

## Anticipation of climate change with reservoir in tidal swampland (case Pinang Luar, West Borneo, Indonesia)

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**Abstract:-** The tidal swampland is located in the estuary of the lowland river that is affected by the tide. It is one of the reliable land to meet the needs of agricultural land. Irrigation and drainage currently done by using the tidal movements of the sea water. It is less favorable condition during the dry season, because of the decreasing of availability fresh water from the upstream. When the condition of high tide occurs, the sea water can be flow into the land, but when the water at low tide, the water will instead flow toward to the sea and can caused possibility of going overdrain. Potential of monthly rainfall in the area of research is relatively high, averaging of 267 mm/month. In the dry month, the rain that occurred is less than 200 mm. To overcome this situation, it is necessary to built a reservoir as water storage that can be used to meet the water needs in the dry season. Reservoir is used as storage and water level controller. The capacity of reservoir will be adapted to the needs. With potential of discharge flow in the upstream that kept in the reservoir and rainfall, it can be used as water supply to irrigation.

**Keywords:-** Rainfall, reservoir, swampland, water control, West Borneo.

### I. INTRODUCTION

The development of tidal swampland utilization for agriculture land has great potential to ensure food security [1]. Potential of agricultural production of rice can reach 5 ton/ha from tidal swampland in Indonesia that has land area of 20.11 million hectares area [2]. Tidal swampland is one of the marginal land that can be widely found in West Borneo (Kalimantan-Indonesia), the land area of tidal swampland and non tidal swampland measured approximately 18,32% of West Borneo province area (2,803,744 ha) [3]. As food demand increases, tidal swampland can be an alternative to be a productive land. But it will need adjustments that include planning, management and proper utilization, and also application of technology especially land and water management.

The influence of global temperature rising which will last until next century, result the shifting of rainfall patterns, extremely heat and cold event that happens frequently and sea level rise [4]. These changes can influence hydrology of surface and ground water which can potentially have serious impact to swampland [5]. Swampland is a transition zone between water and land, it will be susceptible if changes in hydrology happen as a result of climate change [5]. Decrease in agricultural productivity, instability of price of agricultural products to threaten food security, are impacts that can happen in agricultural sector [6]. Decreased productivity will cause farmers to switch to plantation.

Tidal swampland has a potential to become agricultural land that should be supported with control of water supply during growing season. One of the adaptation that could apply is water supply management. Water management in tidal swampland has an important meaning, since if there is water excess it can be saved to increase water supply in times of shortage. Agricultural plant will be maintained from water demand during rainy season and dry season [7]. It is necessary to further the study of water storage, which is reservoir. With reservoir, it can be a solution of tidal swampland utilization for productive agriculture land in West Kalimantan.

### II. LITERATURE REVIEW

Natural phenomenon such as flood and drought in extreme condition, have significant impact to environment and economy, especially agricultural sector [8]. The amount of rainfall during dry season is not sufficient to supply crops needs. Therefore, on dry season, the level of evapotranspiration is higher than the rainfall occurred. During this season, the land that holds as water storage will suffer as water deficit. If supply of ground water is reduced, crops will drought [9, 10].

Changes in water utilization can increase the water cycle on land surface and groundwater, so it is necessary to develop water storage with sufficient capacity to supply water demand, especially water for crops [11]. Water storage aims to mantain water resources and rainfall in ponds, water holes, low lands, gravel, clay and sand [12,13,14,15]. Also, to prolong water cycle that increases the effectiveness of water in catchment area [15].

According to California State Integrated Regional Water Management Plant (2002), with water storage means that utilization could be maintained for short and long term continuously. This management can decrease runoff, increase infiltration and as water resources for study area and downstream area, so the aims to storage and distribution of water can be achieved [16].

Water management in tidal swampland that has been done in Indonesia is generally based on water level in the waterway and high water level in agricultural land. This management was done based on type of overflow land and hydrotopography. Research about water storage development for agricultural land has been done in Nova Scotia, Canada, which apply design of wetland reservoir system. This system's objective is to create water storage that can sustain agricultural productivity during growing season and improve water quality. Artificial subsurface which has hydrolic and pollutant loads will be absorbed by aquatic plants, Cattail (*Typha* spp) in Constructed Treatment Wetland (CTW). Effluent the result from the CTW will be stored in reservoir. Water management in Nova Scotia already applied treatment and reuse system [17].

Construction of lowland reservoir is different with reservoir in upland. This is because of soil condition on tidal swampland specifically has high porosity level. Construction of reservoir can be done by building dam embankment with Multi Purpose Panel System. This system is environmental-friendly with cost of construction is relatively low and duration of construction is short. Beside that, it has proven its strength when flood exceed from this system. It has many beneficial uses in agricultural land, such as irrigation, avoid and decrease potential of flood and erosion [18].

