The Spanish Review of Financial Economics

www.srfe.journals.es

INTERIOR MODIFICATION OF RESIDENTIAL HOUSING IN FLOOD PRONEAREAS

ZAKIAH HIDAYATI[a], MAFAZAH NOVIANA[a] and MUHAMMAD FADZILLAH ROSYIDI[b]

[a] Arsitektur Bangunan Gedung Study Program, Politeknik Negeri Samarinda, 75136, Indonesia.
[b] Architect, 75124, Indonesia.

Abstract

For over two decades (1998, 2008, 2019), floods have occurred in Samarinda in various intensities and different areas. In Bengkuring, flooding has submerged houses for days since 2008. It happens for days with an average depth of 0.5-1 meter. Flooding can cause minor, moderate, and severe damage or destruction of homes, property, and community disorders. People whose homes are submerged by floods make some adaptations to mitigate. Some modifications are to create a small barrier in front of the house, raise the floor, and repair waterways. Safe space is crucial during floods, especially in a one-story house. This study aims to improve the form of adaptation in residential homes in flood-prone areas. Similarly, the objective is to modify the interior to create a safe space for goods and occupants. The method of data analysis is based on Space Syntax Analysis J-Graphs. Occasionally, J-Graphs can efficiently explain interior modifications, including the ratio and layer of safe spaces, the number of indoor and outdoor connecting rooms, and the ring configuration. Through the design approach and prototype demonstration, it is possible to install interior modifications by making mezzanine floors and utilizing the attic. Although most previous research on building adaptation focused on home construction, home interior modification promises advantages that will result in a more straightforward and workable project for the community's needs.
Keywords: flooding; housing; interior; design; demonstration.

Abstract

For over two decades (1998, 2008, 2019), floods have occurred in Samarinda in various intensities and different areas. In Bengkuring, flooding has submerged houses for days since 2008. It happens for days with an average depth of 0.5-1 meter. Flooding can cause minor, moderate, and severe damage or destruction of homes, property, and community disorders. People whose homes are submerged by floods make some adaptations to mitigate. Some modifications are to create a small barrier in front of the house, raise the floor, and repair waterways. Safe space is crucial during floods, especially in a one-story house. This study aims to improve the form of adaptation in residential homes in flood-prone areas. Similarly, the objective is to modify the interior to create a safe space for goods and occupants. The method of data analysis is based on Space Syntax Analysis J-Graphs. Occasionally, J-Graphs can efficiently explain interior modifications, including the ratio and layer of safe spaces, the number of indoor and outdoor connecting rooms, and the ring configuration. Through the design approach and prototype demonstration, it is possible to install interior modifications by making mezzanine floors and utilizing the attic. Although most previous research on building adaptation focused on home construction, home interior modification promises advantages that will result in a more straightforward and workable project for the community's needs.
Keywords: flooding; housing; interior; design; demonstration.

INTRODUCTION

Samarinda experienced intense floods in 1998, 2008, and 2019 (Hutauruk, Kusuma, & Ningsih, 2020) (Kompas, 2008). The causes of flooding are extraordinarily diverse. Flooding may be caused by the limited capacity of the Benanga Reservoir, the silting of local rivers (Karang Mumus River/Sungai Karang Mumus/SKM), the clearing of residential land, and coal mining activities. Low and moderate flooding can occur several times yearly, especially after heavy rainfall and river tides recede.

Bengkuring is a large Samarinda settlement built between 1998 and 2000. A number of individuals established themselves by the end of 2000. Flooding has submerged houses in Bengkuring (first occurred in 2008) and other urban areas for days for more than a decade. Inundations are capable of causing minor, moderate, and severe destruction or damage to homes, property, and disturbances in the community. As a result, the house's structure, functionality, and appearance sustained severe physical damage. As a space created by the structure of the building, the interior also sustains flood damage. It affects the condition of the floors, walls, window and door frames, furnishings, and occupants.

The community has constructed a small wooden shelter as an adaptation. Local people call it 'andang' or 'panggung.' The shelter supports the people's belongings and provides a place to rest during the flood. People construct modified shelters because they cannot leave their homes due to security concerns. However, the shelter's space and construction materials are insufficient. Their inadequate handmade shelter makes them and their belongings susceptible to flooding. During floods, safe space is essential, particularly in a single-story house. A house should have a mezzanine or attic as a safe space (Logan_City_Council, 2020).

Figure 1. Wooden shelter as a flood adaptation for the community.

Various methods, including sustainable design (wet proofing, dry proofing, and elevation), building structure work, and interior modification, are utilized to research the adaptation of buildings in a flood-prone area. This research focuses on modifying the interiors of one-story homes to create a safe space for goods and occupants during flooding. Through a design approach (Adeyeye, Codinhoto, & and Emmitt, 2016); (Saqib, Alam, & Muzzammil, 2013); (Khan & Ahmad, 2017), the community can produce physical / non-physical forms of adaptation (APFM, 2012). To generate appropriate responses, the community must comprehend flooding (Nurhaimi & Rahayu, 2014). People's responses to flooding are also influenced by social and economic factors (wealthy and poor) (Husain, 2016). The authors (Khan & Ahmad, 2017) and (Saqib, Alam, & Muzzammil, 2013) discuss a sustainable design approach; sustainable design considers security, economic, environmental, and social aspects and requires design considerations to reduce house renovation costs.

The adaptation of communities includes the construction of wooden shelters. For flood prevention, design strategies are necessary. The repurposed wooden shelter can be utilized as a dry place to store belongings during a flood (Logan_City_Council, 2020). Infrastructure planning must also incorporate local government regulations into the design (Adeyeye, Codinhoto, & Emmitt, 2016).

This modification is typically implemented after assessing flood damage (Shrestha, Kawasaki, & Zin, 2021). Most research on physical adaptation in residential houses in flood-prone areas focuses on structure and utility (Hidayati & Octavia, 2016), whereas research on space function and aesthetics is still limited.

Architects significantly impact the design of flood-resistant and adaptable houses in flood-prone areas (Brisibe, 2018), particularly regarding design skills, material knowledge, and construction. However, the forms of building adaptation vary considerably. For instance, (Khan & Ahmad, 2017) adapted by elevating the floor of the building and employing wet floodproofing materials. Husain B. Sarkawi also described the form of adaptation by elevating the house, installing a water pump, and constructing a small barrier in the house's required area (Husain, 2016).

Similarly, (Nurhaimi & Rahayu, 2014) explains that post-flood actions may include elevating homes and constructing a physical barrier. Similar research was conducted by (Brisibe, 2018) and (Shrestha, Kawasaki, & Zin, 2021), which concluded that the addition of basements to buildings, the use of stilt houses, and the raising of floors must be adapted to flooding. Due to flooding, one of the necessary adaptations is the use of flood- resistant building materials (Garvin, 2017). In the same location, researchers have also formulated the concept of adaptation of residential building structures in Tenggarong (Hidayati & Octavia, 2013) and structural rehabilitation (Hidayati & Octavia, 2016).

