Environmental adaptation and hazard reduction strategies in relocation housing development by its occupants case: Indo-Tiongkok housing, Neuheun Aceh Besar

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Abstract. The construction of relocation housing is a form of housing assistance for victims of the 2004 tsunami, with various environmental designs. Indo-Tiongkok housing (Jacky Chan housing) is one of the relocation housing in the Neuheun area, designed with an approach adjusting the hilly topography. The disadvantage of building on contoured land is that it is susceptible to local erosion, which can damage buildings on the land (roads and buildings). This study reveals the phenomenon of environmental adaptation strategies by the community to reduce the risk of hazards in their home environment, and this is important to disclose to find out people's attitudes and actions in maintaining the sustainability of their living space. The research method was in-depth interviews with the community to understand the understanding of environmental hazards and community strategies in reducing the risk of dangers that might occur. The information required relates to 2 things: 1) types of environmental hazards, risks, and patterns of threats; 2) attitudes and strategies of society to overcome these dangers. The results showed that the community understands the risk of hazards logically, by looking at signs of natural elements such as traces of erosion, and the impact on artificial elements (houses, soil, yard boundaries). The community strategy to reduce the risk of hazards is to combine various factors from engineering aspects (building materials and techniques), economic aspects, and suitability aspects of plant selection. Results showed that the strategy for adaptation patterns to the environment would appear in each occupant according to their problems and abilities so that the results of the appearance of the residential environment design would vary. This is so unique in the culture of living in each place, which will distinguish it from other places.

1. Introduction

The 2004 tsunami natural disaster that hit most of the coast of Aceh has damaged, destroyed, and even eliminated some of the coastal settlements in the area [1]. The Aceh rehabilitation and reconstruction program is a program initiated by the central government to plan and manage various types of assistance for victims of the tsunami disaster. One of its programs in the housing and settlement sector is housing relocation assistance, one of which is in Neuheun, Aceh Besar District, whose construction began in 2006 [2].

The Neuheun area, located in Aceh Besar district, is the largest residential relocation area in Aceh. There are five relocation housing that was built and scattered on the edge of the hills of Ujong Batee. Indo-Tiongkok relocation housing (known as Jacky Chan housing) is one of the housings constructed in the hills. The housing development was financed by the Tiongkok government, which was
inaugurated in July 2007. The housing is located at an altitude of 300 meters above sea level on an area of 22.4 hectares consisting of 606 housing units with type 42 [3].

The hills of Ujong Batee are less fertile, rocky stony, and grow shrubs. The potential of mountainous rock is used as a C-excavation mining location [4]. Based on the explanation of the village head (Keuchik) Neuheun, the land was used by the local community for traditional grazing.

Based on observations, the construction of the relocation housing used the cut and fill method and directed the hilly walls so that terracing land was formed according to the needs and planning of the housing environment. This matters a part of the hilly land surface open and prone to erosion during the rainy season. Based on the Government Regulation of the Republic of Indonesia Number 14 of 2016 concerning the implementation of housing and residential areas, one of which is mandated that the housing environment must be safe from danger and not cause environmental damage that reduces the quality of the human environment.

This paper aims to see how far the community has succeeded in adapting to the hilly environment and what strategies the community has taken to prevent erosion so that the environment is disaster-safe. The quality of the housing environment increases. This study is essential to conduct as an evaluation material for the construction of relocation housing for disaster victims regarding the adaptation pattern of the relocation community in a new place. It turns out that the location is not free of other natural hazards after they have been removed from the natural dangers of the tsunami.

2. **Theoretical studies**

2.1. **Housing environment and hill topography**

Understanding the residential environment can be approached with existing theory, which explains five essential elements, namely: nature, man, society, shell, and network [5]. Nature (Nature) is a place of life that is chosen by considering one of them is the aspect of being safe and safe from the threat of natural hazards. Humans who will come from nature will carry out adaptation processes with their knowledge and engineering capabilities to create artificial buildings that make sense of sustainable security. The community will learn in communal challenges so that the pattern of adaptation to the natural environment will become a typical character of the community and, in the long run, will become local wisdom. Houses and other environmental facilities as Shell and Network are designed to follow the character of the natural environment so that the artificial environment is safe from the dangers of the natural environment.

