

The adaptation strategy of dwelling in the riverside settlement of the Arut River in Pangkalan Bun City, West Kotawaringin Regency, Central Kalimantan

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Abstract. This research entitled the adaptation strategy of dwelling in the riverside settlement of the Arut River in Pangkalan Bun City was conducted with the consideration that the settlement has a similar typology to settlements in the Kalimantan which are generally next to/on the rivers. This settlement, located both on the river and in the transition points between lands and rivers, is familiar with damp environments. The people dwelling in this place, dealing with damp environments and striving to continue their life, must adapt to such environment. Therefore, this research tries to discover what kind of strategy done by these people to live in this kind of settlement.

The research method used is mixed method. Mixed method is a combination of quantitative methods based on interview data and questionnaire, and qualitative exploration method that is based on field observation in the exploration of adaptation strategies settled in Arut River settlement.

The research finally discovered the adaptation strategy of dwelling in this riverside settlement particularly the adaptation strategy to deal with tides and climate problems related to wind movement, precipitation, temperature, humidity, and other factors related to socio-economic condition of the people.

Key words: adaptation strategy, riverside settlement, continue their life.

1. Introduction

In general, developed traditional settlements in Indonesia have their own uniqueness when it is related to the geographical location. There are settlements located on the hillsides, over the river, are on the banks of the river. Initially, the existing settlement was linked to the livelihood of the community, for example, the settlements on the river of Kalimantan. Many settlements is located on the river/ near the river because of the most people livelihood, firstly, is fishermen. In the past, this riverside was the grown settlements centre with village background. Aside from being the source of life for the people, the river is also used as inter-island transportation on Kalimantan. From the past until now, the rivers in Kalimantan has an important function in the economic development and has become a vital part related to the activities of the community as a whole, where various activities of the community are undergone, both settlement activities and other social activities. So the existence of settlements along the banks of the river is not something new. The geographical condition of the country in Indonesia which has many rivers as the life orientation makes the river as a place to live and seeking livelihood, even its existence has become a tourist spot now [1],[2],[3].



In the subsequent development, the settlements existence on the riverbank experienced dynamics mainly related to environmental conditions. Some rivers have been considered disturbing the community life as it causes flooding, especially during the rainy season. In addition, flooding disturbance, climate factors also contribute to environmental disturbance for the settlements [4].

A study, entitled settling adaptation strategy in the urban waterfront settlement of Pangkalan Bun was deliberately conducted as the settlements had similar typology to the settlements on the banks of Kalimantan. The settlement experiences the phenomenon of natural disturbance affected by the flood from the Arut River, especially during the rainy season and climate disturbance. With the phenomenon of natural disturbance, to maintain the survival of life, inevitably, the residents have to adapt to their environment. What we want to explore through this research is the process and form of adaptation.

Adaptation and change are inseparable for living. Adaptation is applied in every living things to survive in a constantly changing environment. Adaptation is a human responsive behavior towards the environmental changes. Such responsive behavior allows them to organize certain systems for their actions or behavior, in order to adapt to the situation and conditions. Those behaviors are related to the necessities of life, having previously passed certain circumstances and then developing a strategy and a certain decision to deal with the next situation. Thus, adaptation is a strategy used by humans in their lifetime to anticipate changes in both physical and social environment [5]. Adaptation strategies can be defined as the ability of a person to apply a set of ways to deal with the many of issues which is surrounding his or her life. This problem-handling strategy is basically the ability of the community to manage all its assets [6].

2. Literature review

2.1. *Natural phenomena and physical environmental changes as the causes of adaptation*

Physical environmental changes can be considered as a pressure for families or communities to make adjustments so that the residents' needs can be adequately fulfilled. Briefly, these adjustments are expressed in terms of on-site adjustments and adjustments by residence movement. If a settlement area is disturbed by a natural phenomenon, then certainly the residents will make adjustments to nature. Sea level rise directly or indirectly impacts the lives and livelihoods of the residents, will be answered in accordance with unique natural adjustment processes. Various adjustments to stress are revealed in accordance with the cultural and habitual form that the residents possess. The natural phenomenon and physical changes in the environment in question are floods and climatic conditions [7].

