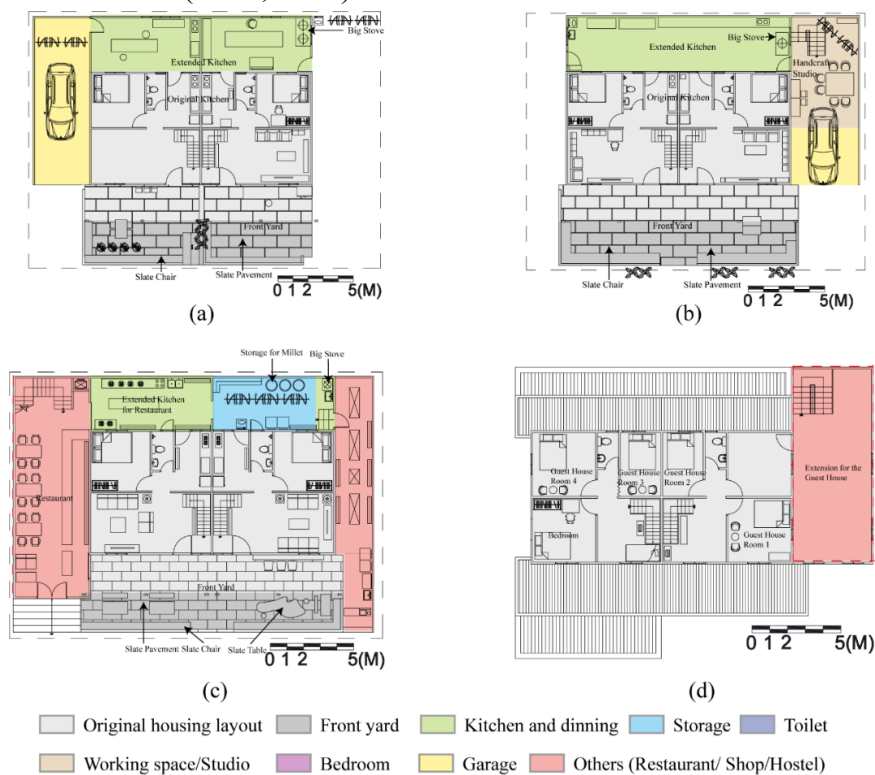
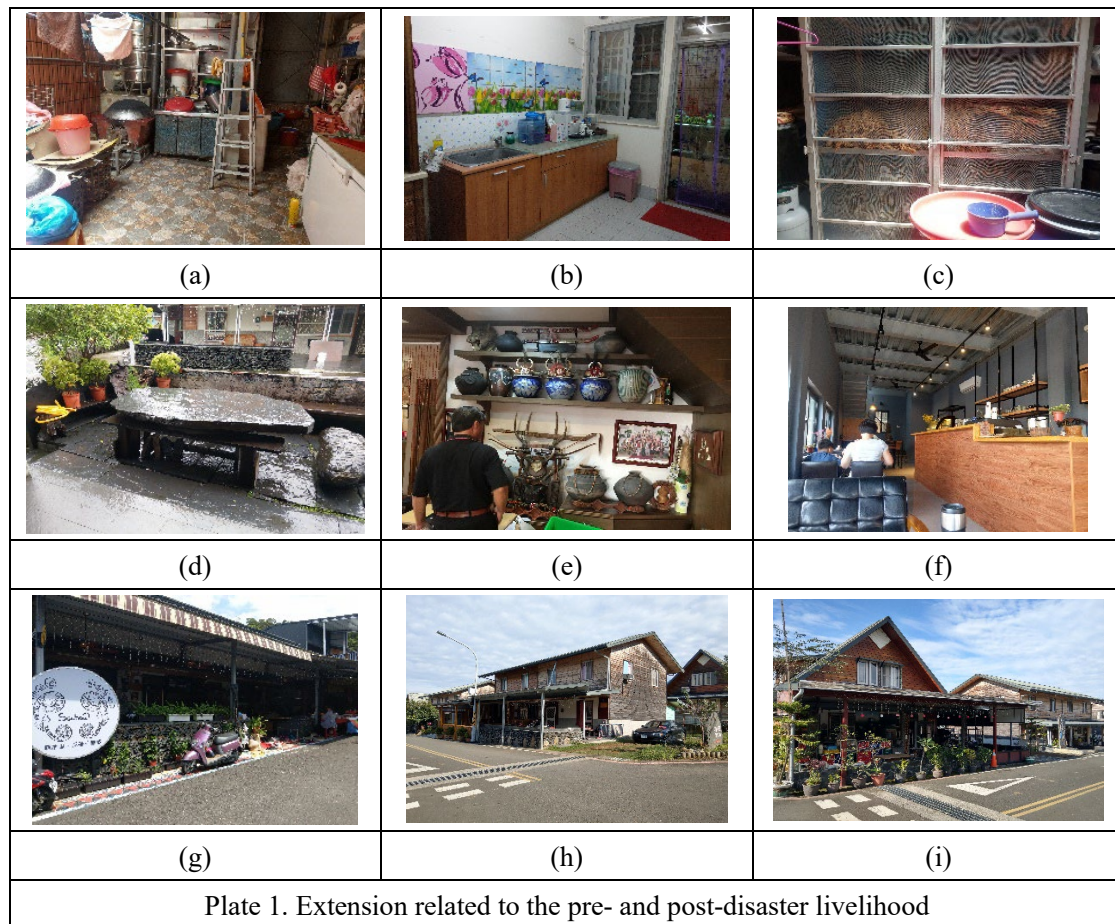


