

Review

## **“RUMAH PANGGUNG” FOR THE SETTLEMENT WITH SEA LEVEL RISE PROBLEM IN THE FISHERMEN SETTLEMENT OF TAMBAK LOROK SEMARANG**

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### **ABSTRACT**

*Global warming is the natural phenomenon caused by increased glasshouse gases and thinned ozone layer in the atmosphere. The increasing temperature of the earth causes climate change and sea level rise. Some coastal regions in Indonesia have suffered because of it, and the greater impact is on the people's life because their activities in the settlement of coastal city are influenced directly or indirectly by this natural phenomenon. With the conditions as mentioned above, Indonesia as the biggest archipelago state in the world with its long coastal region seems to experience significant loss. The loss suffered by coastal houses because of sea level rise can be the loss of the physical functions and the investment of the houses. If the impact of sea level rise can be anticipated, so the loss can be prevented by conducting adaptation on natural changes that last slowly by, for example, making dams and utilizing the rumah panggung model. The use of rumah panggung is chosen as one of the solutions to deal with the impact of sea level rise in the troubled settlement of fishermen, Tambak Lorok Semarang, because the area experiences the tide for around 80 days in a year. The other benefit of rumah panggung is to minimize the negative impact, such as the physical damage of houses, humid house environment, and the material of the house cannot last longer. Besides, rumah panggung can use bamboo as local material, which is available with reasonable price.*

Keywords : *rumah panggung*, sea level rise, fishermen settlement

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## **INTRODUCTION**

Global warming has caused sea level rise that threatens the existence of coastal cities in some Asian countries. For example, in Thailand, the coastal regions have been flooded by seawater so that we can only look the telecommunication posts along the streets. Erosion in coastal area has also damaged the mangrove forests. In China, the rice fields and fishponds are flooded so that it stops people's economic activities. Likewise, in India, the

populated people live in coastal area. It is predicted that sea level rise will harm people because the streets damage. The wave breaker dam should be built to break the wave crash, and the people should move (The data of Book of Sea Level Rise, 2000; UNESCO, 2000).

Coastal regions, considered as one of assets in every economic development, start to face various problems because the coastal lines are being more shifted to land so that the tide

damage the facilities and infrastructures of coastal area, and floods the buildings on it (Adeel and King, 2002; Kawabe, 1998; Pamekas, 2002; Salm, 1989).

Indonesia is the biggest archipelago state in the world with 17,110 big and small islands having the coastal region, if it is spread, with the length of 81,000 km. In the conditions as mentioned above, it gives much benefit for the people's life in which Indonesia as the developing country still relies on natural resources. On the other hand, coastal regions, in fact, also face the danger of sea level rise and tide.

The problem of sea level rise is the classical problem of Semarang city. Almost every year, particularly in dry season, some areas near the beach always experience sea level rise. Houses always have the impact. Nevertheless, not many people choose to move to other locations. Even, most people choose to stay in the areas although seawater floods their houses and yards.

People of Semarang city living near the beach get used to live in the house flooded by high tide. When it comes, it causes damage to their houses and furniture. In low tide, they still have the other problem and diseases. It seems to be the annual tradition for the people in the regions. The impact of sea level rise does not only harm from the economic side but also from the social life of the people.

The handling to the impact of sea level rise in the coastal area of Semarang city is relatively difficult because the problem is quite complex from the technical sides and the handling is quite expensive from the cost sides. However, based on the existing data and information, people have adapted the condition by staying in the settlement that is always flooded.

This article discusses and offers the model of "*rumah panggung*" for the settlement in the danger of sea level rise, particularly in the fishermen settlement of Tambak Lorok, as the alternative for handling the impacts.

## SEA LEVEL RISE AS THE PHENOMENON OF GLOBAL WARMING AND THE IMPACTS ON COASTAL SETTLEMENT

### Sea Level Rise as the Phenomenon of Global Warming

Global warming is the natural phenomenon occurred because of the changes in climate variables globally and the microclimate, especially, the temperature rise and the changes in rain distribution pattern. The effects of climate changes are:

- Ice melts in the north and South Pole, and the expansion of sea mass cause sea level rise.
- Cycle changes and downpour quantity on the whole of earth surface so that they cause flood and drought.

