Housing Based on Communal Connectivity to Enhance Resilience in Response to Rob Flood

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Abstract—**Rob flood is one of flood types caused by the increasing sea level rise submerging in area with lower level than the sea surface. With the hazard occurring regularly, this will be able to threaten the community's vulnerability in responding to rob flood which includes social, economic, and physical impacts. With the existing housing precedents that lacks in providing a multifaceted aspect between users and its built environment, this paper aims to offer design concept based on communal connectivity to increase the resilience of community in responding rob flood. Communal connectivity focuses on the concept where communities are able to adapt and mitigate either pre-disaster, during disaster, and post-disaster. The study takes place in Semarang at Jl. Ngilir Timur that regularly has rob flood each year with 2050 as the time context. The typology offered in this design is a co-housing settlement with community resilience approach, where this approach focuses on ways to increase the communities'adaptive capacity. Using force base framework, the main concept offered is a settlement with communal connectivity concept which focuses on several aspects in formal, spatial, material, construction, landscape, and utility. The main concept of this design mainly discusses on social connectivity and supported co-housing in formal and technical explorations which will be able to enhance community resilience in social, economy, and environment aspects.**

Keywords—**Community Resilience, Resilient Design, Rob Flooding Mitigation.**

I. INTRODUCTION

ROB or tidal flooding is one of flood types caused by the increasing sea level rise submerging in area with lower level than the sea surface [1]. The variations sea level rise may be affected due to the rising exposure of tidal bulge in diurnal tides or semi-diurnal tides, human-induced activities, increase of population, climate change, gas emissions, thermal expansion, and glacier melts. Rob flood can potentially cause an endangering balance of water ecosystem as well the livelihoods of coastal communities of giving unhabitable dwelling [2]. As a consequence, it will cause coastal communities to relocate to safer places [1]. With the increasing exposure of the hazard, it will also threaten social vulnerability of communities. Social vulnerability defines as abilities of a community to respond over hazards in terms of managing the risk, preparing resources, as well increasing awareness [3]. Social vulnerability relates to resilience as both attempts to anticipate the hazards faced. Decreasing social vulnerability of communities are necessary in reducing the risk received from rob flood. Illustration of rob flood issue can be seen at Figure 1.

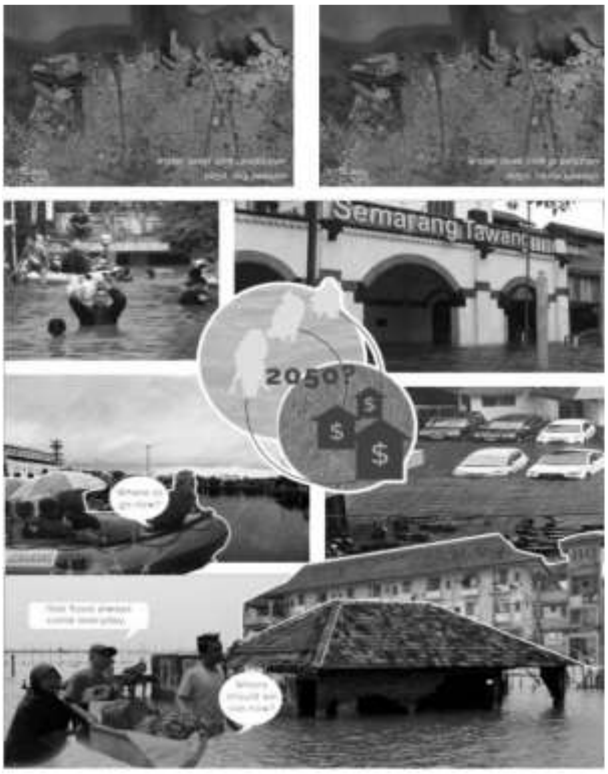

Figure 1. Illustration of rob flood issue.

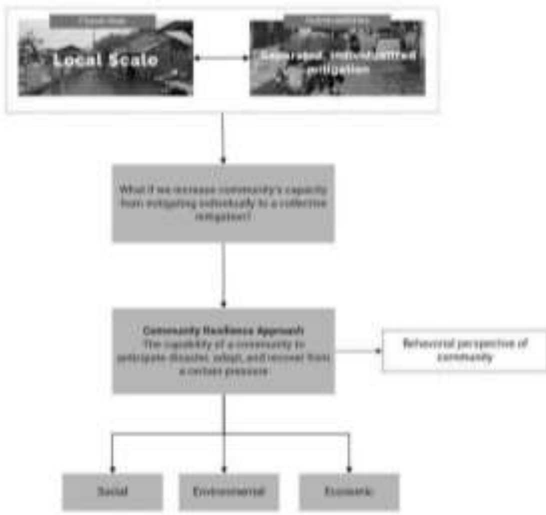

Figure 2. Community resilience approach diagram.