Figure 4. Permanent housing plan for the four selected extended households





In this section, it is evident that spatial characteristics were influenced by multiple perspectives related to the communities' pre-and post-disaster circumstances and people's indigeneity. The motivation of housing extension ranging from providing a satisfactory living space, catering to traditional livelihood, expressing one's identity and indigeneity, and catering to post-disaster livelihood.

## 5. Proposed framework

Considering the abovementioned findings, a framework for implementing sustainable post-disaster housing for indigenous communities is proposed here. The framework (Figure 5) is multi-stage to facilitate implementation, consisting of preparedness, initiation, planning and construction, monitoring, and readjustment (Bilau et al., 2015; Bilau et al., 2018).

First, the framework suggested that some countermeasures should be taken to build a foundation for indigenous post-disaster housing development during pre-disaster preparedness. The council of indigenous peoples—a government department should outsource research projects to university researchers to conduct the livelihood, cultural, socio-economic, and housing investigation in the disaster-prone indigenous

communities (1). These achievements can be an essential database for future indigenous post-disaster housing development design guidelines. Conversely, the council of indigenous peoples should also allow some capacity-building NGOs, which trust the indigenous population to the indigenous community to enhance the indigenous residents' human capital for participatory design and discussion with outside stakeholders (2).

At the initial stage, the Ministry of Interior, which is in charge of PDR projects, should ratify clear PDR implementation regulations, encourage bottom-up strategies, and encourage local participation in the design and construction process (3). Moreover, the Ministry of Interior should release a new building code that applies to the local indigenous population, adopting vernacular construction skills and styles (4). A committee formed by the government and indigenous representatives should be established to scrutinize the eligibility of the NGOs and architects who assist the PDR projects (5).

For the planning and construction stage, the database gathered from the pre-disaster period should be fully used by the NGOs and architects to facilitate decision-making regarding the housing layout and the materials that suit the local climate, site, culture, indigenous skills, and socio-economic conditions (6). The design and construction process should allow proactive participation of the communities, allowing variation or alternation for the residents afterward and with the envision for future livelihood restoration (Tucker et al., 2014). The disaster reconstruction committee—a government sector established for the specific PDR project—should secure adequate time and funds for the communities, NGOs, and architects to finish the design and construction process without sacrificing indigenous livelihoods and culture (7).

After the completion of the post-disaster reconstruction project, monitoring and adjustment are essential. Some detailed regulations regarding post-disaster housing extension in the legislative framework are necessary given the ubiquitous yet unlawful extension behavior, which needs to be solved by the Ministry of Interior and Council of Indigenous peoples (8). Residents should be able to discuss and construct the extension of post-disaster housing under the government's and NGOs' supervision to ensure living safety (9). Communication platforms initiated by the government should be established to allow communities to address problems and for the government and NGOs to alleviate any potential socio-economic discrepancies in the communities (10).

The feature of the framework is that it targets the indigenous disaster-prone community,

which the relative field has not studied. Additionally, a comprehensive process including every stakeholder can provide practitioners with a clear direction to follow. Last, the framework considers the DRR and participatory concept, facilitating a resilient post-disaster community. However, this framework requires appropriate adjustments to accommodate the various post-disaster scenarios.