The scenario of sea level rise issued by IPCC (International Panel on Climate Change) in 1990 states the presence of three scenarios on sea level rise. The scenarios in detail are as mentioned in **Table 1** as follows:

Global warming causes sea level rise as the consequence of ice melting in the north and the South Pole and the sea expansion. Some studies conducted by IPCC show that the sea level rise occurred in the last 100 years is 1-2 meters. By the assumption that humans still have their activities without considering the environmental support capability, so IPCC estimates that in 2030 the sea level rise is more than 8-29 cm than what we have today (**Table 1**).

The sea level rise and flood occurred flood in coastal cities. People who live in the coastal area of North Semarang feel it. They experience high tide that is getting higher, more frequent, and longer (Suhaeni, 2002). The sanitation facilities and clean water are disrupted so that the domestic works are stopped automatically.

**Table 1.** The Estimation of Sea Level Rise (in cm)

Sea Level Rise Scenario (year)	1990	2030	2070	2100
Low	0	8	21	31
Average	0	18	44	66
High	0	29	71	110

Source: IPCC Scenario-A (1990)

The neighborhood streets that give access to people to do their activities in the area are also disturbed and terminated. The social loss occurred is not only suffered by the people but also the city managers. The cost of the city management will be more increased along with the increased sea level rise.

The disruption and the loss occurred depend on the height, the length, and the frequency of the flood. As a description, when Jakarta got significant flood, the electricity, communication, and transportation were shut down so that the distribution of goods and services were terminated and the people could not run their activities.

For Semarang city, the sea level rise reaches 50 cm. The electricity for Tambak Lorok occupants were shut down for the sake of safety. With the nonexistent facilities and infrastructures supporting people's activities, it will cause the stoppage of all daily domestic works, such as cooking, washing, eating, drinking; the productive activities such as going to work, to business places, and to schools; the recreative activities such as kids' play, sleeping, worship, etc.

Furthermore, the observation results of some researchers in 1990 and 1991 in some regions show the variations of sea level rise as

follows; Belawan (7.38 mm), Jakarta (4.38 mm), Semarang (9.27 mm), Surabaya (5.47 mm), and Panjang Lampung (4.15) (Kurdi, 2002).

### The Impacts of Sea Level Rise on People's Activities

The research results conducted to some coastal cities are presented in the form of matrix in **Table 2** as follows:

Based on the data shown in **Table 2**, it can be concluded that Semarang has the highest frequency among the other cities. With the length of 1 day, so Semarang city has 80 day-flood of 365 days in a year. The following is, Surabaya which has the frequency and the length of flood as mentioned above, so within a year Surabaya is flooded from 21 to 36 days.

Jakarta city is flooded from 3 to 9 days in a year, Banjarmasin from 7 hours to 124 hours, and Makassar from 6 hours to 12 hours in a year.

Concerning the frequency and the length of flood happened in those areas, so it can be concluded that Semarang city has the highest risk of the biggest impacts of sea level rise.

**Table 2.** The frequency, length, height of high tide flood in the coastal areas of some cities in Indonesia

	The Frequency, Length, and Height of Flood				
	Banjarmasin	Jakarta	Makassar	Semarang	Surabaya
Flood Frequency (times/year)	7-12	3	6	80	7-12
Flood Length	1-12 hours	1-3 days	1-2 hours	1 day	1-3 days
Flood Height (cm)	50	100	50	50	70

Source: Kurdi and Zubaidah (2002)

Then, it is followed by Surabaya, Jakarta, Banjarmasin, and Makassar.

**Table 2** also provides the information that the height of flood in Jakarta and Surabaya is quite worrying. The height of flood occurred because of the sea level rise and flood suffered by the two cities show that the lower course of Jakarta and Surabaya rivers has high sedimentation so that by the time of tide and rain, the rivers are overload.

Regarding the high frequency and the length of flood as described above, so the flood occurred will influence people's activities. The routine activities of people such as the routine works at home, production activities, and other activities will be disturbed because of the flood (**Table 3**).