2.1.1. *Flood*

Flood is one of the most frequent disasters in the last decade. The impacts of this flood include damage to residential areas and infrastructure damage. Indonesia is one of the countries considered to be vulnerable to climate risks, which is affecting the occurrence of floods [8].

Flood is a frequent phenomenon and directly could impact community activities. Areas that are often affected by floods are no exception dense residential areas in the river border due to overflow of the river. Floods occur due to two events namely floods and puddles that occur in areas that are often flooded and the second is the flood that hit an area due to river water runoff [9].

The factors causing floods on Kalimantan are very diverse. Some of them are forest destruction caused by forest exploitation, illegal logging, land fires, and so on. Then, there is the mistake of the area designation, with the real evidence that the number of water catchment area is now clearing, and it leads many expansion of open land. In addition, many large rivers on Kalimantan contributed to the cause of the flood. The character of the river on Kalimantan is generally a tidal river and influenced by the rainy season and the conditions of the upstream and downstream.

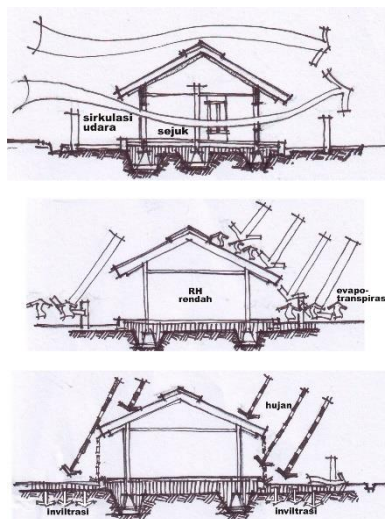
2.1.2. Climatic conditions

The tropical climate into several classifications based on average daily temperature and the difference between day and night temperatures. In this grouping, only cities or regions with average daily air temperatures of 28° C or more are included in tropical climatic categories. A prominent feature of the tropical climate is the high average daily temperature compared to other climates. The problem posed by this climate is the warming caused by solar radiation. The implications of solar radiation to the surface of the earth depend on the falling angle, depending on the conditions of the cloud that can block the radiation emission and depending on the difference in surface character so as to have a difference in terms of reflection and absorption of the radiation [10],[7], [11].

In many ways, architectural design is less attention aspect of tropical climate in solving problems in various settlement areas, both in urban and rural areas. Problems caused by humid hot tropical climate such as high rainfall, temperatures generally above the comfort tolerance, stinging solar radiation especially with global warming issues, high humidity and relatively slow airflow for gaining the thermal comfort, is not anticipated by a residential area planner or designer. Though, it can disrupt the comfort and stability of residents in a residential area. For the environment adaptive architectural design is expected to reduce the microclimate, thereby generating thermal comfort in occupancy in the tropical city. Convenience can be obtained from aspects of the building itself, and from the environment outside the building [12].

There is a balance relationship between microcosm in the architectural building where humans live with the macrocosm that is the universe where the architecture building is related to nature and tropical climate. Architectural buildings in Indonesia are mostly influenced by nature and tropical climate, namely the influence of sunlight and the orientation of buildings, wind and air space, temperature and protection against heat, precipitation and heat humidity [13].

The architectural design, especially architecture of houses must adapt to the tropical climate in Indonesia [14]. The embodiment of adaptation is manifested in the design of the building which has the following characteristics (figure 1):



Maintain the air movement within the house where living, thus it is able to move heat and humidity out the building by convection, so that the air in the house is always relatively cool and comfortable

Open space provides an opportunity for evapotranspiration, to suppress excessively high humidity

In the rainy season, open spaces are useful in maintaining hydrological cycles by suppressing run-off and keeping infiltration on green land. On a broad scale, it could prevent floods and maintain a balance of freshwater and saltwater pressures to prevent sea water intrusion.

