The Role of Indigenous Knowledge in Achieving a Flood Resilient Society in Flood Risk Area of Musi River, Case Study: 3-4 Ulu Palembang, Indonesia

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Abstract. Waterfront settlements are commonly found in Palembang, where the housing is spread around the river. River flooding is an annual natural phenomenon and people living near the river built houses that are floodproof with the height of the building exceeding the highest water level. Many years of experience with floods have given rise to indigenous knowledge of flood-proofing construction systems. A Wooden stilt house is a well-known housing that can be spotted along the Musi River and is an example of indigenous knowledge in the flood protection system. The study area is in the riparian of 3-4 Ulu which has a high risk of flooding. It is a qualitative-descriptive study that uses questionnaires to determine indigenous knowledge about flood control practices implemented with an assessment tool called Flood Resilience Rose (FRR). The digitization of existing indigenous knowledge with ArcGIS is conducted to provide an overview of indigenous practices in the study area and how a resilient society in a flood-prone area functions in sustaining and adapting to floods. The outcome of this study is expected to inform the decision-making process in reducing flood risk in the Palembang municipality.

Keywords: Indigenous Knowledge; Flood-proof Housing; Flood Resilience Rose

1. Introduction

Palembang is a city in Indonesia that develops on the banks of the Musi River. Settlements usually develop near water, where resources are abundant and offer hope and life to the people. Waterfront settlements are common in Palembang, where houses spread out around the river. A look at history shows that the development of settlements on the banks of the Musi River was triggered by trading activities. As we know, the Musi River has been one of the international trade routes in the Sumatra region for centuries. This has led to the development of settlement patterns along the banks of the Musi River. The city of Palembang has a relatively apartment topography with an average elevation of 12 meters above sea level. Only about 47.72% of the urban area of Palembang is dry flood-free area, while the remaining 52.28% is a flood-prone lowland [1], The flat topography condition and the presence of large and small rivers that are influenced by tides are causing a drainage problem. Specifically, there is a serious problem that occurs in waterfront settlements in the Musi River caused by natural

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factors such as flooding. Flooding from the river is a natural disaster that happened frequently during the wet season and high tides [2]. river is a natural disaster that occurs frequently during the rainy season and high water [2]. These problems are controlled by the current flood control system, such as the construction of retention basins, the normalization of the river, and the construction of dams for the drainage system along the river. However, flooding continues to affect the activities of residents in riparian settlements.

Resilience is the capability of local communities to cope, adapt, and bounce back from certain disasters and risks they may cause. Long exposure and experiences with disasters allow the local communities to understand profoundly how to respond and adapt to all the circumstances caused by disasters [3]. For example, the people who have long lived in the Musi River riparian area are accustomed to flooding. Their adaptation practices are reflected in the form of housing structures. The people who live near the river have built their houses to withstand floods, with the height of the building exceeding the highest water level. Some of them adapted to the wet environment by creating their living space in the form of raft houses. Architecture and environment are closely related, and it can be argued that architecture is the result of the environment itself. Stilt houses with wooden materials and rafting houses are the best practices of indigenous knowledge for settlements in the riparian of Musi River. These structures form a safe space for them to live in, despite the flooding from the rivers that occurs frequently. Indigenous knowledge forms a society that adapted to flooding by improving its robustness, adaptability, and transformability.

Indigenous knowledge plays a significant role in disaster risk reduction, in this case flooding, because it forms a valuable capacity that empowers people to cope with any kind of hazards and disasters, and eventually it is awakened the social awareness of flooding and shaped a flood-resilient society [4]. Furthermore, effective flood resilience should consider not only on the technical side but also on the social-ecological aspect. The categories of indigenous knowledge based on its implementation and acquirement, are; (1) transmitted indigenous knowledge inherited from ancestors, and (2) experienced knowledge that has been learned from various earlier experiences. [5]

Additionally, a tool for achieving flood resilience exists to make flood risk management more resilient and holistic by helping the practitioners to measure the already taken and the upcoming flood management system namely the Flood Resilience Rose (FRR) [6]. Figure 2 represents FRR which consists of multi-layer actions such as; protection, prevention, preparedness, and recovery. In flood risk management, those actions represent resiliency to flooding (robustness, adaptability, and transformability).

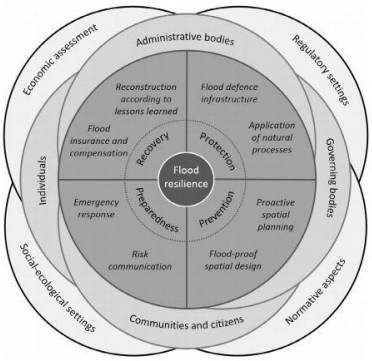

Figure 1. The Flood Resilience Roses [6]

According to [7] The four phases to achieve flood resilience in the FRR represent their purposes and advantages, as described below;

- **Protection** stage intended to avoid the casualties and losses caused by the flooding. For instance, by preparing the flood protection infrastructure and facilities in the affected area.
- **Prevention** stage aims to prevent flooding and reduce flood risks. Examples of these actions are by generating disaster management plans, policies, and studies (passive mitigation) and increasing the disaster preparedness of the community through infrastructure development (active mitigation).
- **Preparedness** stage purposes in preparing for the disaster before it happens by installing the early warning system. So, when initial disaster sign appears people are being noticed and they can prepare how to protect themselves. Moreover, creating a flood evacuation route and communicating it with the locals are important in initiating local engagement and empowerment in achieving a flood-resilient society.
- **Recovery** stage is conducted post-flood disaster to re-achieve the initial condition prior to the disaster. This stage consists of environmental recovery, infrastructure recovery, social recovery, health-care provision, etc.