The high frequency of the flood causes the termination of domestic works in Semarang city. Instead, in Makassar, the domestic works still can run well but the disruption level of the flood has been great. In the other cities, the activities still can run well.

In production activities, Jakarta city is the most suffering city because of the high frequency of the flood, followed by Semarang and Makassar. Although Surabaya has a relatively high frequency of flood, the production activities are not significantly affected. It might be caused by the adaptation power of Surabaya people to the flood is good enough.

Except Jakarta and Makassar, every people in the mentioned cities get sleeping disorder. It might happens because people in Jakarta and Makassar have anticipated earlier the occurrence of flood compared with the other cities, or the sea level rise and the flood are followed by high downpour so that people of Semarang, Surabaya, and Banjarmasin cannot conduct preventive activities. The social

interaction in Semarang city cannot be performed at all, whereas the flood in Banjarmasin is not very bothering. For the other cities, the social interaction activities still

run well although it cannot be conducted as the whole.

Except Surabaya, the worship activities in the cities are very disturbed. Moreover, in Jakarta, the activities cannot be done at all. In addition, the playing activities in Jakarta and Banjarmasin experience the most disturbances because of the flood in those settlements. Semarang, Surabaya, and Makassar are the cities mostly disturbed.

### **The Problems Of The Settlement In The Danger Of Sea Level Rise In Tambak Lorok Area, Semarang**

Tambak Lorok is a fishermen housing in Tanjung Mas Village, the sub district of North Semarang. This area has 1,051 families. This area is located in the east of Tanjung Emas Port Semarang. It also has unique problems concerning the environmental condition. Each year, there is a decrease in its environmental quality having the ecological risk for the continuation of life. The area in Tanjung Emas Port area is highlighted on its environmental condition. The environment has a decrease quality in supporting the life continuation as the effect of sea level rise.

### **The Impact of High Tide on the Fishermen Settlement of Tambak Lorok**

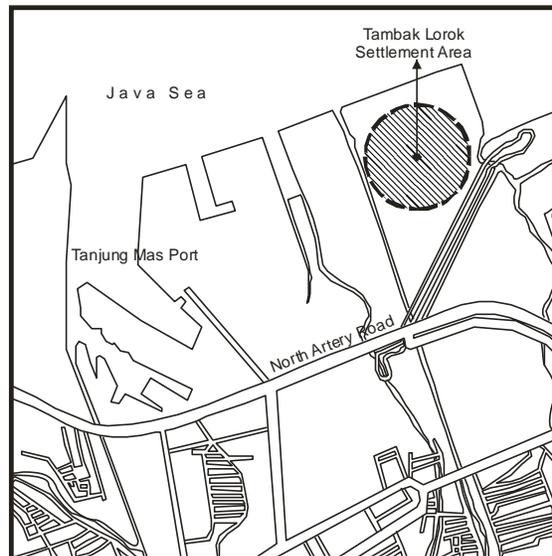
A city has its function as the service center for its people if various activities remain accommodated and facilitated. Likewise, the people will exist if the need for clean water is still available. The function of city will be terminated if the people cannot do their activities (Hantoro, 2002). For example, when Jakarta got a quite significant flood, at certain spots, the lamps, communication, and transportation were terminated so that the distribution of goods and services were stopped and people could not do their activities. The conditions above are experienced by people of

Tambak Lorok Settlement, Tanjung Emas Village, and the sub district of North Semarang by the time the high tide occurred.

**Table 3.** The Relation between The Flood Frequency and The People’s Social Activities

Type of Activities	The Annual Flood Frequency				
	Banjarmasin f = 7-12	Jakarta f = 3	Makassar f = 6	Semarang f = 80	Surabaya f = 7-12
<b>Housework</b>					
Cooking	8.4	22.2	80	100	24.4
Eating	20.4	26.7	52	100	24.4
Drinking	3.6	24.4	52	100	15.6
Washing	20.4	24.4	56	100	24.4
<b>Production Activities</b>					
Working	23	100	65	7701	15.6
Studying	0	91.1	70	80	11.1
<b>Non-Curricular Activities</b>					
Sleeping	100	24.4	43	100	100
Social Interaction	77.8	22.2	22.2	100	22.2
Worship	86.7	100	52	85.1	13.3
Playing	22.2	15.6	47	97.3	95.7