According to Katic, some of the few variables related in developing resilience are socioeconomic status, rural, locations, and residential property [3]. These variables show an importance on how built environment, either based on its spatial and formal qualities, may help to decrease social vulnerability as well increasing resilience for communities. In this context, the aim is to increase the community resilience in facing rob flood. It is can be seen at Figure 2.

Several built precedents have been made by practicians as solution in responding to rob flood and similar hazards. For instance, a firm named NLÉ has built Makoko Floating School in response to coastal flooding and lack of education facilities in Makoko, Nigeria. It is a school made out of sustainable and lightwood material constructed on top of

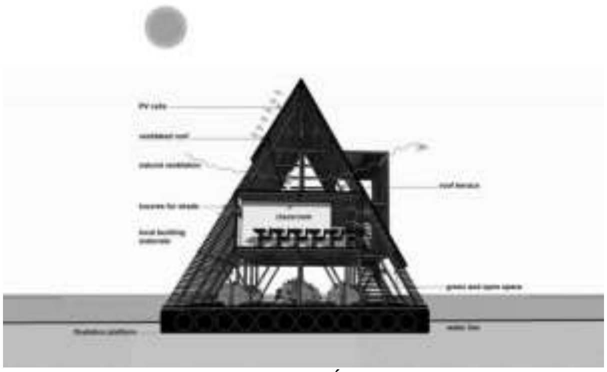

Figure 3. Makoko floating school (NLÉ) concept.

Figure 4. Real-time perspective of makoko floating school.

Figure 5. FLOAT house by morphosis architects.

water under barrels that acted as a self-sufficient rainwater collection, NLE can see at Figure 3 and Real-time perspective of makoko floating school can see at Figure 4. This winning Aga Khan Award for Architecture has three levels with scalable and adaptable attributes along with triangular frame to ensure the stability of the building. Unfortunately, this building has short-span of strength as it collapsed in 2016 due to heavy rain. Another example is the FLOAT House made by Morphosis Architects in 2009 can be seen at Figure 5. This house is chosen as an example to most of the amphibious house built by today. This amphibious house is a pre-fabricated low-income house that is able to survive from flood water and hurricane. This house sits on a 4-foot base

Figure 6. Study case of the research at Genuk, Semarang.

Figure 7. Non-flood condition (left) and flooding condition in Genuk, Semarang (right).

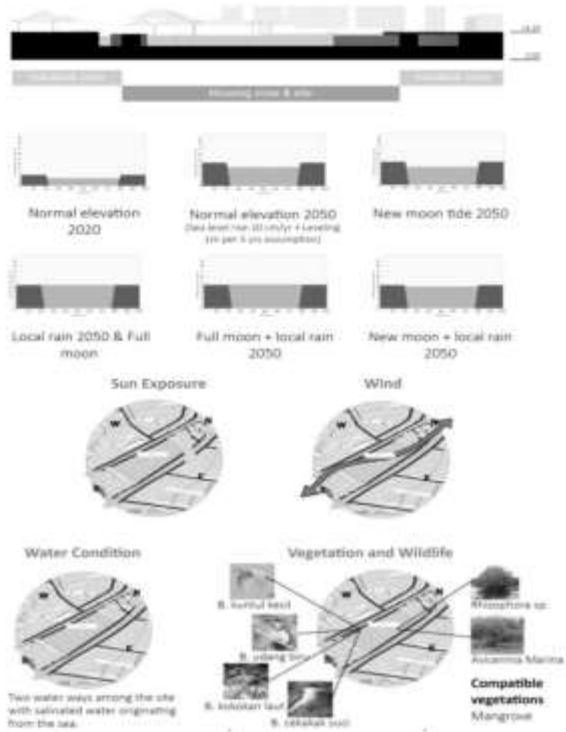

Figure 8. Natural data analysis of the site.

and rises up to twelve feet when water level rise anchored with two concrete frames in between of the house. However, this house doesn't designate its occupants to stay at home during the disaster but to minimize the damage and preserve the user's belongings property.