Figure 1. Architectural design adapting to tropical climate

Local wisdom manifests in the form of Indonesia architecture that is adaptive-responsive to the tropical-humid environment of the tropical archipelago. The original architectural form of Indonesia presents a number of appropriate characteristics to the tropical-humid nature situation. This characteristic is an adaptation and response to the local environment (Wikantari, 2008). One of the characteristics of tropical-humid in traditional houses is the use of stage structures near riverbank (figure 2) [15],[4],[16].

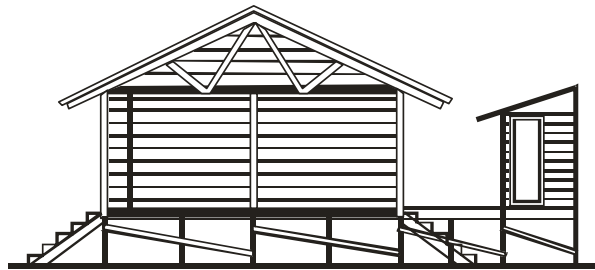


Figure 2. Sample of house on stilts house model

2.2. Characteristics of settlements on the banks

River is the lifeblood of the people who have inherited in developing Kalimantan, so that cities in Kalimantan basically grow and develop from the embryo of the riverside settlement. The cities in Kalimantan are now developing very rapidly, but pay less attention to the potential of riverside settlements and pay more attention to the growth of land settlements [17].

Settlements on the banks of the river consist of many variations of houses and housing. Such variation will be more pronounced in a heterogeneous society. For example in Kalimantan society there are various forms of houses, although it can be said that almost everything is a house on stilts. In indigenous communities Kalimantan, Dayak tribe, main form of the main is the elongated *rumah panggung* (stage house) extends to the left and right inhabited by a number of families. Although architecturally, the house of stilts has almost the same shape but the similarity in some places is somewhat different. For example, there is a call by the name of "lamin" there is also a call as "betang" house. Among the Malays who mostly live in the lowlands or beaches, most of the houses are also houses on stilts.

The main materials used to create a house on stilts are wood that can be easily obtained from the surrounding environment. It is just in the present, because of the technological developments of house on stilts, the wood has been using non-timber materials, such as floor mounted wooden pegs, it is affecting the existence of wood as the main materials of house building. The settlements form for the riverside area has the shape of a house on stilts. This is due to the influence of natural components in the form of tidal surface of the river (figure 3). As for the settlements away from the river, there are some which the shape is house on stilts, yet because the existing land is a swamp sediment, then the existing resident houses form the house on stilts pattern [4].



Figure 3. Rows of Housing on the banks of the Arut River

Community activities on the banks of the river make the river as the center of everyday life, such as livelihood and as a water taxi. The river is made by the surrounding community as a means of connecting with the surrounding village/town. In general, the construction of residential buildings on the banks of the river has a form of house on stilts. This stilt house is suitable to be built in swamp

area, because this area is risky to flood which will rise every time and also the influence of tidal affected by the river. In accordance with geographical conditions, the houses are built on poles by the river, or over the river. The residents' houses are constructed of forest wood which is widely found in Central Kalimantan. Originally, houses were built on the banks of the river, facing the river so that the river into the front yard [4]. According to Kertodipoero's description [18] about rivers and settlements on Kalimantan, houses stand on poles, all facing the river, and each house has wooden stalks. He mentions villages along the banks of the river as a "station", connecting one village to another village, and anyone passing through it can stop.

2.3. Adaptation strategy

Hardesty, in [19] put forward the notion of adaptation: "Adaptation is the process through which beneficial relationships are established and maintained between an organism and its environment". Meanwhile, cultural ecologists define that adaptation is an adjustment strategy that humans use during their lives to respond to environmental and social changes [19].

When humans are confronted with a solid situation, which can be perceived as situations that threaten their existence, humans will adapt. This means that there is an interactionist relationship between the environment and humans. Environment can affect humans, humans can also affect the environment [20]. Because of their mutual influence, there is an adaptation process of the individual in responding to the pressures coming from the environment. To some extent, humans have the flexibility that allows individuals to adjust to their environment. This adaptability has a value for their sustainable life.