Source: Kurdi and Zubaidah (2002)



**Fig. 1** Map of Tambak Lorok Settlement in Semarang  
 Source: Purwanto (2008)



**Fig 2:** Image of Fishermen Settlement in Tambak Lorok, Semarang  
Source: Field Survey (2009)



**Fig 3:** Fishermen boats in Tambak Lorok Semarang.  
Source: Field Survey (2009)

### **The Disturbance of Sea Level Rise to People's Activities**

Sea level rise flooding houses as high as 50 – 100 cm has caused the termination of daily

domestic works totally. For example, the people of fishermen housing in Tambak Lorok experience some of them, such as:

- Domestic works like cooking, washing, eating, and drinking are stopped.

- Productive activities with economic value, such as going to work or to business, and to school.
- Recreative activities such as interaction among people, children playing, sleeping, and worship are disturbed because of sea level rise flooding people's houses in coastal area.

### **The Disturbance of Sea Level Rise to Facilities and Infrastructures**

Viewing the conditions above, it related to the availability of facilities and infrastructures. When the tide reaches 100 cm, the electricity for people of Tambak Lorok is shut down for safety so that people activities as mentioned above are stopped because the nonexistent of supporting facilities and infrastructures during the high tide. For example:

- The sanitation and clean water are disturbed so that the domestic works are stopped themselves.
- The local streets providing access for people to run their activities in the neighborhood are disturbed and stopped automatically.

### **The Potential Social Loss**

The definition of loss is the decrease of goods or stuffs value, or additional costs expensed, or losing opportunities to do economical activities. The estimation of social loss experienced by people because of sea level rise is the accumulation of collective data of each people, with the assumption that each families is the smallest unit in a community. If a minimum sea level rise disturbs for 80 days a year, so every productive domestic works having economic value and recreative activities are disturbed minimally for 80 days per family. If every kind of activities have effective economic value, so the total loss is the multiplication between the time disrupted and the disrupted kinds of activities.

### **The Loss to Buildings and Houses**

The loss to buildings and houses is calculated based on the estimation of loss because of the presence of additional cost to spend in the condition in which it should not be discharged. For example, a normal house has the building age of 25 years. For 25 years, it means there is no additional cost to pay, such as heightening the floor, wall, and roof. Thus, the costs are the financial loss to spend, which it should not happen in a normal condition.

### **The Other Immeasurable Social Loss**

There are some other immeasurable social losses, such as:

- Financially, the additional cost to pay to heighten the floor is continuously every 2-3 years. In that period, they have to, not only, save their money but also to spare their time and to delay their activities in the household that will be disturbed.
- Besides, they have to pay additional cost to splice the wall and the roof of their houses every 10-15 years. In that period, they have to, not only, save their money but also to spare their time and to delay their activities in the household that will be disturbed.
- They also have to change their furniture, like wardrobe or cupboard, every 2-3 years.
- The time wasted for unfinished things should be used for something more productive.
- There is no sense of belongingness and no privacy because it feels like renting their own houses.
- Psychologically, people have continuous fatigue and restlessness because the tide must come but they do not know for sure when and until how long it would last.
- Their ways of life are relatively hard.
- The post-flood loss, such as cleaning houses after the tide is low, seeing a doctor because of health disorder, and so on.