Based on these two precedents, two gaps can be taken. First, properties haven't been strategized to respond in a multifaceted context especially focusing on the community. Sea level rise along with its disasters such as rob flood will inevitably to happen naturally in many occurrences. However, design should be considered from aspects other

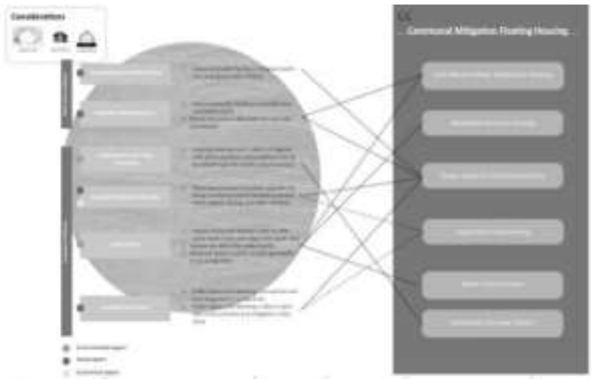

Figure 9. Criteria translation to concept.

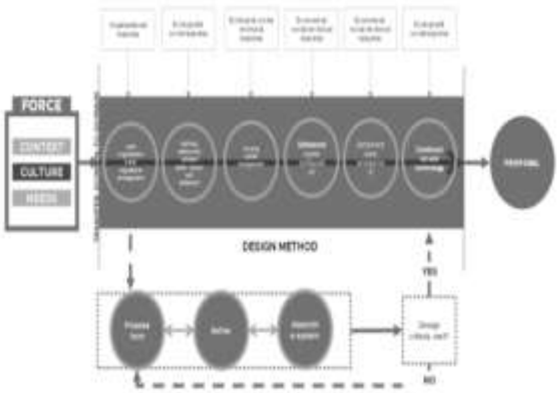

Figure 10. Design methods proposed using force based framework.

Figure 11. Forecasting of trends in 2050.

than sea level rise and its hazard. Architecture should also consider on how community adapts pre-disaster, during disaster, and post-disaster while respecting the biological, social, and cultural factors of the context. It is inevitable that these factors create a reciprocal relationship between users and its built environment. The second gap is how buildings that responds to this issue hasn't strategized any long-term aspect in maintaining resilience other than sea level rise. In a long-term, we will face population increase and other issues that might happen depending on the context. In the meantime, resilience should cover a multi-dimensional aspect that will help to improve the community's vulnerability towards hazard either in a short-term and long-term.

Communal connectivity is a concept proposed by the author for this issue in designing housing to enhance community resilience. Communal connectivity focuses on how architecture as the built environment helps the community to prepare pre-disaster, during disaster, and post-disaster in terms of building design. This strategy focuses on vertical and horizontal connectivity by utilizing the diversity of rob flood that can change from time to time. In another side, buildings should also maintain its connectivity despite of the time changes.

This article purposes to understand how communal connectivity is able to be implemented as strategy in retaining community resilience either in a short-term or long-term facing rob flood along with methods and design strategies used in designing based on this concept. By understanding this concept, one will be able to implement this concept in designing a resilient building in responding to rob flood with concern focusing on communities.

II. RESEARCH METHOD AND EXPLORATION

A. Approaches and Case Study

Community Resilience is the approach chosen for this project. In general, resilience defines as an ability of a certain matter, community, or society to prepare, respond, absorb, transform, and recover from the exposed hazard in an efficient duration of time through risk management [4]. Meanwhile, community resilience is the capability of a community to anticipate disaster, adapt, and recover from a certain pressure [5]. Figure 6 show that study case of the research at Genuk, Semarang. Capability relates to capacity which refers to strengths, attributes, and resources available within the community for this context [4]. This way of thinking encourages to focus on increasing community's resilience in adapting to rob flood, where we are thinking a holistic and evolutionary way to integrate social and environmental aspect to tackle vulnerabilities. This approach will be closely related in thinking ways to accommodate behavioral change on pushing towards a collective-based mitigation in the design. Meanwhile, this approach adopts social-ecological resilience, a resilience framework that embraces a certain pressure or problem as a dynamic system that a community face and adapt from time to time [6]. In this context, flood will be the vulnerability that is embraced as a part in the proposed living community. Figure of non-flood and flood condition can be seen at Figure 7.