The occurrence of adaptation can not be separated from perceptual understanding [21]. According to Bell, perceptions may vary due to physiological processes. In terms of human interaction with the environment, humans will always try to obtain harmony with the environment. It is possible by the present of cognitive ability to make certain reactions to the environment that contain certain things that interest them in fulfilling their needs. How is the process of relationship with the environment that occurs since humans interact through sensing up to the occurrence of reactions, depicted in the scheme of perception as follows:

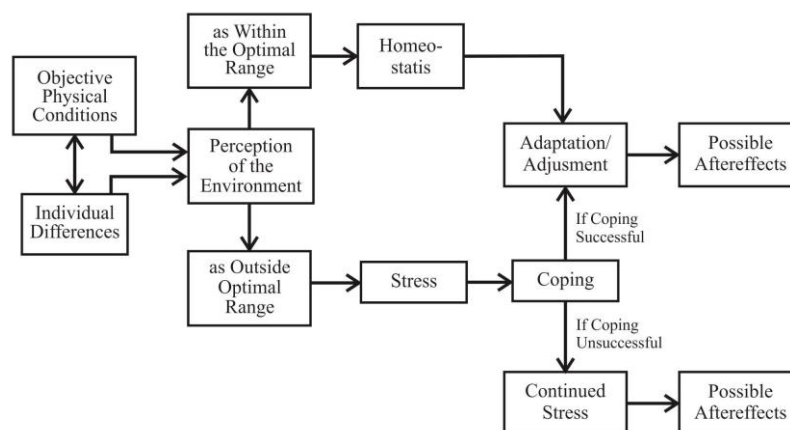


Figure 4. Perception of the environment scheme

Figure 4 explains the results of human interaction with the objects resulting in human perception of the object. If the perception is within the optimal limit, then the human being is said to be in a static homeo state, that is a well-balanced state and usually always wanted to be defended by every human being because it creates a pleasant feeling. Conversely, if the object is perceived as beyond the optimal limit, then people will experience stress, there is an increase in energy, so it must be done coping to adjust the environment on their condition. Human adjustment to the environment is called adaptation, while the adaptation of the environment to humans is called adjusment. In terms of human interaction with the environment, humans will always try to obtain harmony with the environment. [22] distinguishes between adaptation behavior and adaptation strategies. Adaptation behavior is, behavior

aimed at overcoming problems encountered or to obtain something desired and this is different from adaptation strategy. Adaptation strategies are defined as the patterns of various efforts planned by humans to meet the minimum requirements they need and to solve the problems they face. The patterns in question here are patterns of behavior or action.

3. Methods

The research method used is mixed method [23]. Mixed method is a combination of quantitative methods based on interview data and questionnaire and qualitative exploration method that is based on field data (field observation) in the exploration of adaptation strategies settled in Arut River settlement.

The boundaries of the study area are settlements along the Arut River that belong to the administrative area of Mendawai and Raja villages. The reason for determining the area of this research is because this area became the starting point of the growth of Arut river settlement and became the forerunner of Pangkalan Bun city (figure 5). The number of home population in the identified research area is 2,580 units with relatively similar homogeneous level, thus the number of samples set as many as $\pm 10\%$ or as many as 260 houses and its occupants as respondents.