## THE “RUMAH PANGGUNG” AS THE ALTERNATIVE MODEL FOR THE SETTLEMENT IN THE DANGER OF SEA LEVEL RISE IN TAMBAK LOROK AREA

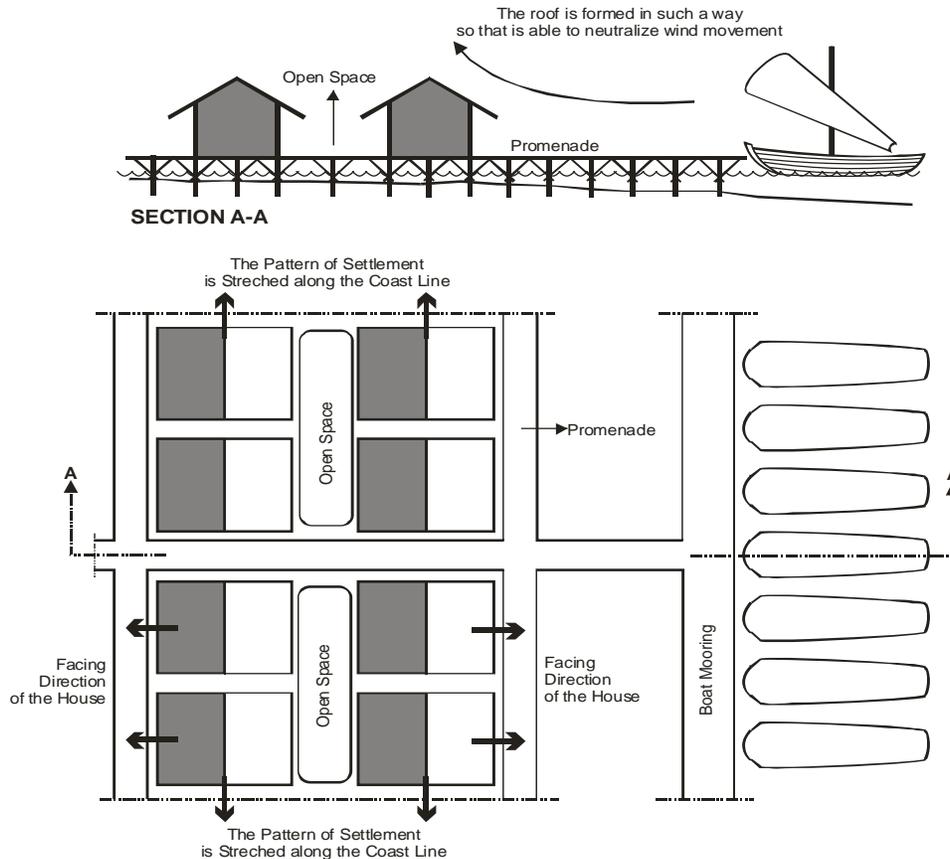
### Pattern of Settlement

The effort of arranging Tambak Lorok fisherman settlement using the platform house model should be viewed in its environmental context; it means, it does not only consider its building aspects.

In order to be able to rearrange Tambak Lorok fisherman settlement, especially in the

outside arrangement, it should consider the characteristics of its inhabitants’ activities, consisting of [i] their livelihood activity movements as fishermen, and [ii] business activities in form of fish processing, [iii] neighboring relationships.

Besides those factors, it is also important to consider physical factors consisting of [i] pattern of settlement that tends to be in parallel and in line to the coast in order to ease the access to boat mooring, [ii] the condition of high-tide level, and [iii] movements of sea breeze that surely influence the design of its pattern of settlement (Naing, 2008; De Wall, 1993; Chancellor, 1994).



**Fig 4:** Siteplan of Settlement Pattern  
 Source: Purwanto (2008)

The pattern of settlement for Tambak Lorok fishermen is proposed to use a grid pattern, with the consideration that the constructed alleys will ease fishermen's movements when they go to boat mooring. Besides that, grid pattern will also ease inhabitants to interact each other with their neighbors. Design of alleys is constructed with the model of a pier, which it is then named as promenade (Gospodini, 2001). Building orientation faces parallel to the coast line with the consideration of anticipating wind movements ranging from 4 – 32 km/h (source: Semarang Meteorological and Geophysics Bureau, 2009). With the building facing orientation that is parallel to coast line, therefore, roof angle will be easy to neutralize pushing force of the wind so that the building construction remains strong (Lippsmeier, 1994; Satwiko, 2007).

At the back part of the house, an open space is provided used for the place of fish-based food processing business, such as, small fish, small shrimp, *terasi* (fermented fish/paste condiment), and so on (Tweedale, 1994).

To give a clearer image of the pattern of settlement arrangement for Tambak Lorok fishermen, **Fig. 4** is presented.