Adaptation of the building structure to the house is present in certain house types. Several flood-resistant homes have been investigated (Piatek & Wojnowska-Heciak, 2020) in amphibious structures, stages, and floating structures. In areas susceptible to flooding, boathouses and boatlifts are also effective (Khan & Ahmad, 2017). In the meantime, Warebi supports flood-resistant stilt homes (Brisibe, 2018). Saengpanya also suggests building floating houses in flood-prone areas (Saengpanya & Kintarak, 2019).

Creating a safe space from flooding (safe refuge) (Logan_City_Council, 2020), the addition of basements (Brisibe, 2018), and spaces under the roof (attic) are discussed in research on interior modifications (Brisibe & Pepple, 2016).

Based on research with comparable issues, the following solutions are provided:

- **Physical approach**

Renovation or rehabilitation may be used to assess the physical approach. Renovation involves the construction of stilt, amphibian, and floating houses that differ from the previous structures. Meanwhile, the scope of rehabilitation is that the house's floor will be raised, a basement will be added, flood-resistant materials will be utilized, and the house's foundation will be strengthened. The disadvantage of the physical approach is that it is expensive and is only sometimes applied to the real world. In this instance, reconstruction takes longer to implement and is more expensive than rehabilitation.

- **Non-physical approach**

Non-physical perspectives include community training in carpentry and plumbing/building code compliance. Multiple factors, including education, the economy, culture, and others, influence society's non-physical approach, occasionally causing it to miss the mark.

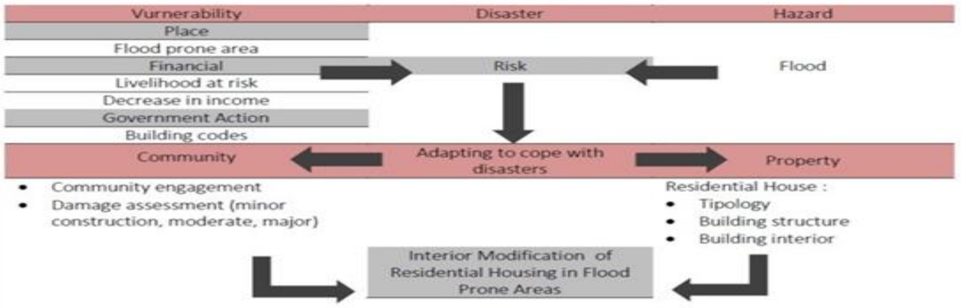


Figure 2. Research issue (Modified from (SESYNC, 2016)).

Figure 2 illustrates the primary concern associated with the hazard (flood) and adaptation (community and property). A hazard is any potentially dangerous phenomenon, material, human activity, or condition. It may cause death, injury, and other adverse health effects, destruction of property, loss of livelihoods and infrastructure, social and economic disruption, and environmental damage. Adaptation refers to the modifications made to ecological, social, or economic systems in response to actual or predicted climatic triggers and their effects. In this study, hazard refers to the variable flood. Meanwhile, this adaptation relates to the local neighborhood and property (housing).

This study aims to improve the adaptation in residential areas prone to flooding. Similarly, the objective is to modify the interiors of residential homes in flood-prone areas to create a secure space for residents and their belongings. The potential improvement spaces are the attic and floors (mezzanine). This study will examine the feasibility of transforming an attic or constructing a mezzanine into a safe space for belongings or occupants, especially during floods.

METHODS

The study's variables, indicators, and parameters are derived from the identified research issue.

Table 1. Variables, indicators, and parameters.

	Variable	Indicator	Parameter	Methods of data collection
Hazard	Food	• Average indoor water surface • Duration	• The higher the water level, the less safe space exists for the occupants of a one-story house. • The longer the duration of the flooding, the less safe the occupants.	• Semi-structured interviews • Reviews of the literature
Adaptation	Community	• Community engagement • Damage assessment • Income	• High level of community engagement, adaptation advancement • Minor, moderate, and severe damage	• Semi-structured interviews • Observation
	Property	• Typology • Space for potential rehabilitation work	• Most common house type • Space for goods/users	• A semi-structured interview • Observation • Mapping • Drawing

Data was collected through semi-structured interviews, observations, literature reviews, mapping, and drawing. The data analysis technique is based on Space Syntax Analysis Justified Graphs (J-Graphs). Space syntax is a set of methods for analyzing spatial configurations and human activity patterns in buildings and cities. Moreover, it is a collection of theories linking space and society. Space syntax is concerned with the location of humans and how they move, adapt, and interact with their surroundings (Hillier & Hanson, 1984)

The justified graphs (j-graphs) inspired the normalization formula and its possible applications. It generates graph structure, and the differences in their constructions are readily apparent. It also explains why numerical comparison analysis is necessary and how it can be performed by representing all numbers in a standard format.

Space syntax, in this study, is a method for analyzing the spatial layout as a consequence of interior modification from the original house layout to the existing house and the newest house layout. The spatial layout was modified due to the flood and users' needs. The j-graph of different periods of house layout, it will show how a new space: exists, changes, is connected, isolated, and its depth.

The j-graph explains the space effectively by relating it to other spaces. Compiling the properties of j-graphs to demonstrate complex-wide characteristics requires identifying the various internal perspectives from which the complex can be viewed.

A node may be placed at the bottom of the graph to represent the root, and then all nodes directly associated with that root - meaning depth 1 - may be aligned directly above it, as well as whole nodes at depth two are directly associated with these at depth 1, and so on until whole levels from depth emanating from that root may be resolved.

This property is characterized by the fact that graphs of patterns and spatial layouts appear significantly different when viewed from different perspectives in the chart. Using a j-graph, it is possible to graphically display how. By sketching j-graphs emanating from whole nodes, we can imagine a few rather profound characteristics of patterns (Hillier B., 1996).

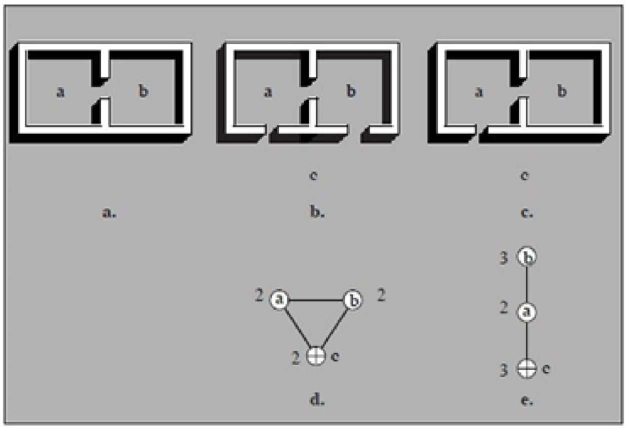


Figure 3. Symmetrical and asymmetrical configuration (Hillier B., 1996).