Hilly areas are vulnerable due to sloping topography, and certain geological conditions can be unstable due to developments on them. In selecting the site of a residential neighborhood, it is justified to choose a location with a particular slope and relatively stable geological conditions, by engineering the site, by making terrasering to get flat land for the house site in it [6]. Related to the movement and people movement and vehicles in environmental space are reflected in the determination of the pattern of the housing environment and the form of environmental facilities and infrastructure. Therefore, based on geographical considerations, various concepts of the provision of facilities can be applied integratively.

2.2. **Natural hazards and adaptation strategies**

Natural hazards will become natural disasters when natural disasters threaten human life and destroy the natural environment itself [7]. In the Law of the Government of the Republic of Indonesia No.24 of 2007 concerning disaster management, it explains about the standard of rehabilitation and reconstruction of natural disasters, the scale of handling various approaches, namely; a) time aspect (immediate, medium-term, and long term); b) Scope of the problem (partial; holistic/integrative); c) Treatment objectives: (emergency, medium-term, sustainable). The design of the housing environment is required to follow geographical conditions related to geological, soil, air, and climate conditions so that the artificial building is adaptive to withstand damage from natural dangers in the long term and sustainable.

Sustainable development is following the concept of resilience, which is defined as a system problem that is disrupted and rebuilt when it changes to maintain the same function, identity structure, and
feedback [8]. In handling for the long term, holistic/integrative and sustainable, an approach is needed in all aspects of life for disaster-affected communities for the sustainability of their lives. It is necessary to know the level of vulnerability of a place and the character of the community that will occupy it. The concept of vulnerability of a place, which is related to the form of its threat, vulnerability to vulnerability. Concerning the formula, if an increase in the vulnerability of a regional community and the community will be reduced. Therefore, knowledge of disaster forms and patterns, and understanding personal vulnerability, humans can create the necessary adaptation patterns.

To develop adaptation patterns, it requires public openness to knowledge about disasters or transparency to previous experiences, which made the conditions mentioned above vulnerable. In the next life process, a culture close to disaster will be formed (cultural disaster). In a cultural disaster, people know and understand several things related to disasters, namely: a) types of threats; b) frequency of threats; c) the magnitude of the danger; and d) the aftermath of the risk. Thus, they can create adaptation strategies for their resident culture. Adaptation patterns can be developed in three models according to the problems at hand [10], namely:

- a) Limitation, avoidance, related to the threat and risk of known disasters, then take avoidance actions.
- b) Stabilization/protection, related to reducing threats and simultaneously increasing the capacity factor to prevent disasters.
- c) Mitigation, related to efforts to reduce or eliminate the impact of a disaster in a combination of limitation and stabilization.

Natural and environmental hazards that can be recognized from an area can be converted into potentials through engineering on land. It is managed by hilly areas that are prone to runoff from rainwater and minimal groundwater reserves, often applying the concept of an air collecting system to prevent air shortages and function from capturing flowing water [9]. Also, an area landscape can be engineered to obtain the desired landscape quality so that it can improve the quality of human living space, such as outdoor plants, which are following geographical conditions [10]. Thus it is hoped that, with a formally planned housing environment, the quality of the hilly landscape will be better and can improve the land surface in the housing environment. The experience in several places where the artificial environment of housing can enhance the natural qualities of nature itself.

3. Research methods

The research approach is qualitative-phenomenological-interpretive research on the spatial adaptation of the physical environment, to see the tendency of changes in people's behaviour in reading patterns of natural environmental hazards and survival strategies through the creation of responsive artificial environments [11]. The data needed is related to community perceptions about the form of dangers and threats, and survival strategies and patterns of community capacity building. Data obtained by in-depth interviews, reconstructing hazards, and what plans the community is using to reduce the risk of harm. Interviews were conducted with community leaders and selected community members because they can know about people's lives in general. The data is processed and analysed using the dynamic system method to compile causal events so that the optimal strategy can be found for the survival of life in the future. The validation by looking at the structure and logic of thinking.