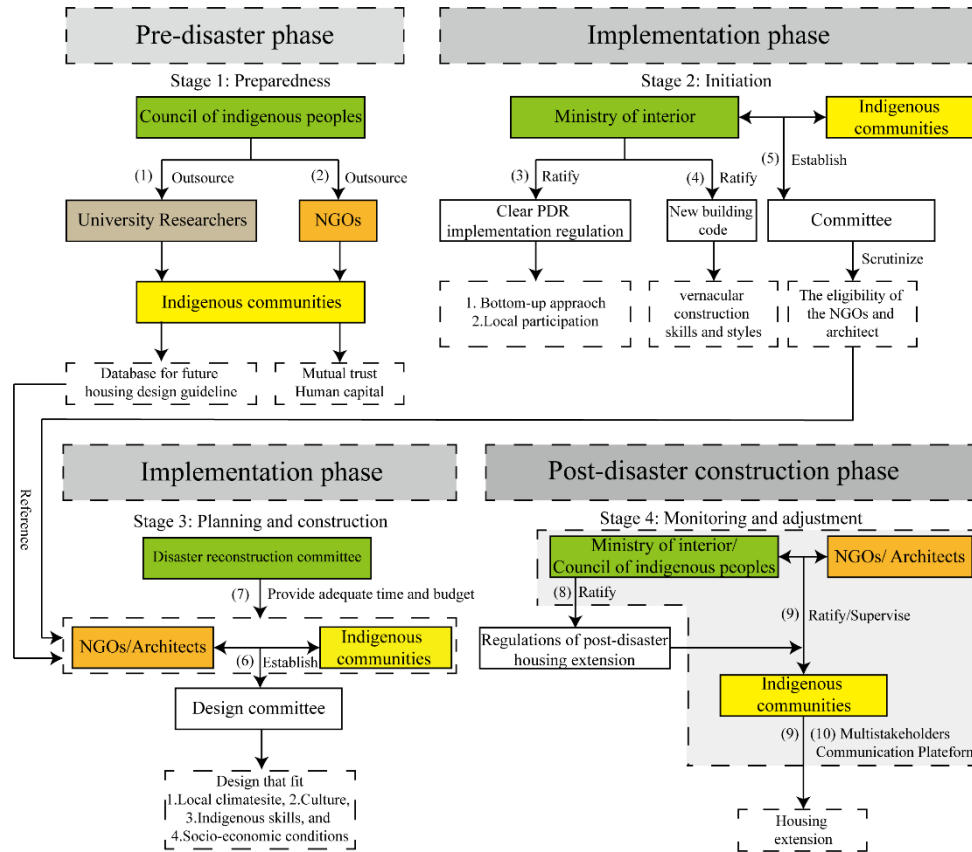


Figure 5. A resilience post-disaster housing framework for the indigenous population

## 6. Discussion and Conclusion

Given the scarcity of literature regarding the comprehensive understanding of spatial characteristics and socio-economic factors in the PDR context, using the indigenous Hao-Cha community after Typhoon Morakot, this research indicated that the post-disaster housing extension was closely interrelated with the indigenous population's pre-and post-disaster livelihood and culture factors. From the viewpoint of DRR and resilience, the government relocated the Hao-Cha community to a safer settlement without the threat of future natural disaster risk. However, given the limitations of time, budget, and knowledge of indigenous culture, the participatory scheme initiated by the NGO and architect was limited, thereby hampering the indigeneity of the disaster-affected households. Housing extension could secure their livelihoods and culture.

The research findings can expand the findings of Rapoport (1999) in the post-disaster

context and compensate for the findings of Hsu (2015) and Lin and Lin (2016). This research showed that the PDR policy after Typhoon Morakot undermined the solidarity of indigenous communities and deprived the local community's participation in the design process, and motivated the housing extension. Similar to Carrasco et al. (2016), this research showed that unlawful housing extensions might hamper future livelihood restoration opportunities and deteriorate the relationship with the government. Moreover, this research also enriched post-disaster inequality research (Häberli, 2013; Kammerbauer and Wamsler, 2017), which suggested that post-disaster housing extensions might contribute to post-disaster economic inequality within the households in the community. Given that post-disaster housing development in the indigenous context remained unclear and untouched, this research also proposed a comprehensive resilience post-disaster housing development framework for the indigenous community. Integrating the concept of DRR, the framework ranges from preparedness, initiation, planning and construction, monitoring and readjustment, and the participatory concept, including all-rounded stakeholders, to construct a resilient post-disaster community.