### **“Rumah Panggung” Model**

Commonly, the model of “*rumah panggung*” exists in some parts of Indonesian regions and local cultural assets. “*Rumah panggung*” is particularly addressed for settlement at the bank of rivers. With its distinguished shape, the floors are heightened from the foundation so that the floors are always dry and the occupants do not have troubles in their daily activities.

The “*rumah panggung*”, located at the bank of rivers commonly found in Sumatra and Kalimantan island, initially used hard wood called “ulin” or “merbau” wood that is water resistance. As the time goes by, it is difficult to find “ulin” or “merbau” wood because of the lack of production and the government policy

to protect these woods. Consequently, “*rumah panggung*” makings are getting fewer and even left by people.

The other advantage of *rumah panggung* is its adjustment to temperature in the house quickly changes because it does not have direct contact with ground or concrete so that the air circulation is better (The Decision of Public Work Minister No. 403/KPTS/M/2002).

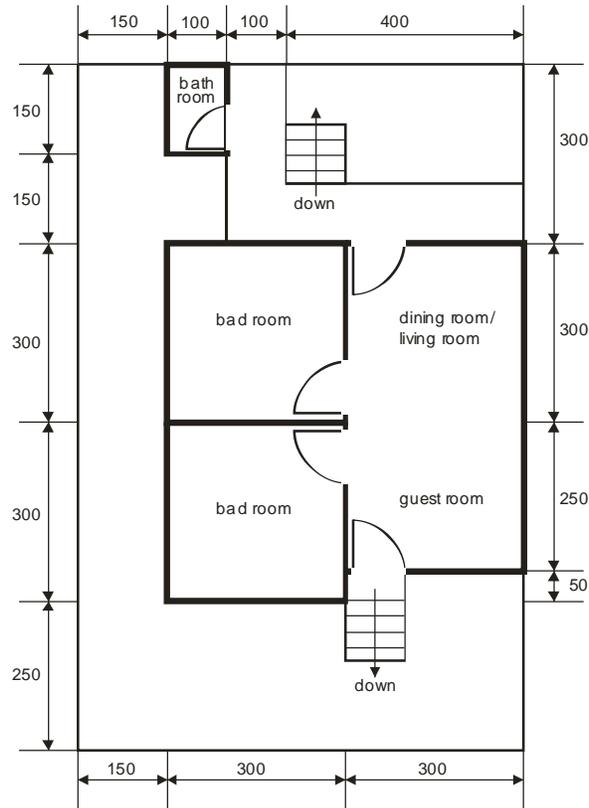
Besides, “*rumah panggung*” meet the technical requirement, and its correct direction orientation provides huge benefits for the comfort of the occupants. The position of “*rumah panggung*” at coast has the advantage because the wind circulation is smooth. Consequently, windows and doors opening position should be made cross one to each other. The orientation on building, the most ideal, is to the direction of south north because building get natural lighting from the sun optimally (Jauregui, 2005).

Building settlements with “*rumah panggung*” construction can be a good solution for Tambak Lorok settlement in danger of sea level rise. By implementing “*rumah panggung*”, people are free from high tide striking the area as long as 80 days in a year so that the technical and non-technical loss can be minimized.

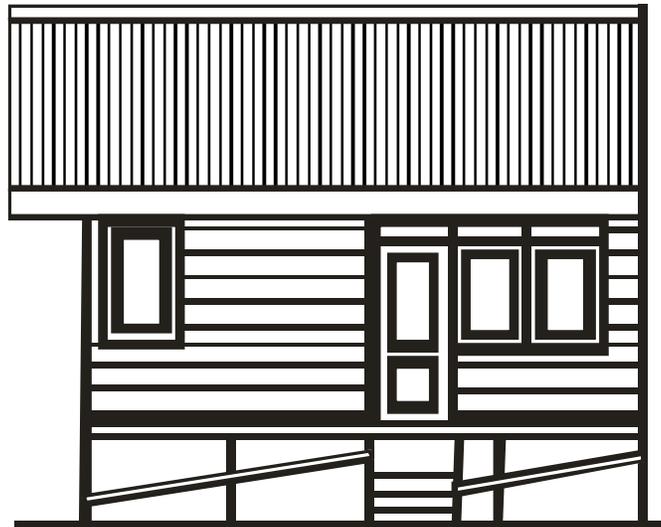
In the figure below, it is drawn a “*rumah panggung*” model made of wood material, but as mentioned before that it is hard to find so that bamboo material can replace it.