Figure 3 shows the relation configuration of spaces. d is a j-graph of b, whereas e is a j-graph of c. a does not have any j-graph due to the lack of permeability between the outside and inside spaces. It means any spaces (outside and inside) and their permeabilities/circulations influence the j-graph. The numbers in the j-graph index are contiguous to each space by showing the total depth from each space to the other two. In comparison, d may have created a 'ring' that connects all three spaces, implying that everyone has a choice of routes to all others. When spotted for each of its spaces, the chart from d is possibly the same, whereas e, b, and c are possibly identical, though a is possibly different.

However, there is a visually appealing way to highlight the key differences between the two spatial patterns before we get to the numbers. It is a j-graph, also known as a justified graph. Initially, we imagine being in a space known as the graph's root or base, represented as a node with a cross inside. Then, using nodes to represent spaces and lines to represent access relations, we align immediately above all spaces directly connected to the root and draw in the connections using nodes to represent spaces and lines to represent access relations.

RESULTS

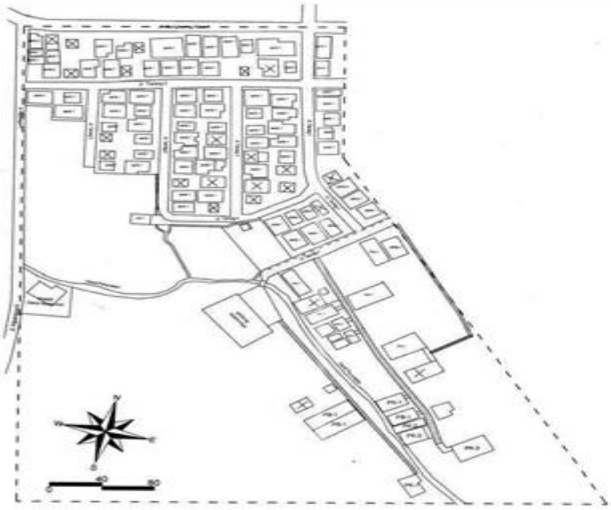


Figure 4. The mapping of Bengkuring settlement (authors).

Building surveys were conducted on 106 homes. This research produced a map depicting the location of the settlement. It consists of constructions such as buildings, roads, and canals. The homes were then classified according to local typology matters.

Table 2. Local house typologies

House typologies	Structural and construction building type			
	Wood construction	Concrete construction	Stilt house	Non-stilt house
One-story house	√		√	
One-story house	√			√
One-story house		√		√
One-story house		√	√	
Two-stories house		√		√

Although the research focuses on the interior, it cannot be separated from the building's structure and construction. The interior modification is influenced by the structure's primary material, roof construction, attic and room height, and square space.

Based on their structure and construction, it is reduced to stilt and non-stilt/concrete houses. The concrete houses were built on a formerly filled-in wetland. The exterior of the wooden stilt houses, in contrast, was constructed more recently on natural wetlands. The Ministry of Public Works and Public Housing forbade the filling of the wetland to prevent water from entering the Karang Mumus River.

Figure 5. Stilt house type. Most are built by ulin wooden

The roofs of the dwelling house are built with wooden construction. The zinc roofs cover most houses with a standard slope of 25-30 degrees. In almost all houses, the attic space is used for electrical wiring. Very few houses use attic rooms for storing goods or occupants' activity space. The attic room and mezzanine use are flexibly applied in wooden buildings without renovating the house.

The wooden stilt house has the potential for interior modification by raising floors, making mezzanine floors, and converting attic spaces. Timber as a main building material is a part of the answer to beat the challenges of environmental and sustainability issues (Karjalainen, Ilgın, Metsäranta, & Norvasuo, 2021). Adding additional wooden floors might make residential districts more appealing (Karjalainen, Ilgın, Metsäranta, & Norvasuo, 2022).

The mezzanine level can be utilized in homes with a floor-to-ceiling height greater than four meters. According to the Ministry of Public Works and Public Housing Building Code Number: 29 / PRT / M / 2006, an attic is permitted if its use does not deviate from the building's primary function. It is necessary to focus on the health, security, and safety of the attic room and prohibit its conversion into a kitchen or other activities that could cause accidents/fires. If the mezzanine is larger than fifty percent of the area of the floor below, it is considered a separate floor.

Figure 6. Non-stilt houses type. Most are built with concrete.

Concrete houses have a limited capacity for interior modification due to their heavier construction materials compared to wooden houses. The concrete house's interior may be altered if it conforms to the building's height, roof construction, and floor area. Almost all concrete homes have been renovated by adding floors or expanding existing ones. When a two-story building has been flooded is of little consequence. Meanwhile, a one-story house must be carefully designed to create a safe space in a massive structure.

The location of the study is Rukun Tetangga (Neighborhood) Number 37 of Bengkuring, which consists of public housing and is surrounded by human settlements. Bengkuring public housing was formerly a relocation district for the riverbank community of Karang Mumus. The community moved into this public housing in the early 2000s. Initially,

family heads were fishermen. Twenty years later, the family's primary breadwinner works as a government employee, private worker, and laborer. Most of the population is between 15 and 50 years old, while the number of seniors is under 15.
According to the findings of eighteen interviews, when Karang Mumus River residents gradually moved to Bengkuring Housing in the early 2000s, some did not feel at home because they were removed from their daily environment, the river. They rented a house near the river and eventually returned to the old neighborhood to return. In 2022, only a handful of the original Karang Mumus River relocation residents will remain in Bengkuring. Others are relocating out-of-state residents.

The community of Bengkuring is crucial to mitigating the effects of the flood. Interviews with thirty adults revealed that they discussed strategies for coping with identified hazards, rehabilitating, and renovating their homes (including structural, interior, and utility factors). Typically, neighborhood residents share information in the mosque or other communal spaces.

Figure 7. The men installed the stilt space as a communal space etc (left), and the stilt room was completed (right) (Source: author).

Based on interviews with former Bengkuring residents, building surveys, and observations of the homes, it has been determined that approximately 25 percent of the population has relocated in the last twenty years due to flooding (mostly) and other factors. The percentage was determined through interviews with the neighborhood's leader. The authors validated it based on the remaining empty houses on the locus site. In most cases, residents relocate because they still own homes in locations that are relatively safe from flooding. The remaining residents have chosen to stay in this community with physical and non-physical adaptations to mitigate the flooding.

The owners of the vacant homes decided to rent or sell them as soon as possible. If they cannot find tenants or buyers, the home remains vacant and suffers extensive damage. Due to a lack of physical maintenance and repair, an unoccupied home is susceptible to damage. When the flood-damaged home was not cleaned, the house slowly began to deteriorate due to moisture. Empty houses have permanently sealed windows and doors, so there is no change in air circulation. If leaking roofs are not repaired immediately, rainwater will flood empty homes.
During floods, people may experience temporary unemployment because they cannot leave

their homes due to blocked access. Jepara teak artisans are one of the residents' jobs. If flooding occurs, they must stack and secure teak furniture to prevent it from being washed away. Teak furniture still requires a secure warehouse for storage. As a result of the flooded workshop, the company's operations were completely halted. It implies that profits have also decreased. Floods on the Karang Mumus River banks cost residents approximately four billion rupiahs per week, according to a 2020 article (Hutauruk, Kusuma, & Ningsih, 2020).