This study had several limitations. First, given the relationship with households, only one community with 28 households was selected under purposive selection. Therefore, although the research presented the majority of the community extension situation, some minor cases might have been overlooked. Second, although a relatively holistic perspective was applied in the research, some factors might have been overlooked because of the design of the research methodology. In the future, this research can expand its findings by researching other indigenous and Chinese disaster-affected communities to compare the reasons and extent of housing extensions.

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### Notes

1. Rukai is the seventh-largest of the 14 officially recognized indigenous groups in Taiwan. "Rukai" means "people living in the mountain."
2. The south Ai-Liao River is a tributary of the Gaoping River in Taiwan. It flows through Kaohsiung City and Pingtung County for 68.5 km. The South Ai-Liao River has been regarded as a holy river in the Hao-Cha traditional culture.

### Reference

1. Ahmed, I., and McEvoy, D. (2014), "Post-tsunami Resettlement in Sri Lanka and India: site planning, infrastructure and services", *International Journal of Disaster Resilience in the Built Environment*. DOI: 10.1108/IJDRBE-08-2012-0028
2. APEC (2013), "Building natural disaster response capacity: sound workforce strategies for recovery and reconstruction in APEC economies", working paper, APEC Natural Disaster Workforce Project, November.

3. Arefian, F. F. (2018), *Organising Post-Disaster Reconstruction Processes: Housing Reconstruction After the Bam Earthquake*, P5, Springer, Switzerland. DOI: 10.1007/978-3-319-70911-6\_5
4. Arimah, B. C., and Adeagbo, D. (2000), "Compliance with urban development and planning regulations in Ibadan, Nigeria", *Habitat International*, Vol. 24 No. 3, pp. 279-294. DOI: 10.1016/S0197-3975(99)00043-0
5. Avruch, K. (1998). "Culture & conflict resolution", US Institute of Peace Press, Washington, D.C. Available at: [https://books.google.co.jp/books?hl=zh-TW&lr=&id=OofmUheyGJAC&oi=fnd&pg=PR9&dq=k+avruch+culture+and+conflict+resolution+&ots=bNcunOWnRs&sig=ORzCPQdHWKXZCXHpodGEq7\\_AE9E&redir\\_esc=y#v=onepage&q=k%20avruch%20culture%20and%20conflict%20resolution&f=false](https://books.google.co.jp/books?hl=zh-TW&lr=&id=OofmUheyGJAC&oi=fnd&pg=PR9&dq=k+avruch+culture+and+conflict+resolution+&ots=bNcunOWnRs&sig=ORzCPQdHWKXZCXHpodGEq7_AE9E&redir_esc=y#v=onepage&q=k%20avruch%20culture%20and%20conflict%20resolution&f=false) (accessed 12 May, 2021)
6. Ayeb-Karlsson, S., van der Geest, K., Ahmed, I., Huq, S., and Warner, K. (2016), "A people-centred perspective on climate change, environmental stress, and livelihood resilience in Bangladesh", *Sustainability Science*, Vol. 11 No. 4, pp. 679-694. DOI: 10.1007/s11625-016-0379-z
7. Badura, B. (1986). "Social Networks and the Quality of Life", *The Quality of Urban Life: Social, Psychological, and Physical Conditions*, Walter de Gruyter, Berlin, pp. 55-60. DOI: 10.1515/9783110884968.55