This paper is intended to elaborate on the answers to these research questions through a study using the FRR tool in relation to the existing indigenous practices in the selected site, as follows;

- How indigenous knowledge is forming a robust society in a flood-risk area considering flood resilience?
- How is the existing indigenous knowledge still going in the study area to support the flood resilience society by using the FRR assessment tool?

The result of this study is expected to assist the decision-making process as well as to improve society awareness and empowerment in flood risk reduction for the selected site in particular, and Palembang municipality in general.

2. Materials and Methods

2.1 Area of Study

Figure 2. Study Area of 3-4 Ulu (Source: Esri, 2022)

3-4 Ulu District has a total area of 250 ha. This area is mostly swampy with a height of 5 meters above mean sea level. In this area, there is also a small Musi tributary, namely the Kedukan River. The existing condition of the 3 - 4 Ulu area is slightly irregular, due to the long-established spatial pattern of the area. This problem is exacerbated by the presence of squatters living around the area. These squatters build houses by not obeying the regulations set by the government. Likewise, the old buildings in this area are mostly neglected and abandoned by their owners especially building in which the residents are unable to remodel or repair their houses. As the result, it affects the conditions, characteristics, and spatial patterns of the residential areas and tends to become slums. In 3-4 Ulu, most of the traditional settlements are called *Limas* houses and *Gudang* houses that are more than 100 years old. But there are other typologies of building, namely; houses on stilts, rafting houses, and colonial houses. The area of 3-4 Ulu is passed by several tributaries of the Musi River, which quite affects the orientation of the buildings in the past. Musi tributaries are also used for river transportation in the past.

The study area of this research is limited to the riparian of 3-4 Ulu with a distance of 30 m from the river bank (Figure 2). Based on the regulation of [8] the riparian (*garis sempadan sungai*) of Musi River is 30 m from the river body. Seeing the condition of Palembang, which region is strongly influenced by tidal fluctuation from the Musi River, it is understandable that most of the people's houses are pillared (stilt houses) located on the banks of the river above the swamp area or floating (floating houses) on the river. Traditional houses with those characteristics are very suitable and adaptive to the surrounding environment. In addition, the existing open space in 3-4 Ulu is mostly a reclaimed area and still not optimally utilized for instance as a public open space for leisure activities, catchment areas, or riparian green open spaces. However, several swamps are used as infiltration areas and still not transformed into other functions yet. There are several potential reasons behind the site selection for 3-4 Ulu to be the study area of this research, which are: in a high-risk area of flooding [9], a swamp area with a low elevation of 0-3m above the mean sea level, and the slope of 0-2% [10], a high-density slum of 28 inhabitants/km^2, the population of 2650 inhabitants, and total area of 162.4 km^2 [11], wooden stilt houses (*Rumah Panggung Kayu*), Rafting House (*Rumah Rakit*), and *Rumah Limas* (Figure 3) with strong traditional characters, the example of the indigenous knowledge can be found in this area [12]

Figure 3. *Rumah Panggung, Rumah Rakit, Rumah Limas* (Field Survey, 2022)

2.2 Research Methodology

This research uses a qualitative-descriptive focusing on identification, reasons, and data collection from interviewees about indigenous knowledge of flood-resistant homes. One-on-one interviews were conducted with questions about existing Indigenous practices related to FRR (Protection, Prevention, Preparedness, Recovery) based flood protection systems in order to capture the overall perspective of this study. The following sections describe each step of the data analysis for this study;

- Literature, research, and theories will be used to support the study, and secondary data will be collected from other reliable sources
- Interviews with residents directly affected by flooding were conducted to list existing indigenous knowledge about flood control practices in the study area
- The list of existing indigenous practices in the study area is explained using the FRR to identify the four stages of achieving flood resilience.
- The collected data of the existing flood control structures are digitized using the ArcGIS geographic information system to determine the materials of the buildings, the total area, and the exact locations.

There are two types of data in this study; primary data which are collected directly in the field, and secondary data which are collected from other sources. For the primary data, a systematic sample survey was conducted using questionnaires to the 96 residents of the study area. The details of the data collection process are shown in Table 1.