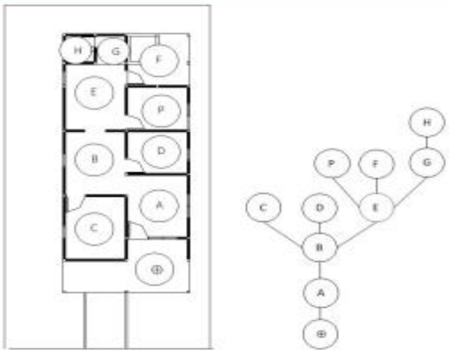
The table below displays community assessments of the building's interior damage. They should understand their property's level of flood risk. People used to evaluate the building's condition before implementing the strategies. Based on the extent of building damage, the community considers repair options. The repair is influenced by the income, creativity, chance, and decisions of the people.

Table 2. Assessment of the interior elements

Table 2. Assessment of the interior elements.

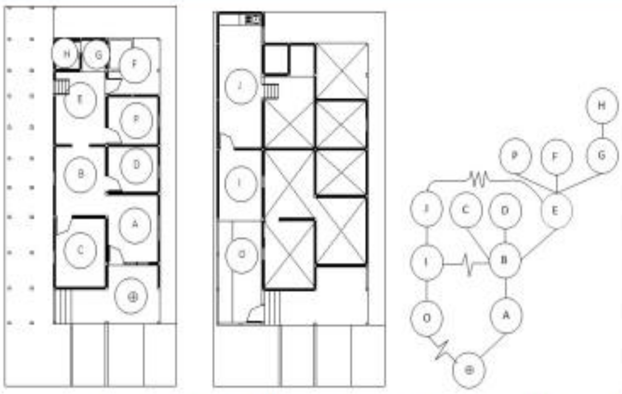
Interior elements	Minor damage	Moderate damage	Severe damage
Furniture (solid wood and particle boards)	Mold can develop if the furniture is exposed to water for an extended period. Additionally, the foam within the cushions can become wet and stink.	Wooden furniture is susceptible to rot when exposed to moisture.	The wood becomes unusable because it expands and warps. When the particle boards are filled with water, they are destroyed.
Brick wall	The wood becomes unusable because it expands and warps. When the particle boards are filled with water, they are destroyed.	Mossy walls, peeling paint and plaster, visible cracks in the masonry, and electrical damage in some areas.	Numerous electrical devices are damaged due to large cracks in the masonry that cause it to split and shake/lose, the plastering on the walls to fall off, and the walls to lose their plastering.
Ironwood (ulin) wall	Slightly damp	Damp and curved floors	-
Others wooden wall	Damp, moldy	Moldy and fragile walls.	The wood swells and warps, rendering it unusable.
Ironwood (ulin)flooring	It is moderately damp, so it needs to be dried immediately.	Moist and can moldy	-
Tiles	The floor is stained, grout peels off, cracked hair less than 3 mm, dull color	Hair cracks more than 3 mm, ceramic detached, rupture, peel off and lifted	Ceramics crushed a lot and broken floors
Window/door frame and pane	Damage to door/window accessories, peeling paint layers, small cracks in the frame, loose door/window accessories, and sills that are difficult to move.	Wide cracks in the frame, a gap between the frame and the wall, detachment of the sealant, and a separation at the joint.	Porous on the sills due to dampness and broken sills Broken/cracked glass
General stuff	Without repair, goods can still be used; only cleaning is necessary.	Goods can still be utilized after undergoing specific repairs	Damaged goods cannot be repaired

The selection of building samples is guided by several criteria, including the prevalence of homeownership and an accurate representation of building types (wooden stilt houses and non-stilt concrete houses). Sample house 1 is a wooden stilt dwelling on the outskirts of the housing zone (settlements). This wooden house is situated southeast of the Bengkuring settlement, near a wooden bridge constructed by the government. About 250 meters separate the house from the Karang Mumus watershed. Multiple modifications have been made to accommodate the flood conditions. This area is submerged by more than 1 meter during floods.



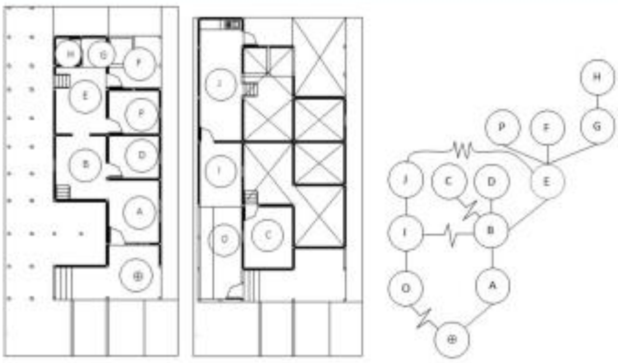
⊕	Veranda
A	Living room
B	Family room
C	Bedroom 1
D	Bedroom 2
E	Dining room and kitchen
F	Clothsline room
G	Washing room
H	Toilet
P	Bedroom 3

Figure 8. The first period (2014) of housing layout (left), j-graphs (middle), and the house plan symbols (right)



⊕	Veranda
A	Living room
B	Family room
C	Bedroom 1
D	Bedroom 2
E	Indoor storage room
F	Semi outdoor storage
G	Washing room
H	Toilet
I	Dining room (raised floor)
J	Kitchen (raised floor)
O	Clothsline room (raised floor)
P	Bedroom 3

Figure 9. The second period (after the flood of 2019) of housing layout (left), j-graphs (middle), and the house plan symbols (right)



⊕	Veranda
A	Living room
B	Family room
C	Bedroom 1 (raised floor)
D	Bedroom 2
E	Indoor storage room
F	Semi outdoor storage
G	Washing room
H	Toilet
I	Dining room (raised floor)
J	Kitchen (raised floor)
O	Clothsline room (raised floor)
P	Bedroom 3

Figure 10. The third period (after the annual flood) of housing layout (left), j-graphs (middle), and the house plan symbols (right)

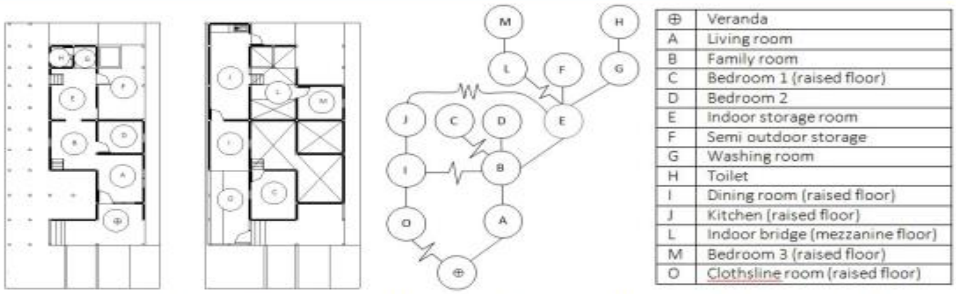


Figure 11. The fourth period (after the annual flood) of housing layout (left), j-graphs (middle), and the house plan symbols (right)