8. Carrasco, S., Ochiai, C., and Okazaki, K. (2016), "Impacts of resident-initiated housing modifications in resettlement sites in Cagayan de Oro, Philippines", *International journal of disaster risk reduction*, Vol. 17, pp. 100-113. DOI: 10.1016/j.ijdrr.2016.05.001
9. Chen, J.C. (2010), *One Year Later—Reconstruction after Morakot*, Post-Disaster Reconstruction Council, Executive Yuan, Kaohsiung, Taiwan
10. Chen, Y., Tan, Y., and Luo, Y. (2017), "Post-disaster resettlement and livelihood vulnerability in rural China", *Disaster Prevention and Management: An International Journal*. DOI: 10.1108/DPM-07-2016-0130
11. Daly, P. (2016), "Cycles of destruction and reconstruction: responding to disasters in Asia", *Rebuilding Asia following natural disasters: Approaches to reconstruction in the Asia-Pacific region*, Cambridge University Press, Cambridge, UK, pp. 1-56. DOI: 10.1017/CBO9781139683548.002
12. Dikmen, N., and Elias-Ozkan, S. T. (2016), "Housing after disaster: A post occupancy evaluation of a reconstruction project", *International Journal of Disaster Risk Reduction*, Vol. 19, pp. 167-178. DOI: 10.1016/j.ijdrr.2016.08.020
13. GhaffarianHoseini, A., Berardi, U., Dahlan, N. D. (2014), "What can we learn from Malay vernacular houses?", *Sustainable Cities and Society*, Vol. 13, pp. 157-170. DOI: 10.1016/j.scs.2014.04.008
14. Häberli, I. (2013), "Aid distribution after hurricane mitch and changes in social capital in two nicaraguan rural communities", *Post-disaster reconstruction and change: Communities' perspectives*, pp. 31-54. DOI: 10.1201/b13027-3
15. Holling, C. S. (1973), "Resilience and stability of ecological systems", *Annual review of ecology and systematics*, Vol. 4 No. 1, pp. 1-23. DOI: 10.1146/annurev.es.04.110173.000245
16. Hsieh, Z.H., Fu, Z.H., Chen Z.C., and Lin, W.Y. (2012), "A road farther and farther away from the original hometown?: Rethinking the policy of reconstruction in different places after Typhoon Morakot", *National Taiwan University Social Work Review*, Vol. 26, pp. 41-86.
17. Hsu, M., Howitt, R., and Miller, F. (2015), "Procedural vulnerability and institutional capacity deficits in post-disaster recovery and reconstruction: Insights from Wutai Rukai experiences of Typhoon Morakot", *Human Organization*, Vol. 74 No. 4, pp. 308-318. DOI: 10.17730/0018-7259-74.4.308
18. Jamshed, A., Rana, I. A., McMillan, J. M., and Birkmann, J. (2019), "Building community resilience in post-disaster resettlement in Pakistan", *International Journal of Disaster Resilience in the Built Environment*. DOI: 10.1108/IJDRBE-06-2019-0039
19. Johnson, C., and Blackburn, S. (2014), "Advocacy for urban resilience: UNISDR's making cities resilient campaign", *Environment and Urbanization*, Vol.26 No. 1, pp. 29-52. DOI: 10.1177/0956247813518684
20. Kammerbauer, M., and Wamsler, C. (2017), "Social inequality and marginalization in post-disaster recovery: Challenging the consensus?", *International journal of disaster risk reduction*, Vol. 24, pp. 411-418. DOI: 10.1016/j.ijdrr.2017.06.019
21. Kardash, H. (1999), "Breaking Through the Barrier of Standardization", *Housing Provision and Bottom-up Approaches: Family Case Studies from Africa and South America*, Ashgate Publishing