Table 1. Data Acquisition Methods (Author, 2022)

Data	Types	Methods	Sources
List of indigenous knowledge	Primary	Questionnaire	Field Survey
List of housing with indigenous practices	Primary	Questionnaire	Field Survey
List of existing social engagement and empowerment	Primary	Questionnaire	Field Survey
Map of 3-4 Ulu	Secondary	Online	*Bappedalitbang* Palembang
Map of Flood-risk Area in Palembang	Secondary	Online	*Bappedalitbang* Palembang

2.3 Questionnaire

This research is using a 4-multiple-choice-question-questionnaire about the multi-layer sections in the FRR (protection, prevention, preparedness, recovery). Hence, the questionnaire is used to identify the details of indigenous practices that have been implemented for each section in the study area. The four questions are stated as follows;

- What are the existing indigenous flood protection systems in your home? (protection)
- What are the indigenous flood prevention systems in your home/living area? (Prevention)
- What are the indigenous ways for the preparedness systems implemented in the 3-4 Ulu community in the event of a flood? (preparedness)
- What are the indigenous post-flood recovery systems implemented in 3-4 Ulu communities when a flood occurs? (recovery)

2.4 Respondents

Respondents are the 96 local inhabitants (49 men and 47 women) who are affected directly by the flooding in the study area of 3-4 Ulu within the range of 30 m from the river (Figure 5).

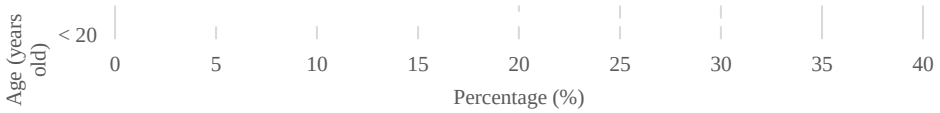

Figure 5. Respondents' Age (Field Survey, 2022)

3. Result and Discussion

3.1 Indigenous Knowledge of Flood Protection Practices with the FRR Assessment Tool

The indigenous practice related the flood resiliency of 3-4 Ulu has been identified through the field survey using the questionnaire. The questionnaire consists of four questions and each question represents the 4 phases of the FRR. The result shows the list of minimum actions that have been implemented for flood protection systems in the study area (see Table 2).

Table 2. List of Indigenous Flood-Protection Knowledge in 3-4 Ulu (Author, 2022)

Present Indigenous knowledge	**4 Phases in achieving Flood Resilience**			
	Protection	Prevention	Preparedness	Recovery
A stilt house is using wooden material that is commonly found in this area. Since a long time ago, local inhabitants have been using *kayu ulin*/ironwood (*eusideroxylon zwageri*), a native rare timber to the Indonesian region. Some of the houses in 3-4 Ulu are built below the highest water level, so they are still flooded.	✓	✓	✓	
A rafting house is using bamboo material for the base structure/foundation, and wooden material for the upper structure. The rafting house follows the fluctuation of river water level. However, the number of rafting houses is slowly deteriorating due to people prefer living inland to living above the water. Furthermore, rafting houses require high maintenance and are costly. Currently only 1 house exists in the area of 3-4 Ulu, the other building is functioning as a Mosque.	✓	✓	✓	
Inland bricked house is commonly	✓			

used nowadays with the intention to create houses that are more resilient to flooding than those made out of wood. Some people had transformed their wooden stilt houses into the inland brick house. However, due to flood water levels that worsen each year, some of the bricked houses, that are designed below the highest flood water level, are still affected by the flood.	
Fundraising for supporting the affected residents is usually conducted post-flooding. Fundraising is generally supported by the government with funding from other citizens who are willing to help. The funding is distributed directly to the affected residents in the form of cash, food, and goods.	✓

3.2 Existing Indigenous Flood-resilient Structures in The Study Area

The result of the existing indigenous flood-resilient practice identification in 3-4 Ulu shows that from 108 houses, mostly structures have wooden stilt structures has a percentage of 83% (90 buildings), followed by houses on land 16% (18 buildings) made of bricks, and wooden rafting house only 1% (1 building). The result of the digitation of existing flood-resilient indigenous practices in form of building structures using ArcGIS is shown in Figure 6.

Figure 6. Digitation of Existing Flood-Resilient Indigenous Structures (Field Survey, 2022)

4. Conclusions and Recommendations

In summary, indigenous knowledge of flood-proof housing is the result of a robust society that has been dealing with floods for a long time in 3-4 Ulu. Indigenous knowledge is believed to be able to remain applied for a long time considering its adaptability and effectiveness. Indigenous knowledge in 3-4 Ulu is categorized as transmitted knowledge, therefore the implementation should be considered in a flood mitigation system through The Flood Resilience Rose (FRR). Flood resiliency in 3-4 Ulu could be achieved since the four phases (protection, prevention, preparedness, recovery) exist in implementation. However, to move forward successfully, each phase of the FRR should be integrated and applied comprehensively. The FRR is beneficial for understanding flood resilience through indigenous knowledge of a society or area, therefore, the Palembang Municipal Government should consider the FRR as an assessment tool in the flood protection system. Moreover, it can be argued that architecture contributes significantly to the formation of a flood resilient society through a flood resistant structure as an example of indigenous knowledge. Nevertheless, the technical aspect is not the only key to achieve a flood resilient society. Social-ecological aspects such as social awareness and social engagement, social empowerment and participation should also be promoted. The results of this study are not limited to the study area of 3-4 Ulu, but can also be applied to other potential flood risk areas along the Musi River.

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