### **THE UTILIZATION OF BAMBOO MATERIAL FOR “RUMAH PANGGUNG”**

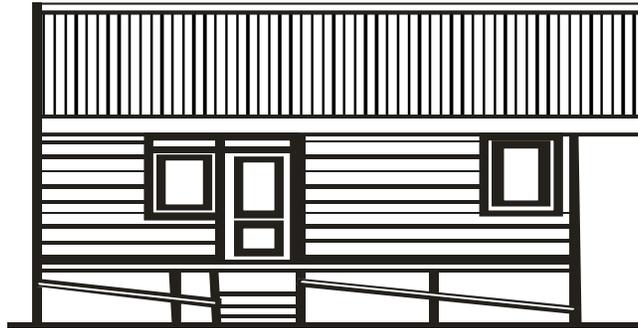
Bamboo is the forest product of non-wood known well by public because it grows around people's life. Bamboo is included in the member of *Bamboidae*, the sub family of grass. It has 1,250 – 1,500 varieties in the world, and Indonesia has only 10% or around 154 kinds of bamboo.



**Fig 5:** Plan of “Rumah Panggung”  
Source: Purwanto (2008)



**Fig. 6** Front Elevation  
Source: Purwanto (2008)



**Fig. 7** Back Elevation  
Source: Purwanto (2008)



**Fig. 8** Left Elevation  
Source: Purwanto (2008)



**Fig. 9** Right Elevation  
Source: Purwanto (2008)

Bamboo is the renewable source of building material and available in big quantity in Indonesia. Indonesian people have used bamboo for house buildings, furniture, farming equipments, handicrafts, music instruments, and food. However, bamboo has not become

the priority to development and it is still viewed as “the Poor’s fragile property”. Bamboo, which is harvested properly and well preserved, is the strong, flexible, and cheap material that can be made as the alternative to replace the rare and expensive woods.

The use of bamboo as the alternative for building construction is one of new business for people living in villages. Viewed from the rejuvenation point of view, in 3-5 years, it can be processed into building materials. Instead, woods require more than 10 years to be processed. Bamboo has also has its specific artistic value when it is applied as building materials. It can last more than 70 years if it is chemically preserved.

Principally, the model of “*rumah panggung*” using bamboo material must be made based on the requirements as follows (Marjono, 2006):

- Using old bamboo, preserved and in dry condition.
- Bamboo house is built on flat ground.
- The foundation and sloof are around the house (sloof is anchored to foundation in each 50 – 100 cm).
- The bottom end of bamboo column is put into foundation, anchored, and the inner part of column bottom end is filled with mortar and frame (*tulangan*).
- The wall element related to sloof and column must be anchored in several points.
- In the upper end of column is given ring block around the building site, the wall element must also be anchored with the ring block.
- If there is a door opening like vent-hole (*angin-angin*), window and door, must be given strengthening around it.
- In each joint of wall part with the other ones, there must be the column and wall anchored by the column.
- Roof frame (gantry) can be constructed with a simple support (joint-roll) on which each roof frame seat must be put on its position and it needs to be anchored with column.
- Wind binding over the roof must be set on each gantry. It is set on the slope of roof under roof cover and on the vertical sector between two gentries.

The advantages of bamboo use as building materials:

- Bamboo is known as building material.
- It does not require skilled worker.
- It only requires simple tools and they are available around us.
- Living in bamboo house is quite comfortable
- Short construction period.
- Cheap construction cost.

With all the advantages, it is expected that more people use it because it is easy to get, cheap, easy to handle, long lasting through preservation process, particularly for the building of “*rumah panggung*” in the fishermen settlement of Tambak Lorok Semarang.

## CONCLUSION

The impact of sea level rise occurred in the fishermen settlement of Tambak Lorok Semarang causes loss for the people, such as the loss of low settlement quality, house material damage, disrupted domestic works, and obstructed economic activities.