- Ltd., Aldershot, UK, pp. 55-76. DOI: 10.4324/9780429452390-3
22. Kelman, I., Mercer, J., and Gaillard, J. C. (2012), "Indigenous knowledge and disaster risk reduction", *Geography*, Vol. 97 No. 1, pp. 12-21. DOI: 10.1080/00167487.2012.12094332
  23. Lee, Y.C. (2012), "A study for Exterior space improvement of relocated village and homeland recognition after disaster-a case study of Hao-Cha tribe in Rinari", unpublished master thesis, National Taiwan University, Taiwan.
  24. Lin, J. J., and Lin, W. I. (2016), "Cultural issues in post-disaster reconstruction: the case of Typhoon Morakot in Taiwan", *Disasters*, Vol. 40 No. 4, pp. 668-692. DOI: 10.1111/disa.12172
  25. Mannakkara, S., Wilkinson, S., and Potangaroa, R. (2019), *Resilient Post Disaster Recovery through Building Back Better*, Routledge, Abingdon, UK. DOI: 10.1201/9781315099194-11
  26. Mertens, D. M., and Hesse-Biber, S. (2012), *Triangulation and mixed methods research: Provocative positions*, SAGE Publications, Los Angeles, CA. DOI: 10.1177/1558689812437100
  27. Naithani, S., and Saha, A. K. (2020), "Social capital and livelihood strategies in response after 2013 Kedarnath disaster (India)", *Disaster Prevention and Management: An International Journal*. DOI: 10.1108/DPM-07-2019-0221
  28. National Council for Aborigines. (2019), "Demographic information of Taiwanese ethnic group", available at:<https://www.apc.gov.tw/portal/docList.html?CID=277F552950733982&type=D553881BB72C42C9D0636733C6861689> (accessed 20 February 2020).
  29. Pelling, M. (2003), *The vulnerability of cities: natural disasters and social resilience*, Earthscan, UK. DOI: 10.1061/(ASCE)1527-6988(2004)5:4(195.2)
  30. Rapoport, A. (1983), "Development, culture change and supportive design", *Habitat International*, Vol. 7 No. 5-6, pp. 249-268. DOI: 10.1016/0197-3975(83)90076-0
  31. Rapoport, A. (1999), "On the relationship between family and housing", *Housing Provision and Bottom-up Approaches-Family Case Studies from Africa, Asia, and South America*, Ashgate Publishing Ltd., Aldershot, UK, pp. 1-36. DOI: 10.4324/9780429452390-1
  32. Régnier, P., Gaillard, J. C., Texier, P., Neri, B., Scuteri, S., and Miniati, S. (2008), "From emergency relief to livelihood recovery", *Disaster Prevention and Management: An International Journal*. DOI: 10.1108/09653560810887329
  33. Siriwardhana, S. D., Kulatunga, U., Samaraweera, A., and Shanika, V. G. (2021), "Cultural issues of community resettlement in Post-Disaster Reconstruction projects in Sri Lanka", *International Journal of Disaster Risk Reduction*, Vol. 53, 102017. DOI: 10.1016/j.ijdrr.2020.102017
  34. Taiban, S. (2016), *History of the Hao-Cha tribe*, Taiwan History Center Publisher, Taipei, Taiwan.
  35. Taiban, S., Lin, H. N., and Ko, C. C. (2020), "Disaster, relocation, and resilience: recovery and adaptation of Karamemedesane in Lily Tribal Community after Typhoon Morakot, Taiwan", *Environmental Hazards*, Vol. 19 No. 2, pp. 209-222. DOI: 10.1080/17477891.2019.1708234
  36. Tauber, G. (2015), "Architects and rural post-disaster housing: lessons from South India", *International Journal of Disaster Resilience in the Built Environment*. DOI: 10.1108/IJDRBE-07-2013-0025
  37. Tucker, S., Gamage, A., and Wijeyesekera, C. (2014), "Some design aspects of sustainable post-disaster housing", *International Journal of Disaster Resilience in the Built Environment*. DOI: 10.1108/IJDRBE-06-2012-0019
  38. UNISDR (2005), "World conference on disaster reduction, Kobe, Hyogo, Japan Hyogo framework for action 2005-2015: Building the resilience of nations and communities to disasters, (No. A/CONF.206/6)", World conference on disaster reduction. Kobe, Hyogo, Japan, available at: <https://www.undrr.org/publication/world-conference-disaster-reduction-proceedings-conference> (Accessed 2 May 2021).
  39. UNISDR (2009), "UNISDR terminology on disaster risk reduction", UNISDR, Geneva, Switzerland, available at:<https://www.undrr.org/publication/2009-unisdr-terminology-disaster-risk-reduction> (Accessed 2 May 2021).
  40. UNISDR (2015), "Sendai framework for disaster risk reduction 2015-2030 (No. UNISDR/GE/2015-ICLUX EN5000 1<sup>st</sup> edition)", UNISDR, Geneva, Switzerland, available at: <https://www.undrr.org/publication/sendai-framework-disaster-risk-reduction-2015-2030> (Accessed 2 May 2021).
  41. United Nations General Assembly (2007), "Declaration on the rights of indigenous peoples", Resolution adopted, without reference to a Main Committee(A/61/L.67 and Add.1), 61/295.
  42. Weldegebriel, Z. B., and Amphune, B. E. (2017), "Livelihood resilience in the face of recurring floods: an empirical evidence from Northwest Ethiopia", *Geoenvironmental Disasters*, Vol. 4 No. 1, pp. 1-19. DOI: 10.1186/s40677-017-0074-0