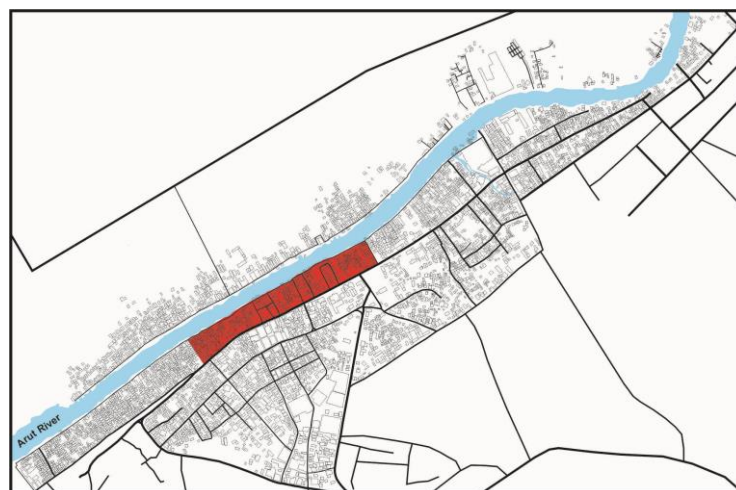


Figure 5. Boundaries and research location

Components of the object of observation are: : [i] dimensional of buildings, [ii] building structure, [iii] roof cover used, [iv] wall material used, [v] flooring material used, and [vi] distance between buildings. Interview data is needed to know the social, cultural, economic and perception backgrounds of respondents as residents. The observations and interviews were then analyzed to produce findings in accordance with the objectives of this study: to reveal adaptation strategies in settlement on the banks of the Arutriver, especially to tidal discharges and climate disturbance related to wind, rain, and temperature, humidity and other factors based on socio-economic conditions of the community.

4. Discussion

4.1. Geographical condition, administration, and population of Pangkalan Bun city

Pangkalan Bun City is a part of South Arut Subdistrict of West Kotawaringin Regency which is geographically located between 02'-44'-03"South Latitude and 111'-42'-04" East Longitude. The administrative boundaries of Pangkalan Bun City are as follows:

North : Medang Sari Village
 South : Kumpai Batu Atas Village
 West : South Arut River
 East : Kumai Sub-district

The total area of Pangkalan Bun city recorded 821 km² consists of 9 villages (Mendawai, Mendawai Seberang, Raja, Sidorejo, Madurejo, Baru, Raja Seberang, Natai Baru, Pasir Panjang), which includes 39 RW and 149 RT.

The population in the city of Pangkalan Bun at the end of the year 2016 is 98,691 people. The composition of population by sex is known that the population of male sex is 51,024 people and the population of female is 47,667 people. Based on the data, the largest population is in Baru village which is 24,324 people and at least in Natai Baru village is 2,132 people (Kotawaringin Barat Regency in Figures, 2017).

The pattern of settlements in downtown Pangkalan Bun is divided into two parts, namely North Arut River and the South side (figure 6). North of the Arut River, the settlement is relatively low density, that is a linear pattern along the riverside. The area includes Village Mendawai Seberang and Raja Seberang. While in the South River Arut is the heart of the city that became the center of the activity so the settlement is high density.