4. Results and discussion

4.1. Geographical characteristics of Neuheun area and natural environmental hazards

The geographical characteristics of the Indo-Tiongkok relocation housing area cannot be separated from the geographical characteristics of the Neuheun area, which is an integral part of the northern tip of Sumatra Island. Natural hazards come from hydrometeorological and geological threats. The Neuheun area is on the eastern side of the hills around the Banda Aceh Delta, which is influenced by the monsoon climate. These climatic dynamics affect the waters of the Andaman Sea and the Indian Ocean in the West and the Asian Continent in the North, which cause relatively sudden, high-rainfall West winds, hurricanes, and hot and dry air. Meanwhile, the wind from the east from the Malacca Strait causes
eastern winds with the character of the air a lot of rain, and the wind is relatively soft [12]. The difference between the two seasons affects the geographical characteristics of the hills around the Banda Aceh Delta, including the conditions of the Ujong Batee hills. See a map of the geographic location of the Neuheun Region against the Banda Aceh Delta and the monsoons as Figure 1 illustrates.

Figure 1. Location of Neuheun area in the hills of Ujong Batee to the geographic delta of Banda Aceh City [13].

By looking at the monsoon wind pattern map in the Delta area of Banda Aceh City, the condition of the hilly area around the city of Banda Aceh, during the East wind season (the rainy season), will experience the danger of flooding and landslides. In contrast to the West (dry season), hot winds have occurred, which have caused fires in the hills around the city of Banda Aceh, including the hills of Ujong Batee [14].

The geographical characteristics of the Neuheun area are rocky hills mixed with relatively infertile soils. The large stones appear on the surface scattered all over the surface of the hills, making it difficult to grow large plants, which grow in the form of shrubs and grass. The flow of rainwater easily peels off the ground surface. The land is suitable for livestock grazing, which the local community has cultivated for a long time and has become the traditional way of life of local people as livestock herders. Reconstruction of the Neuheun area after the tsunami, including the C mine excavation site, many parts of the area are now open.

4.2. Indo-Tiongkok relocation housing development

The Aceh provincial government determined Indo-Tiongkok housing built in the Neuheun hill area. The distance from the city of Banda Aceh is about 20 km. This hilly area has a height of 300m above sea level, making it very safe from the reach of the tsunami, making it ideal for coastal housing. Figure 2 shows the location of the Neuheun hill area and the placement of the relocation housing.

From Figure 2, it can be seen that the geographic character of Neuheun is a relatively open landscape. At the time after development in 2007, the hills appear rocky and relatively minimal plants, so that it seems less fertile so that development planning must be careful about natural hazards if the extreme weather is rainy or dry. In 2020, there will be environmental conditions that are relatively greener than before, and this indicates that there is an environmental potential that can be empowered and managed.

Based on the explanation of the village head (keuchik) Neuheun, the construction of an Indo-Tiongkok relocation house was carried out in 2005 and then occupied in 2006. That is what was built with the concept of "building Indo-Tiongkok brotherhood". Therefore, the residents of the Indo-Tiongkok Housing who were victims of the 2004 earthquake and tsunami were relatively heterogeneous, with diverse cultural, professional, ethnic, linguistic, and religious backgrounds. Based on the explanation of the chairman of Indo-Tiongkok housing, initially, this housing consisted of 600 households according to the number of housing units and 100 ethnic Chinese families who came from
Chinese residents in Peunayong Banda Aceh as victims of the tsunami, but currently, the number of households is only around 490 households.

Figure 2. Image of relocation housing location, Indo-Tiongkok housing environment map and conditions a) 2007, and b) 2020.

Various types of occupations for residents of the Indo-Tiongkok housing are farmers, fishermen, businessmen, construction workers, traders, civil servants, retirees, and others. With a variety of jobs that are expected to be a positive aspect of the sustainability of housing, people will learn from each other from experiences of various aspects of life and culture. The residents of the housing consist of various ethnicities, ethnic groups, indigenous tribes, Aceh-Java, Padang, Batak, Chinese and other tribes; they live mingled together.