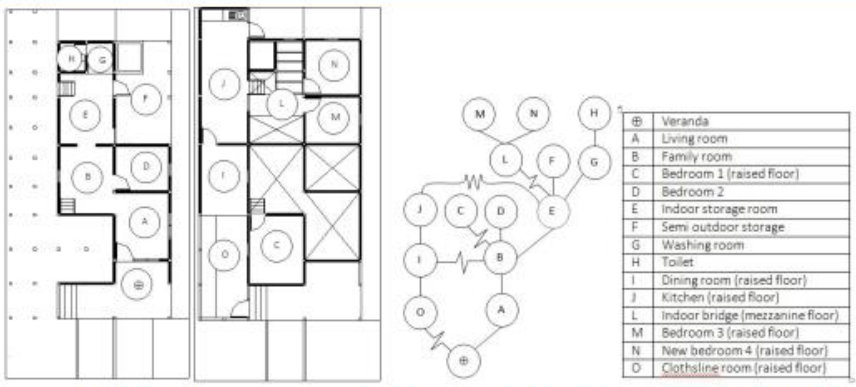


Figure 12. The fifth period (2022) of housing layout (left), j-graphs (middle), and the house plan symbols (right)

The authors interviewed the house's owner so researchers could comprehend the interior transformation. Figure 8-12 chronologically depicts five different adaptations of the sample wooden house. During the second period, this wooden structure was extensively renovated. Depending on the needs of the occupants and the frequency of flooding, the residence was rehabilitated multiple times.

The first-period house plan consists of ten rooms and meets the family's needs. When the flood reached the community, the proprietor decided to convert the new elevated floor into three new spaces (clothesline room, dining room, and kitchen).

Table 3. Summary of j-graphs result for the first period of the wooden stilt house.

#	Space	⊕	A	B	C	D	E	F	G	H	P	Total Depth	Mean depth	Real Asymmetry	Integration
0	□	0	1	2	3	3	3	4	4	5	4	29	3.22	0.56	1.80
1	A	1	0	1	2	2	2	3	3	4	3	21	2.33	0.33	3.00
2	B	2	1	0	1	1	1	2	2	3	2	15	1.67	0.17	6.00
3	C	3	2	1	0	2	2	3	3	4	3	23	2.56	0.39	2.57
4	D	3	2	1	2	0	2	3	3	4	3	23	2.56	0.39	2.57
5	E	3	2	1	2	2	0	1	1	2	1	15	1.67	0.17	6.00
6	F	4	3	2	3	3	1	0	2	3	2	23	2.56	0.39	2.57
7	G	4	3	2	3	3	1	2	0	1	2	21	2.33	0.33	3.00

8	H	5	4	3	4	4	2	3	1	0	3	29	3.22	0.56	1.80
9	P	4	3	2	3	3	1	2	2	3	0	23	2.56	0.39	2.57
					Mean							22	2.46	0.36	3.26

Table 3 describes the summary of j-graphs in the wooden stilt house's first period as a data representation (figure 8). The spaces represented all rooms in the building's interior in the same period. All periods had the summary of j-graphs, but the authors resumed the summary recapitulation for the second to fifth periods (table 4) based on figures 9-12.

Table 4. Recapitulation of summary of j-graphs for the 1st-5th period of wooden still house

1st period	2nd period	3rd period
Integration value (mean value: 3.26)	Integration value (mean value: 4.32)	Integration value (mean value: 4.32)
B=E>A=G>C=D=F=P>⊕=H	B>E>I>J>A=C>G>D>P=F>O>⊕>H	B>E>I>J>A=C>G>D>P=F>O>⊕>H
Mean depth value (mean value:2.46)	Mean depth value (mean value:2.44)	Mean depth value (mean value:2.44)
B=E<A=G<C=D=F=P<⊕=H	B<E<I<J<A=C<G<D<P=F<O<⊕<H	B<E<I<J<A=C<G<D<P=F<O<⊕<H
4th period	**5th period**	
Integration value (mean value: 4.33)	Integration value (mean value: 4.48)	
B=E>I=J>A=C>G=L>D=F>O>⊕>H=M	E>B>J>I=L>A=C=G>F>D>O>⊕>M=N>H	
Mean depth value (mean value:2.54)	Mean depth value (mean value:2.60)	
B=E<I=J<A=C<G=L<D=F<O<⊕<H=M	E<B<J<I=L<A=C=G<F<D<O<⊕<M=N<H	

Table 4 provides the value of depth, real asymmetry, and integration of space in the house in the first period. The highest depth value is node/space □ (veranda) and H (toilet). It means that those two rooms are the most isolated. So, if we go to the toilet from the veranda, we have to pass the five-layer depth and vice versa. Nodes B (Family room) and E (dining room) are the most integrated area and have the low value of Real Asymmetry. It means that many rooms are connected by these two. For example, in rooms B and E, there are four rooms connected. So rooms B and E have strategic value in period one of this wooden house.

Table 5. Percentage of safe space in the wooden stilt house.

Period	Percentage of safe space during flood	Note
First period	0%	The house was built in 2014
Second period	=3/13=23%	Following the 2019 flood, the house was renovated.
Third period	=4/13=31%	The residence was rehabilitated following the annual flood.
Fourth period	=6/14=43%	After the annual flood, rehabilitation were made to the house.
Fifth period	=7/15=47%	It has been demonstrated in sample house 1

In the j-graphs, zigzag lines represent two spaces' significantly different floor levels during the second period. During the second period, the owner renovated the house significantly.

Due to the flooding, three new rooms were built on higher floors than the old ones. Based on counting j-graphs, room B (family room) became the most integrated room, just like in period one. The most isolated room is still room H (toilet). The consequence of the split level of floors is some stairs were installed. The stairs are helpful but lack comfort and firmness because of the material. The difference between the second and third periods was only room C's level floor (master bedroom). Room C was rehabilitated by raising the floor to create a safe room from flooding.

The third period described elevating the floor of the master bedroom to create a safe area. The owner then rehabilitated the third bedroom on the mezzanine. The addition of a mezzanine required stairs and a path to the new bedroom. Therefore, the home's owner constructed a bridge to connect the stairs to the new bedroom. However, the homeowner should have prioritized the safety and functionality of the staircase and "bridge ."The following period consists of a new house plan with interior modifications that the owner has never made.