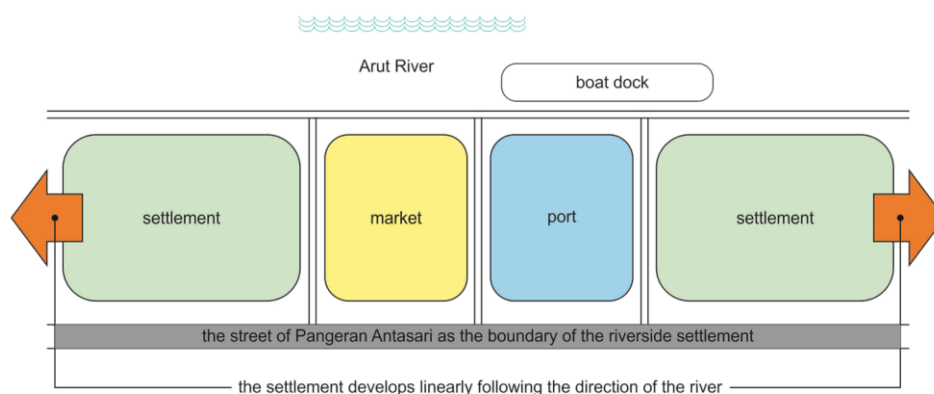


Figure 6. Early area structure of Arut river settlement pattern development

4.2 Research findings

4.2.1. Adaptation strategy based on dimensional of buildings

In the study area there were 57.30% small type houses with an area of <36 and 36-45 m², the remaining 45-54 m², 54-60 m², and > 60 m². Based on this type of field observation, it shows that more on the edge and facing the river. Not much information is obtained from the citizens, but the contention appear that small types are more existing on the riverbank because of the flexibility factor. This means that small type has a lighter weight and certainly has a small impact if the condition of the soil that supports the building is not hard ground. In addition, small type of house has a smaller wall area so that if there is wind blowing from the direction of the river does not have a bad impact when compared with large type of house with a large wall area [16]. Thus citizens have anticipated such conditions, and this is one form of stle adaptation strategy by the river (figure 7, table 1).

Table 1. Dimensional of buildings

NO.	DIMENSIONAL OF BUILDINGS	TOTAL	%
1	< 36 m ²	81	31,15
2	36 – 45 m ²	68	26,15
3	45 – 54 m ²	43	16,54
4	54 – 60 m ²	15	5,77
5	> 60 m ²	28	20,39
Total		260	100,00

**Figure 7.** Small type building example

Residents adaptation to residential design with relatively small dimensions has succeeded in building the physiological comfort of the inhabitants achieved through an understanding of the climate and the human responsive system [24].

On the other hand, according to the residents' explanation, the figure of the building on the banks of the river with a small dimension in addition to saving development costs, is also efficient in maintenance considering the economic condition of the residents who earn an average of 1-2 million rupiah / month.

4.2.2. Adaptation strategy based on building structure

There are 76.92% of buildings using a stage structure with wooden building materials, and the rest using concrete. It shows that the use of stage structures for residential buildings above the river has a specific purpose (table 2).

Table 2. Based on the structure used

NO.	BUILDING STRUCTURE	TOTAL	%
1	Stagestructure with wood material	200	76,92
2	Stagestructure with concrete material	51	19,62
3	Non Stage	9	3,46
4	Floating	0	0,00
Total		260	100,00



Figure 8. The use of a stage structure for residential buildings on the riverside

According [4],[16], the *arsitektur panggung* (stage architecture) of riverside dwellings also tried to adapt to water level elevation conditions. With the house on stilts shape, the rise or fall of the river water surface will not interfere with the activities in the house in daily activities (figure 8).

Residential architecture of house on stilts shape, is an eco-responsive wisdom to the local environment, or appropriate and responsive to the topography of tropical areas that are hot and high humidity [25].

The structure of the stage is related to the tectonics of engineering and the form of arrangement, connection, the circuit consists of various elements and materials that form a construction and building structure [26]. In residential architecture in the area of research, the structure and construction in the form of column frames and beams with dynamic jointed connection arrangement.

Architectural building of residential house in research area is building with construction system connection (peg-hole and pen-hole), it is dominated by wooden/bamboo building material. Tectonics deals with the technique and the arrangement form, connection, the circuit consists of various elements and materials that form a construction and building structure. The wisdom of the geo-adaptive geo-responsive tectonic system, which is appropriate and responsive to the Indonesian archipelago, which tends to sedation and earthquake vibration forces, as well as the force of wind blowing [27]. The determinants of the design and construction of inhabited comfortable buildings are how to relate to the conditions of climate [28].

4.2.3. Adaptation strategy based on the use of roof covering

Based on the data obtained from the respondents, the roof cover of most buildings used is zinc material (86.92%), the rest using tile, asbestos, wood. The results of the interviews show that the reason for the use of roofing material from zinc because it is considered cheaper, lighter and more durable though has the disadvantage of having a catalyst to heat (figure 9, table 3).

Based on the analysis, in addition to cheap, lightweight and more durable, the use of zinc makes the building lighter considering the ground conditions at the bottom / riverside is not hard ground. The use of a saddle roof shape with the terry model is possible because of its correlation with the tropical climate. The shade of a saddle-shaped gaze is a steep angled saddle and a wide-ranging diaphy reveals the role of shade. The roof shape thus reflects eco-adaptive eco-responsive, which is appropriate and responsive to the vertical burden of tropical rain and lateral force of wind blowing [16].