4.3. The development pattern of Indo-Tiongkok relocation housing environment

The Indo-Tiongkok relocation housing was designed to follow the contours of the hills with the concept of cut and fill, cutting cliffs for residential sites and neighborhood roads, so that an environmental pattern was formed in the form of a semi-circular and grid compound. The Indo-Tiongkok relocation housing is designed with a residential area of around 22.4 ha, with 606 units divided into seven blocks and equipped with public and social facilities.

The houses are built with type 42 M2 on plots where the land has been leveled as needed; meanwhile, the ground in the yard is open, with varied topography, so that the soil feels narrow, prone to local erosion, and unsafe for daily activities occupants.

Figure 3. Condition of housing environment at the beginning of construction (a) and currently (b, c).

In Figure 3, it can be seen that the condition of the land at the beginning of development in 2009 (a) in the residential area located on the hills looks arid and lacks trees and the current condition (b) (2020) also looks arid in the hilly part outside the housing (c) so that it is vulnerable to natural hazards, both geological and hydrometeorological factors.
4.4. Characteristics of environmental hazards in Indo-Tiongkok relocation housing

Several natural events threaten the existence of relocation housing, including a) flash floods due to extreme rain and soil erosion, weakening the construction of houses and roads; b) rock slide, prone to hit people's homes; and c) extreme heat often accompanied by strong winds, prone to fires.

Flash floods due to the extreme rainy season and soil erosion have occurred in several places around the hilly areas. According to the residents, this was due to the existence of a C-dug mine on the hill. Currently, the community is anxious about the condition of the hilly environment because the land cover is already open; there are no large trees; the exposed mountain rocks cannot absorb rainwater. During the rainy season, the water will flow swiftly towards the housing. Security in the initial housing planning by building a housing ring road and a relatively wide road border so that the road functions as a buffer. However, the road is also used for access to hills, for the illegal opening of the C excavation business. This effort was unsettling for the community because of the threat of flash floods and landslides, so that in early 2019, the road to the hills was closed [5].

Mountain rock avalanches had occurred in the Cinta Kasih housing nearby and traumatized the community so that the Indo-Tiongkok housing community prevented any construction on the hilly land that was spread across the housing. The effort is being made to control the road to the hills outside the housing.

Extreme heat and strong winds very often occur because of the geographical location in the hills and facing West, which is the direction of the West wind flow or the transition period that often causes drought. People are worried about forest fires that can spread to housing. Therefore people want the area around the housing to be green. However, the community cannot do much to improve the surrounding environment. The effort can be made at this time is only limited to handling in the territory of his residence.

4.5. Environmental adaptation strategies by occupants of Indo-Tiongkok housing on occupancy area

The Indo-Tiongkok housing community, in general, understands the threat posed by contoured landforms. They know the characteristics of the land. Based on their experience while living in Neuheun for more than ten years, in general, this area is safe from floods and landslides, but the community is aware of the threat of extreme rainy season that occurs every year.

Extreme weather conditions, such as heavy rains, will damage the forested yard due to local erosion. Therefore the community generally controls rainwater through technical engineering of the land in the yard. However, land engineering can also be beneficial for residents both in the economic aspects of daily needs and socio-culture.

4.5.1. Engineering front yard. Land improvement in the front yard by changing the ground level parallel to the outside of the building, as seen in Figure 4.

![Figure 4](image-url)

**Figure 4.** The pattern of land change in front of the house lots a) initial house b) front land c) in the yard area.

Changing the front yard land (by hoarding and elevating the land) makes the yard area broader and more qualified. In general, people who grow plants are useful in terms of daily kitchen needs and to get a relaxed home environment. The distance between the house and the neighborhood road as an imaginary separate public space, this allows residents to sit on chairs with the large courtyard in front of the house, the distance between the home and the neighborhood road as an imaginary separate public
space, this allows residents to sit on chairs. Another benefit, a large yard is useful for expanding social areas, such as receiving a larger number of guests.