In the fourth period, the house was renovated to add a new bedroom. The new bedroom was on the mezzanine floor (room M) to avoid wetness during floods. Under the mezzanine level, the owner created semi-outdoor storage to keep old stuff underneath. The position of room M needed stairs and a path to access bedroom 3. The owner installed an indoor 'bridge' as a path to the new room. The different levels of the floors created a void in room E above. Room B (family room) and room E were the most integrated rooms in this period.

In contrast, room M (bedroom 3) was the most isolated room. Based on j-graphs in the fourth period, the safe space was the cloths-line room (The outdoor laundry room was located separately), master bedroom, dining room, kitchen, indoor bridge, and bedroom 3. All those space spaces were created incrementally due to the floods.

The rehabilitation of this wooden home has both advantages and disadvantages. First, it provides safe spaces for goods and residents during floods. Second, there was sufficient space to renovate the interior of the single- story home. Due to the lack of comfort and firmness of the stairs, it is not suitable for elderly residents. Second, the narrow path (indoor bridge) lacks safety and stability.

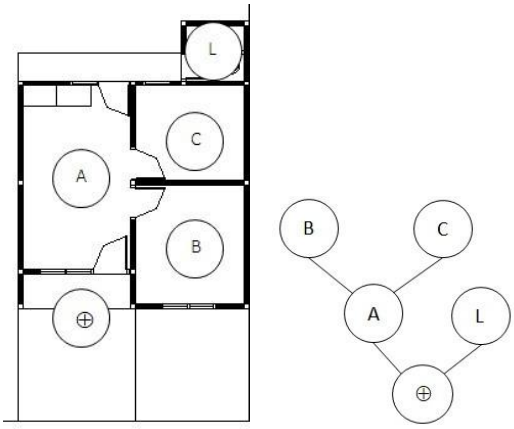
According to the fifth period, the purpose of the study is to modify the interior to enhance adaptation. The study analyzes the potential of new space to create a safe room in a single-story home without significant renovations using a design approach. The fifth adaptation adds two new rooms to the attic of the house. The first room can be used for prayer or any other purpose. A second mezzanine-level room has been installed in the back of the house. It will serve as the new bedroom (room N).

J-graphs show that from the second to the last period, the house had two rings configuration from five nodes (A, B, O, I) and 4 nodes (I, J, B, E). Each node has a minimum of two connections to each other. The rings do not change, but the house configuration changes gradually during the flood. Safe spaces have been added more for each period.

The veranda is the only outdoor area in the j-graphs. Meanwhile, the other rooms are indoor spaces. The veranda is connected directly to two other rooms (clothesline and living rooms). It means that the permeability of water from flooding was distributed from the veranda, then the clothesline room and living room as nodes in the first depth. More indoor spaces connected to outdoor spaces, more permeability of water coming to the house.

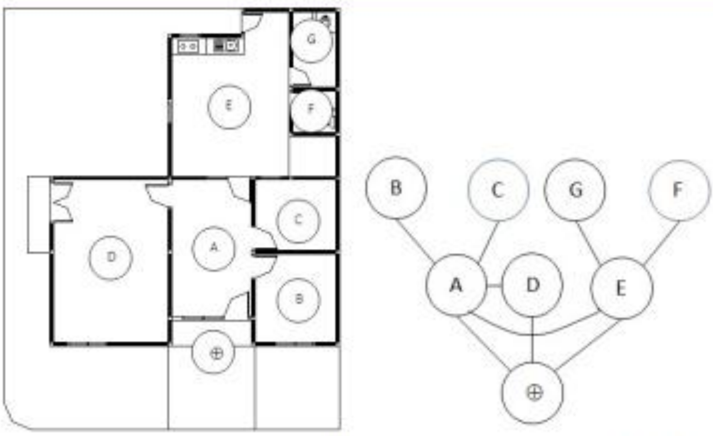
In j-graphs, the interior modification tends to vary per period. The zigzag lines depict the various levels between two connected nodes. In the fifth period, the percentage of safe spaces increases from 23% to 47%. The safe areas were constructed with elevated and mezzanine floors. The homeowner must recognize the value of the attic as a safe space. With some rehabilitation, the attic can be transformed into a secure space. The demonstration of a new safe space in the attic is applied during the fifth period.

Figure 13-17 shows the housing layout of the concrete non-stilt house as a house sample 2 from the first-fifth period.



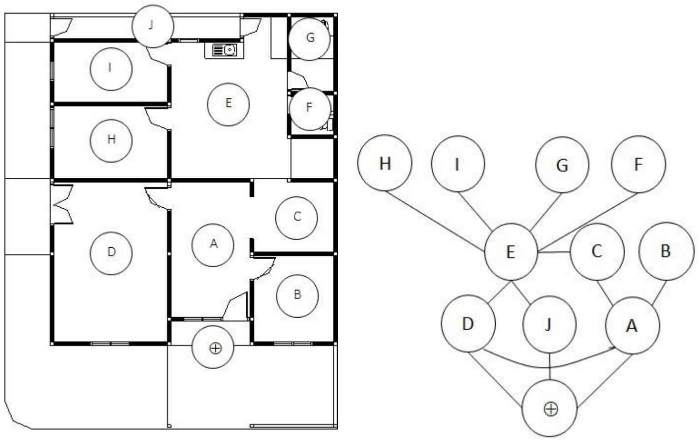
⊕	Veranda
A	Living room
B	Bedroom 1
C	Bedroom 2
L	Toilet

Figure 13. The first period (2000) of housing layout (left), j-graphs (middle), and the house plan symbols (right).



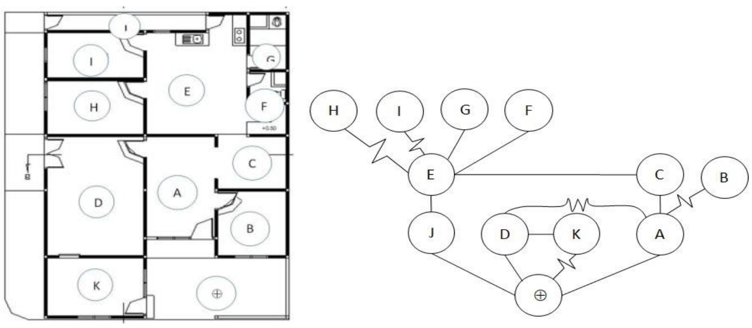
⊕	Veranda
A	Living room
B	Bedroom 1
C	Bedroom 2
D	Master bedroom
E	Kitchen
F	Toilet 1
G	Toilet 2

Figure 14. The second period (after the flood of 2008) of housing layout (left), j-graphs (middle), and the house plan symbols (right).