Case study is used to provide boundaries to the site being studied for this research which consist of data and analysis of the context. In this research, site is chosen at a water site in

Figure 12. Aerial view & programming of design.

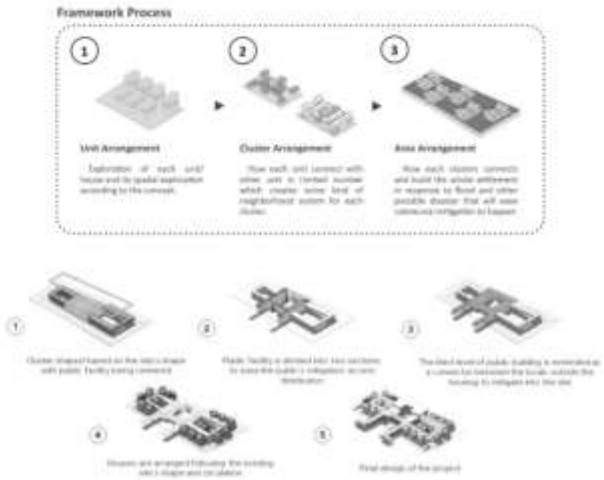

Figure 13. Formal transformation and framework process.

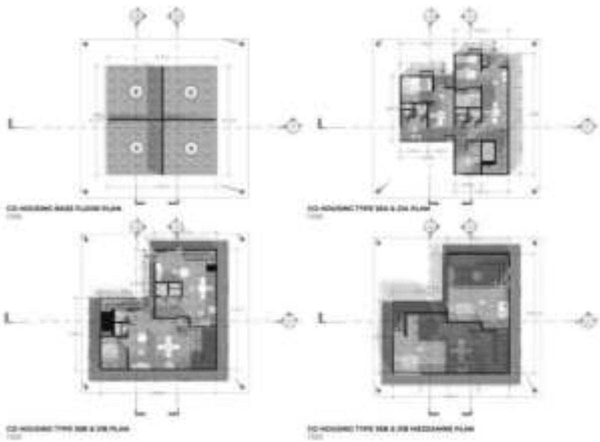
Figure 14. Co-housing plan.

Semarang, Indonesia with specific context at Jl. Ngilir Timur, Terboyo Wetan, Genuk regency. It is bounded with local settlements and industrial zone and surrounded with two estuaries sourced from the northern Java Sea. The time context sets in the year 2050, where every aspect of analysis will be adjusted based on the given context.

B. Data Classification, Forecasting, and Criteria

Site is analyzed into several aspects which are social aspects, natural aspects, and regulatory aspects. Seen in Figure 8, these primary data are indirect observation taken from digital tools to analyze such as Google Map and online mapping tool such as Climate Central. Meanwhile, the secondary data are collected through literature studies and official documents.

After that, forecasting will be taken based on the classified data and compared based to the current (and/or future context). In this case, forecasting is applied by reading trends


Figure 15. Co-housing section plan.

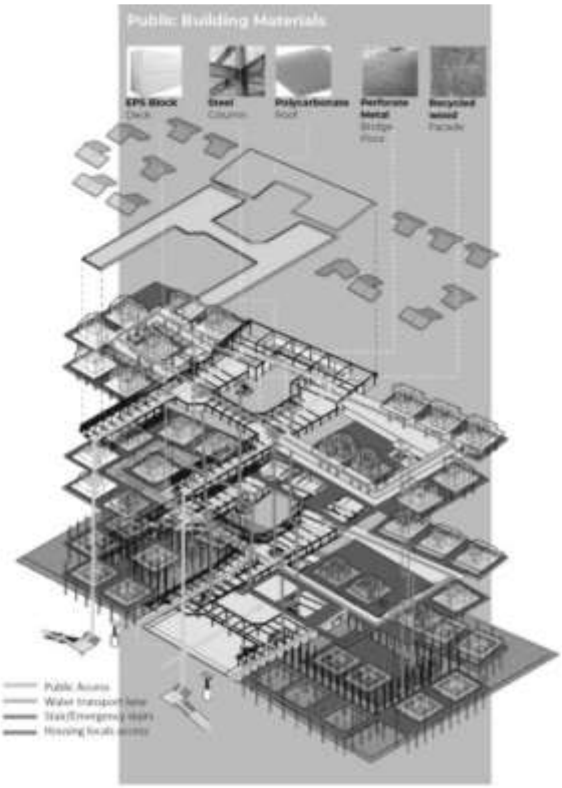

Figure 16. Exploded settlement connectivity.

happening in 2020 and 2050. The forecast will be done based on three aspects: technology, social, and housing.