The use of “*rumah panggung*” is chosen as one of solutions to deal with the impact of the settlement in the danger of sea level rise in the fishermen settlement of Tambak Lorok Semarang because the area suffers high tide for around 80 days in a year.

The other advantages of “*rumah panggung*” is the temperature adjustment in the house changes quickly because it does not directly contact with ground or concrete so that the air circulation is better. In addition, the design of “*rumah panggung*” meeting the technical requirement and having right orientation direction will provide greater benefit for the occupants’ comfort.

The position of “*rumah panggung*” at coast has advantages because the wind circulation flows very well. Consequently, the opening position of windows and doors should be made in cross model between one to each other. The face orientation of an ideal building is the direction

of South-North because the building will get natural lighting from the sun optimally.

By the more reduced availability of wood as the construction material for “*rumah panggung*”, the use of local material like Bamboo is the alternative material because bamboo is available in big quantity and reasonable price.

## REFERENCES

- Adeel, Z. and King, C., 2002, *Conserving Our Coastal Environment*, Publishing by United Nation University, Tokyo, Japan. [Http://landbase.hq.unu.edu/Publication/Policybrief.pdf](http://landbase.hq.unu.edu/Publication/Policybrief.pdf). viewed October 20, 2009.
- De Wall, H.B., 1993, *Recommendation For Building in Tropical Climate, Build and Environ*, 28: 271-285.
- Chancellor, W.J., 1994, Cool Tropical Buidings: Lessons from Old Style Designs, *Build and Environ*, 29 (1): 5-12.
- Gospodini, A., 2001, Urban Waterfront Redevelopment in Greek Cities: A Framework for Redesigning Space, *Cities*, 18 (5): 285-295.
- Hantoro WS, 2002, *The Influence of Marine and Coastal Characteristic toward the Development of Coastal Cities Area*, Bandung.
- Jauregui, I., 2005, *The Human Climate of Tropical Cities: An Overview*, in *Journal of Biometeorology*, Springer Berlin, Heidelberg.
- Kawabe, M., 1998, To Enhance the Environmental Values of Tokyo Bay – A Proposition for Integrated Coastal Zone Management, *Ocean and Coastal Management*, pp. 19-39.
- Kurdi and Siti Zubaidah, 2002, *The Impacts of the Sea Level Rise toward the Fishermen Settlement*, National Seminar the Global Warming Impact, October 30, Jakarta.
- Lippsmeier, G., 1994, *Tropical Building*, Erlangga Publisher.
- Marjono, F., 2006, *The Bamboo Earthquake Resist Building*, Journal Posyanis Department of Civil Engineering, Gadjah Mada University, June 2006 pp. 1-4.
- Naing, N., 2008, *The Architecture Roles Floating House in Tempe Lake in Tropical Building*, Proceeding National Seminar UNDIP Semarang, August 6, 2008, Semarang.
- Pamekas, R., 2002, *The Impacts of Territorial Physical Alteration toward Supporting Capability of Coastal Settlement*, Bandung.
- Purwanto, E., 2008, *Redesigning Coastal Settlements An Anticipation of Global Warming Impacts*, Proceeding International Conference on Coastal Planning and Architecture, October 28, 2008, Manado, Indonesia.
- Salm, R.V., 1989, *Marine and Coastal Protected Areas: A Guide for Planners and Managers*, International Union for Conservation of Nature and Natural Resources, Gland, Swizerland.
- Satwiko, P., 2007, *Developing Tropical Organic Roof for Energy Saving*, Journal “Komposisi Arsitektur”, 2 : 112-122.

Semarang Meteorological and Geophysics  
Bureau, 2009, *Wind Movements Data*.

Suhaeni, H., 2002, *The Deficit upon the  
Building and Territory as the Impact of  
Sea Level Rise in the Coastal Cities in  
Indonesia*, Center of Settlement,  
Bandung.

The Decision of Public Work Minister  
Republic of Indonesia No.  
403/KPTS/M/2002: *Technical Guideline  
of Plain House Construction*.

UNESCO, 2000, *Reducing Megacity Impacts  
on The Coastal Environment*, The  
United Nations Educational, Scientific  
and Cultural Organization, Paris.