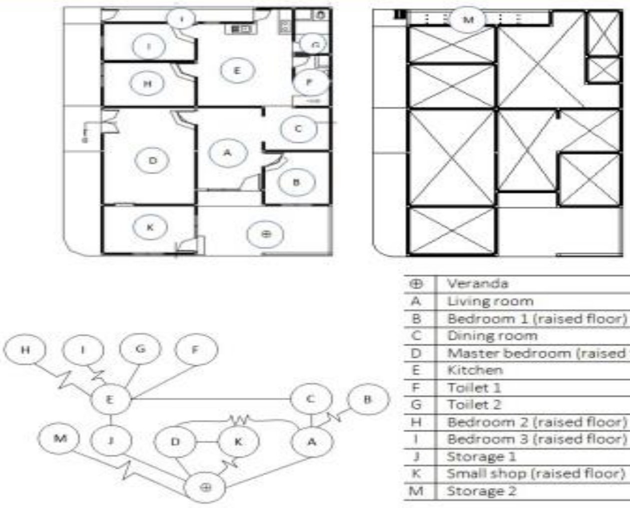
⊕	Veranda
A	Living room
B	Bedroom 1
C	Dining room
D	Master bedroom
E	Kitchen
F	Toilet 1
G	Toilet 2
H	Bedroom 2
I	Bedroom 3
J	Storage

Figure 15. The third period (after the flood of 2008) of housing layout (left), j-graphs (middle), and the house plan symbols (right).



⊕	Veranda
A	Living room
B	Bedroom 1
C	Dining room
D	Master bedroom
E	Kitchen
F	Toilet 1
G	Toilet 2
H	Bedroom 2
I	Bedroom 3
J	Storage
K	Small shop

Figure 16. The fourth period (after the flood of 2019) of housing layout (left), j-graphs (middle), and the house plan symbols (right).



⊕	Veranda
A	Living room
B	Bedroom 1 (raised floor)
C	Dining room
D	Master bedroom (raised floor)
E	Kitchen
F	Toilet 1
G	Toilet 2
H	Bedroom 2 (raised floor)
I	Bedroom 3 (raised floor)
J	Storage 1
K	Small shop (raised floor)
M	Storage 2

Figure 17. The fifth period (2022) of housing layout (left), j-graphs (middle), and the house plan symbols (right).

Table 6. Recapitulation of Integration value and mean depth value of sample 2.

1st period	2nd period	3rd period
Integration value (mean value:1.80)	Integration value (mean value: 4.46)	Integration value (mean value: 3.99)
A>⊕>B=C>L	A>E>⊕>D>B=C>F=G	E>C=J>A>⊕>I>F=G>D=H>B
Mean depth value (mean value:1.87)	Mean depth value (mean value:1.89)	Mean depth value (mean value:2.27)
A<⊕<B=C<L	A<E<⊕<D<B=C<F=G	E<C=J<A<⊕<I<F=G<D=H<B
4th period	**5th period**	
Integration value (mean value: 4.18)	Integration value (mean value: 4.30)	
E>C=J>⊕=E>I>D>F=G>H>B=K	⊕=E>J>A=C>D>I>K>F=G>M>B=H	
Mean depth value (mean value:2.37)	Mean depth value (mean value:2.42)	
E<C=J<⊕=E<I<D<F=G<H<B=K	⊕=E<J<A=C<D<I<K<F=G<M<B=H	

Table 7. Creating safe space due to flood sample 2.

Period	Percentage of safe space during flood	Note
First period	0%	It was built in 1998 and occupied in 2000
Second period	0%	After the flood of 2008, it was renovated.
Third period	0%	The 2008 flood necessitated repairs, afterwhich it was renovated.
Fourth period	=5/12=42%	After the devastating flood that occurred in 2019, it was renovated.
Fifth period	=6/13=46%	The redesigning phase; Sample House 2 demonstration.

Sample 2 of the house represented a concrete house. Non-stilt concrete houses and wooden stilt-house represent the local house typology. The housing was built in 1998 and started to occupy in 2000. For the first eight years, it is flood free. The original house was 21-type, which had only five rooms. During twenty years, this house was renovated three times. From the j-graphs, we can see the transformation significantly in the second period. It created two rings. The first ring was created in three nodes (D, A). Then, three other nodes (A, E) configured the second ring. The rings mean those rooms are connected to two or more nodes. It states that rings form when spaces are linked in circuits that allow access to space via more than one path. The house configuration is symmetry-like based on the layer of depth. Due to the users' needs, the renovation would involve the addition of some spaces. Three new spaces changed the house configuration in the third period. These three created three rings. First, one ring was arranged by four nodes (D, J, E). Then, three other nodes (D, A) built a second ring. Finally, the third ring was formed by five nodes (D, A, E, C).

Fourth and fifth-period house configuration rings were similar. Rings (D, K), (J, E, C, A), and (D, A) were created in these j-graphs. The ring house configuration means the nodes (rooms) are not isolated. Therefore, it is easier to monitor the indoor situation during flooding. Due to the flood, the construction of interior modifications began in the fourth period. Two new rooms, represented by nodes K and I, were constructed. The owner added approximately fifty centimeters to the height of four old rooms (master bedroom, bedrooms 1, 2, and 3). J-graphs illustrate this with zigzag lines. Consequently, there are five rooms on the raised floor (42%), while seven remain 50 centimeters below. Unfortunately, the elevated floors lacked stairs, so people had to ascend 50 centimeters straight up. Although it is uncomfortable, people endure it for years. The new room (node K) was constructed 60 centimeters above the lowest floor and includes stairs for convenience. By elevating the cement floor, the single room becomes shorter.

Due to the twenty-year installation of new rooms, the integration values for periods 1 through 5 and the average depth values tend to increase. Initially, the house had only five rooms, but it now has 12 rooms, and the next house plan will include a safe room. The safe spaces were present on each and every layer of the j-graphs. The kitchen (E) has the highest integration value, indicating that it is the room with the most connections to other spaces (two safe spaces and four ordinary rooms). The fifth-period redesign of the house creates a new secure storage space for goods in the attic. The new room accounts for 46% of flood-safe space. It indicates a 4% increase over the previous period. The interior modification flexibility of a concrete home is less than that of a wooden home. The weight of the materials and the load of the house structure are obstacles to interior modification, as mentioned before. It is the situation we face when redesigning sample 2. The redesign result will be labeled with the owner's approval in the fifth period. The redesign provides additional storage space in the rear attic. Sample 2 contains additional potential redesignable space but at an increased cost. Due to limited indoor access, new goods storage space is accessed from the exterior (veranda). The configuration house has the same rings in the fifth period as it did in the fourth. The kitchen and veranda became the most integrated room in the fifth period. They are connected to between four and five nodes in the house configuration. These two are the doorways leading to another room. During the flood, the most integrated room was converted into a surveillance and command center to monitor the situation. In addition, the two safe spaces (bedrooms 2 and 3) are located in the most isolated area. Therefore, they must be managed from the kitchen, one of the most integrated rooms. The other four safe rooms are located at shallower depths and are easier to control.

As indicated by the j-graphs, the veranda is connected to five rooms. It means that concrete houses have more indoor spaces that connect to outdoor spaces than wooden houses. So the water entering the house is more permeable.

Table 8. Comparison between the interior modification in two sample houses.