The design criteria for this design project are determined based on general resilience characters [1]. Resilience characteristic is divided into short-term resilience and long-term resilience. Other than that, there are three aspect related to resilience: social, environmental, and economic. Social aspect relates to how communities are able to withstand social transformation in daily lifes [7]. Environmental aspect relates to how communities are interrelated to the environment and how its environment influences the wellbeing of the users [7]. Lastly, economic aspect relates to how to incorporate employment, assets, and improving business to the communities in the environment

These aspects are fundamental since it is interrelated and shaping the community's capacity. Therefore, the said factors are important as key components to be implemented in creating design criteria at Figure 9.

C.Data Analysis using Force-Based Framework

Every data that is collected will be purposed to analyze and formulate the design exploration. Characteristics of resilience will be translated into formal and spatial criteria in architecture using the domain-to-domain method. In this design, Force-based Framework is chosen out of the three frameworks formulated [8]. In Force-based Framework at

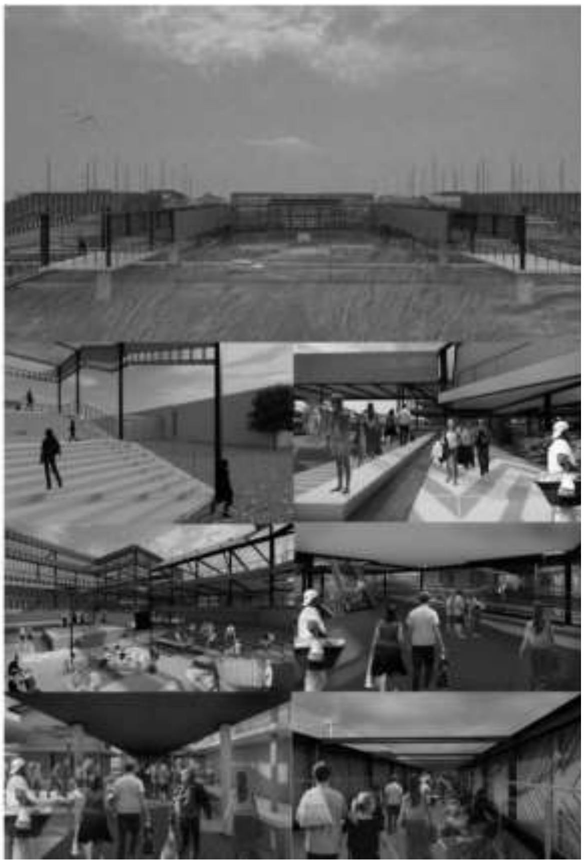

Figure 17. Perspective view of design.

Figure 10, the thinking process is carried in bottom-up manner while managing quality of the external aspects that are translated into architectural domains. This framework is chosen as an appropriate framework for the design due to the high influence of external natural, social, and regulatory aspects that has to be considered to respond towards the rob flooding in Semarang in 2050 show in Figure 11.

D. Formal and Programmatic Exploration

After methods are arranged based on the framework, design will be explored based on formal and spatial aspects according to the method. During the design exploration, design will consider some considerations regarding how it can connect dwellers and communities horizontally and vertically. This design concept responds to the design criteria which derived from the design problems formulated in the previous chapter, which will respond to spatial, formal, construction, landscape, material, and utility aspects. This process is carried out iteratively until formal and spatial ideas that fits the predetermined criteria are discovered.

III. RESULTS AND DISCUSSION

A. Design Criteria

Based on the approach and site description, design criteria are translated to formal and spatial criteria using domain to domain based on characters of resilience that is adapted to the context [1]. These characters include short-term resilience and long-term resilience. The short-term resilience includes connectivity and safe failure with rapidity and responsiveness. Meanwhile, long-term resilience relates to dependence on local ecosystem, spatial/functional diversity, robustness, and socially connected. It is revealed that the scopes of this formal and spatial translations are related to these qualities: spatial relation between the water and settlement, settlement's spatial configuration, housing's spatial configuration, housing construction, and water utility system. Later, these translated domains are arranged in design concept corresponded from the design criteria and specified based on the three aspects of resilience as well resilience design principles which are changing concepts, changing artifacts, and changing contexts [6]. However, in this article, the discussion will mainly focus on two aspects which are supported co-housing and design based on social connectivity which closely related to the paper. Aerial view can see at Figure 12.