Architecture is a shadow. That is the understanding of architecture in Indonesia. For these needs, namely the presence of shade or shade, then the presence of a parade of shade or shelter that the answer. Diversity of roof formation is related to the important and honorable role of the roof. Through the review of the tropics containing the dry season and the rainy season, of course become more stable and real that the first and main elements of Indonesian architecture is the roof. With this main role and position also the structure of the building make the pillars supporting of the roof as the main pillars [16].

Table 3. Based on roof used

NO.	Roof Covering	TOTAL	%
1	Tile	4	1,54
2	Asbestos	5	1,92
3	Zinc	226	86,92
4	Fibers/Leaves	2	0,77
5	Shingle	23	8,85
Total		260	100,00

**Figure 9.** The use of zinc as a roof cover (left)
wooden board as a ceiling to reduce heat (right)

4.2.4. Adaptive strategy based on used wall

Based on data from the respondents, as many as 81.54% of houses using wooden boards as wall building materials, the rest using brick and bamboo walls. With such large amounts indicating that the use of wooden boards for residential walls has a special purpose. According to residents interviewed, initially the use of wooden boards for the walls was done because at that time the supply of wood is very abundant and at a cheap price. The current condition of residents still maintains the existence of wooden board as a wall building material because it still survive its durability and easy in its maintenance (table 4).

The use of wooden wall building materials for walls presents a light-porous membrane. Thus raises eco-adaptive eco-responsive in the formation of the inner baffle and the outer casing of the field to a tropical-humid environment. Wall insulation is made using wooden board arrangement by leaving the gap between them [16].

Table 4. Based on used wall

NO.	WALL	TOTAL	%
1	Bricks	48	18,46
2	Wood/Board	212	81,54
3	Bamboo	0	0,00
4	Zinc	0	0,00
Total		260	100,00



Figure 10. Coloring on wooden wall

The purpose of the use of porous inner and outer sealing walls is to preserve the air circulation system in the dwelling house, to induce heat and humidity out of the building by convection, thereby keeping the air temperature in the house cool and comfortable [14].

Outdoor space with indoor space limited by dingsing should be of particular concern, thus the wall must be capable of providing cross-ventilation media [29].

Some homes provide a combination of wooden window board openings in the form of windows with the aim that the air circulation more smoothly in the room. Even some houses paint a wooden wall with some kind of color to beautify the look of the house. The above explanation provides assertion that from the beginning the community already has adaptation strategy to humid tropical climate especially in the selection of environmentally friendly wooden wall building materials to facilitate indoor air circulation to be more comfortable. In addition, wooden building materials are lighter when compared to bricks (figure 10).

4.2.5. Adaptation strategy based on used floor

Similar to the use of wooden boards for house walls, the use of wooden boards for home floors is also included in large numbers (80%), the rest using stucco and ceramics. Based on interviews with respondents, the use of wooden boards for the floor has a purpose other than lightweight, wooden boards are reducing heat so as to help lower the temperature in the room. This is supported by the structure of the stage, where the underside of the wooden board floor has air circulation so that the accumulated heat can be removed. According to some respondents, some houses coated wooden floorboards with ceramic/plaster to facilitate cleaning. But there is also a wood floor plaster with ceramic floor patterned plastic sheet with the same purpose of ease of cleaning but still aesthetic (figure 11, table 5).

Table 5. Based on used floor

NO.	FLOOR	TOTAL	%
1	Soil	1	0,38
2	Plester	16	6,15
3	Ceramic	35	12,46
4	Wooden Board	208	80,00
Total		260	100,00



Figure 11. Wood floor coated with plastic

The explanation above confirms that the use of wooden planks for the floor has been thought by the community from the beginning, they have tried to develop adaptation strategies for their homes, especially those related to the environmental conditions in which they live in tropical climates.