The engineering on the land demonstrates a compromise between disaster risk and the need for adequate housing. Thus, the archetype is based on disaster mitigation adaptation.

4.5.2. Backyard engineering. The condition of the land behind the house is divided into two types, namely: the ground behind the house on the inner plot of the house and the land behind the house on the field on the outskirts of the housing, which borders the land outside the housing.

4.5.2.1. Rear plot in housing. The land behind the house is generally contoured as high as the house building and borders the neighborhood road, above which is fenced by hard plants such as horse trees. Thus, the limit of land management is back to the boundary of the environmental road above it. Changes in the land behind the house occur when there is a need for house expansion due to the demands of the home owner’s needs. More space is added to the back or side of the house by cutting the ground close to the wall of the house. This makes the house wall unite the earth wall so that the house wall also functions as a follower of the land or a separation between the house wall and the cliff, as shown in Figure 5.

According to the community represented by Mrs. Ani, these plants can prevent land erosion. Based on the above conditions, the danger of erosion always threatens the existence of the house. However, the community realizes this condition, trying to make the back land green by planting lush trees such as soursop, jemblang, and srikaya trees.

The community has built drainage channels around the back and sides of the house, so is no puddle around the house. Rainwater is stuck beside the house, which means used to fertilize the plants around it, and excess is then channeled into the ditch in the front house. Community action to manipulate the site is a form of strategy to reduce the risk of natural disasters in the way of disaster mitigation measures.

4.5.2.2. Rear lots at the edge of the housing. The backyard is relatively long sloping contours. It is possible to function as a border for roads outside the environment. It is hoped that the effects of activities and natural dynamics outside of housing will not affect nearby housing. The backyard is used for orchards while maintaining the land cover with grass. The community is aware of the dangers of erosion that may occur as Figure 6 displays.
Many of the back yards are a divider for residential areas to the hilly environment outside, which is very suitable for the management that will be given to the owners of the plots concerned. The sense of ownership of the land will encourage efforts to care for an environment where the threat is high. If the community has adequate management capacity, then disaster risk will be reduced. Besides, it will increase the food security of the plot owner.

5. Conclusion
Changing the front yard land is a strategy for adapting the interests of residents and improving small-scale ecology, namely:

i. From the aspect of the residents' interests, a flat yard will expand the occupants' activity space, both for social, cultural, and daily activities of residents, such as sitting to fill their spare time or a place to receive large numbers of guests.

ii. From an ecological aspect, the landfill is relatively fertile so that it can be planted with tree crops such as fruit trees. Changing the yardland into a cool garden and producing microclimate changes that will prevent strong winds from entering the house at the same time and cool the atmosphere of the place during the dry season.

Indo-Tiongkok housing shows that the people have succeeded in improving their occupancy environment through technical engineering in site housing. It is beneficial in improving the residential landscape as well as hills, which can enhance the micro-climate environment. However, there is very little attention to public facilities, so that the existence of these facilities is threatened by natural hazards, such as erosion of land and building quality that is not affected due to extreme climate change.

In general, the housing environment has improved the character of the hilly area, but what is worrying is the dangers that come from outside the housing environment that cannot be controlled. Adaptations that are carried out, in general, are disaster mitigation adaptations in the form of compromising between human and environmental interests.

Concerning the land outside the housing which belongs to the local community and individuals, part of it has been cultivated as C excavation (mountain rock quarry), which is also used as pasture land. Therefore, it is necessary to understand the community and carry out dialogue that results in an agreement for the benefit of immigrant communities as well as local communities.

6. Acknowledgments
This paper is part of the research report of the Head Lecturer Research Scheme, PNBP notes for 2020. Thank you to the Syiah Kuala University and the Indo-Tiongkok relocation housing community for the information, as well as the students participating in the coastal area planning course Urban and Regional Planning Study Program Department of Architecture and Planning, Faculty of Engineering, Universitas Syiah Kuala, even semester 2019-2020, which has helped study data activities and make the necessary maps.

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