Stilt wooden house (one-story house)	Concrete house (one-story house)
The phase of interior modification: redesign and demonstration on sample house	The phase of interior modification: redesign.
Used to install in interior modification: raised floor and mezzanine	Raised floor
New safe space in the attic (a transitional room) and on the mezzanine floor (bedroom)	New safe space for goods in an attic
The house has 47% safe spaces during flooding	The house has 46% safe spaces during flooding

Safe spaces are likely to be four layers (1-4).	Safe spaces are projected to be three layers (1-3). The space configuration is more accessible than in wooden stilt houses
The veranda is connected directly to two rooms.	The veranda is connected directly to five rooms. As a result, the water is more permeable in this house than in a wooden stilt house.
It has two 'ring' configurations.	The concrete has three 'ring' configurations. The 'ring ' means that the house layout provides alternative circulation choices for the home users. More rings in the house layout can be helpful during flooding to enter certain rooms.

The percentage of safe space between wooden stilt houses and concrete houses is almost similar. The wooden dwelling has 47%, while the concrete home has 46% of safe room during flooding. The safe spaces are likely to be four layers (1-4) in the wooden house, while safe rooms in concrete houses are expected to be three layers (1-3). It means that the spatial configuration in the concrete home is more accessible than in a wooden stilt house. The veranda in the concrete house is connected directly to five rooms. As a result, the water is more permeable in the concrete house than in a wooden stilt house (its veranda is connected to two rooms). So less connected room to veranda or outdoor space will reduce the water permeability indoors.

CONCLUSIONS

The city has been submerged for days and a couple of times per year due to flooding. As a result of the original structure of their homes, most Bengkuring residents have had to make limited physical adaptations to their dwellings. The adaptation should accommodate the one-story house, as it is the most prevalent structure in this area. The purpose of this finding is to confirm that the interior rehabilitation did not affect the building's structure in any way. Therefore, rehabilitation is an excellent option for existing single-story homes. J-graphs are required to make the house rehabilitation more transparent because it is sometimes difficult to see from the houseplan. The j-graphs models assisted in identifying common and interrelated physical adaptation characteristics across time periods, such as the percentage and layer of safe spaces, the number of indoor- outdoor connection rooms, and the ring configuration. According to the findings, specific periods have developed new safe spaces on the raised floor. With the design approach and demonstration (in sample 1) and the new home layout design (in sample 2), the study enhanced the interior redesign of the previous era. The two designs concern installing the mezzanine and converting the attic into a safe space for the occupants and their belongings in the event of flooding.

Acknowledgments

This work is supported by DIPA Direktorat Jenderal Akademik Pendidikan Tinggi Vokasi, Direktorat Jenderal Pendidikan Vokasi Kemendikbudristekdikti Number: SP DIPA 023.18.1.690524/2022, June 20th, 2022, Fourth Revision June 20th, 2022 according to Research Contract Number 1722/PL7/PG/2022.

References

1. Adeyeye, K., Codinhoto, R., & Emmitt, S. (2016). Integrated Design for Flood Resilience. Proceedings Of The Id@50 Integrated Design Conference 2016. Bath.
2. Apfm. (2012). Integrated Flood Management Tools Series-Flood Proofing.
3. Brisibe, W. G. (2018). Assessing Architects' Knowledge Of Flood Resilient And Adaptable Buildings In Yenagoa, Nigeria. Journal Of Architecture And Construction, 16-24.
4. Brisibe, W. G., & Pepple, T. D. (2016). Attic Habitable: A Study Of Residential Roof Designs In Flood Prone Areas Of Bayelsa State, Nigeria. International Journal Of Research In Civil Engineering, Architecture & Design, 12-21.
5. Garvin, S. (2017). Flood Resilient Buildings – Towards A Mainstream Activity. Bre Centre For Resilience.
6. Hidayati, Z., & Octavia, C. (2013). Studi Adaptasi Rumah Vernakular Kutai Terhadap Lingkungan Rawan Banjir Di Tenggarong. Dimensi, 89-98.
7. Hidayati, Z., & Octavia, C. (2016). Konservasi Struktur Dan Konstruksi Rumah Vernakular Terhadap Lingkungan Rawan Banjir Di Tenggarong. Jurnal Kreatif.
8. Hillier, B. (1996). Space Is The Machine: A Configurational Theory Of Architecture. Cambridge: Cambridge University Press.
9. Hillier, B., & Hanson, J. (1984). The Social Logic Of Space. Cambridge: Cambridge University Press.
10. Husain, S. B. (2016). Banjir, Pengendaliannya, Dan Partisipasi Masyarakat Di Surabaya, 1950-1976. Jurnal Masyarakat Dan Budaya, 18(1), 65-80.
11. Hutauruk, T. R., Kusuma, A. R., & Ningsih, W. (2020). Estimasi Kerugian Ekonomi Akibat Banjir Pada Kawasan Pemukiman Penduduk Di Bantaran Sungai Karang Mumus Kota Samarinda. Jurnal Riset Inossa, 2(1).
12. Karjalainen, M., Ilgın, H. E., Metsäranta, L., & Norvasuo, M. (2021). Residents' Attitudes Towards Wooden Facade Renovationand Additional Floor Construction In Finland. International Journal Of Environmental Research And Public Health, 1-17.
13. Karjalainen, M., Ilgın, H. E., Metsäranta, L., & Norvasuo, M. (2022). Wooden Facade Renovation And Additional Floor Construction For Suburban Development In Finland. In D. Bienvenido-Huertas, Nearly Zero Energy Building (Nzeb) - Materials, Design And New Approaches. Intechopen.
14. Khan, M. K., & Ahmad, S. (2017). Flood Resistant Buildings: A Requirement For Sustainable Development In Flood. International Journal On Emerging Technologies, 113-116.
15. Kompas. (2008, 11 29). Kompas.Com. Retrieved 06 01, 2022, From Kompas.Com: Https://Tekno.Kompas.Com/Read/2008/11/29/0712260/~Regional~Kalimantan
16. Logan_City_Council. (2020). Flood Resilient Home Design Guideline For The City Of Logan. Logan_City_Council.
17. Nurhaimi, R., & Rahayu, S. (2014). Kajian Pemahaman Masyarakat Terhadap Banjir Di Kelurahan Ulujami Jakarta. Jurnal Teknik Pwk, 351-358.
18. Piatek, Ł., & Wojnowska-Heciak, M. (2020). Multicase Study Comparison Of Different Types Of Flood-Resilient Buildings (Elevated, Amphibious, And Floating) At The Vistula River In Warsaw, Poland. Sustainability.
19. Saengpanya, P., & Kintarak, A. (2019). Thailand's Floating House Project: Safe And Sustainable Living With Flooding. International Journal Of Engineering And Technology, Vol. 11, No. 5, October 2019, 299-304.
20. Saqib, M., Alam, J., & Muzzammil, M. (2013). Flood Resistant Houses In Indian Environment. 3rd International Conference On Emerging Trends In Engineering And Technology. Moradabad.