The purpose of the use of apertured wood floors and porous is to keep the movement of air in the house where living, so that it can move heat and humidity outside the residential building by convection, so that the air in the house is always relatively cool and comfortable [14].

4.2.6. Adaptation strategy based on distance between buildings

Based on the opinion of the respondents to the distance between the residential buildings, 24.62% said that there is no distance between buildings / mutually adjacent and as much as 65.00% said the distance between buildings ranging from 1-2 meters. This phenomenon illustrates that the condition of settlements in the study area has a fairly high building density (figure 12, table 6).

Based on the respondents' explanation, the distance between adjacent buildings has the purpose of social relations among citizens, namely the creation of a more familiar communication with neighbors. In addition, promenade deck that formed between two buildings functioned as a means of transportation as well as an open space for the interaction of residents.

Table 6. Distance between buildings

NO.	BUILDING DISTANCE	TOTAL	%
1	No distance	64	24,62
2	Has distance 1 – 2 m	169	65,00
3	Has distance > 2 m	27	10,38
Total		260	100,00

Source, Field survey, 2018



Figure 12. Distance between buildings is near
Source: Field survey, 2018.

At the front of the buildings row, there is a promenade deck, other than as a means to walk while enjoying the river scenery is also used by the community as a place to interact. According to Lenzholzer and Brown [30] and Khatibi[31], humans who are part of nature take the most benefit from natural facilities in the environment so as to create harmonization between the buildings they occupy with the environment (figure 13).

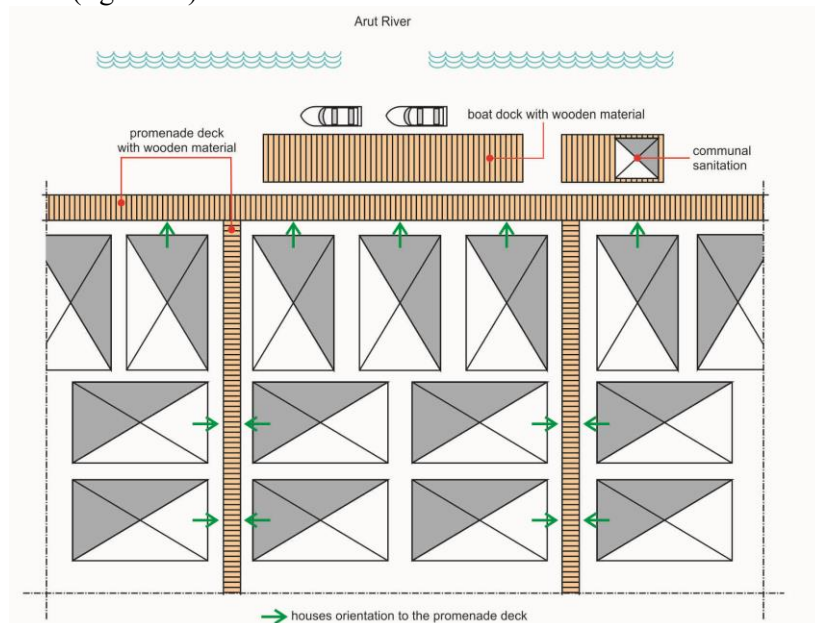


Figure 13. Houses orientation to the promenade deck

5. Conclusion

This research succeeded to reveal the adaptation strategy in settlement caused by natural factors such as Arut River flood disturbance especially during the rainy season and climate disturbance related to wind movement, rain, and temperature, humidity, and other factors related to socio-economic condition of the people. These natural factors affect the physical shape of residential buildings and the environment they create.

Adaptation strategies are referred to as patterns of various efforts planned by humans to be able to meet the minimum requirements they need and to solve the problems they face. The patterns in question here are patterns of behavior or action. Such patterns or actions are human responses to the physical of residential buildings and their environments are based on: [i] dimensional of buildings, [ii] building structure, [iii] roof cover used, [iv] wall material used, [v] flooring material used, and [vi] distance between buildings.

6. Acknowledgments

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