B. Design Method and Exploration

Design method includes a series of design activities in developing ideas obtained from the design context. In this project, the method shifts from micro to macro aspects—starting from the co-housing design, clusters, to areal arrangement. Using the force-based framework, the process starts from considering the type of house through the study of spatial relations of the site and water by the context. After spatial study is done, the process can continue by determining the type of house for several target users as well as the spatial arrangement of each co-housing units, followed by the arrangement of housing clusters and finally the arrangement housing area. This whole process will involve external aspects, either from the analysis of building, environmental, social, and criteria. The final step is to determine arrange construction system and its technology scheme.

For the unit arrangement, formal transformation of the units explored based on the potential circulation and flexibility to mitigate at Figure 13. Therefore, one of the criteria is to have each unit connected to one and another and how spatial arrangement ease users to move and mitigate. The principle for this arrangement is to make sure that each house is able to be connected with the public facilities to ease the mitigation, while also ensuring that public communities can easily mitigate to the public facility through the available public space. In this context, the housing is divided into 4 units which consist of two $21m^2$ types and two $36m^2$ types.

C. Formal Concept

1) Supported Co-Housing

Co-housing defined as a type of residential community living model with several families living together in a house. In this project, the co-housing system allows 12—15 members consisting up to 4 Family Card (Kartu Keluarga) to occupy the house legally where one co-housing is divided into 4 type of units. This type of housing is chosen due to the potentials given in 2050 as well to embrace communal mitigation through connectivity. Meanwhile, floating house is the chosen type for this house due to several considerations: it is safe to be used all year especially when flooding, has minimal retention capacity of the flood plain, which makes it a decent solution for flood protection [9]. Co-housing concept can see at Figure 14 and co-housing section at Figure 15.

2) Design Based on Social Connectivity

As mentioned earlier, co-housing was chosen to embrace communal mitigation through connectivity. People will be able to seek help to mitigate easier through this concept of connectivity. The design strategy is to rely on how leftover spaces used for the remaining room to connect from one unit to another either in a horizontal or vertical connection. Other than during the flood, these leftover places are functioned to provide space flexibility from one room to another. Exploded connectivity at Figure 16.

Meanwhile, the areal settlement is arranged based on orientation and social connectivity to ease users in mitigating communally. Bridge connectors are provided attached from the floating house to prevent breakdown on both system while connecting dwellers to public building and at the same time connecting the external realm so local communities outside is also be able to mitigate into the public hall.

Other than during the flood, local communities will be able to access the public building since it acts as a building that is able to cater various activities indoor and outdoor such as health check at the healthcare (posyandu), socialization regarding disaster mitigation, or any other leisure activities and meetings inside.

When flood immediately comes, people will be able to be directed into the designated evacuation points. At the base floor, existing floor patterns are provided with with arrow sign that directs to the water transportation lane. Meanwhile, by the second and third floor is provided with facade with an arrow sign that directs to the evacuation point.

During the flood, the public building will not adapt but at the base floor has been provided water transport lanes so people are able to hop into the boat and flow through the designated canal to mitigate to other points.

D. Technical Concept

House clustering is surrounded by hall bridges and public hall to connect the houses of local dwellers easily to the building as well the community outside of the settlement to connect into the building. Since it is a floating house, therefore the house is connected with a gangway bridge to the hall bridge to maintain its ease of connection. Meanwhile, Posts is made out of PVC Composite to ensure that the building will not weather or corrode easily.

IV. CONCLUSION

Sea level rise caused by land subsidence in Semarang has the potential to submerge buildings from rob flooding both when it rains or when it doesn't rain in any time especially 2050. The government and designer own an important role in supporting the development of resilient housing, with considerations on how housings are able to spatially connect the community either pre-disaster, during disaster, and post-disaster. It is also important to be noted that formal concept and technical concept are always interrelated in designing with such concept, therefore technical aspects are also important to be considered in terms on how these houses and its surroundings are connected. Perspective view design at Figure 17.

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