### **III. METHODOLOGY AND STUDY AREA**

This study take location at Pinang Luar tidal swampland, Kubu Raya regency, West Kalimantan province. Land elevation is generally a flat area, with a height of land varies between +3 meters to +7 meters above sea level. Located geographically 0°44' North Latitude 1°01' South Latitude and 108°35'-109°58' East Longitude. Rain data collected from Supadio Pontianak Station, hydrometer data collected by field measurement at Pinang Luar tidal swampland latitude of 0°17'33.52" South and longitude of 109°20'32.79" East with elevation on edge of Punggur Besar river is 4.7 - 6.2 meters above sea level. This study take location at Pinang Luar tidal swampland, Kubu Raya regency, West Kalimantan province. Land elevation is generally a flat area, with a height of land varies between +3 meters to +7 meters above sea level. Located geographically 0°44' North Latitude 1°01' South Latitude and 108°35'-109°58' East Longitude. Rain data collected from Supadio Pontianak Station, hydrometer data collected by field measurement at Pinang Luar tidal swampland latitude of 0°17'33.52" South and longitude of 109°20'32.79" East with elevation on edge of Punggur Besar river is 4.7 - 6.2 meters above sea level.

This paper is a concept that adjusted to field condition on Pinang Luar tidal swampland, West Kalimantan. The concept was based on literature study from previous author. So it can be prepared a concept of reservoir in tidal swampland, case study Pinang Luar tidal swampland at West Kalimantan.

### **IV. RESULT AND DISCUSSION**

#### **4.1. Potential of Monthly Rainfall at Supadio Station.**

Coastal areas of West Kalimantan are a lowland swamp that influenced the sea tidal. Water management in a swamp area is based on the type of water overflow to land (hydrotopografi). Most of the research location is a type of land that receding or tidal, also the type which elevation of level water could not reach the land. So the rice cultivation can only be done in small portion of swampland at Pinang Luar, and can only be planted once a year. Because the elevation of sea level is not enough to irrigate the land, the land that intended to grow rice was replaced to grow crops. Another part, many land has change to oil palm plantation.

Potential of rain around research location is relatively high with monthly rainfall averaging 267 mm/month, shown in Figure 1. Base on rainfall data from Agency of Meteorology, Climatology and Geophysics Supadio Station from 1970-2013, that numbers of monthly rainfall for 33 years tend to increase. Annual rainfall average is 3,147 mm. Meanwhile numbers of daily rainfall tend to decrease causing the numbers of dry days tend to increase. This condition is less favorable for farmers to agricultural cultivation.

#### **4.2. Changes in Sea Level High at Agricultural Land**

This study was located at Pinang Luar swampland, Kubu Raya regency, West Kalimantan, where based on the field measurement, water level at study area tends to decrease, so the water will be difficult to reach land gravitationally. It's shown on Figure 2. Because water level difficult to reach land, Pinang Luar swampland become difficult to be used for agricultural land, especially for paddy and even palawija.

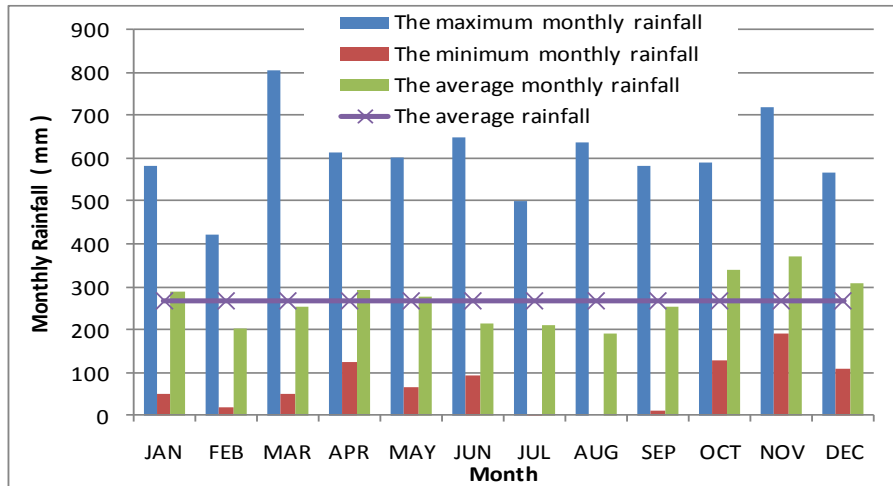


Fig. 1. Monthly Rainfall from 1970-2013 at Supadio Station, [19]

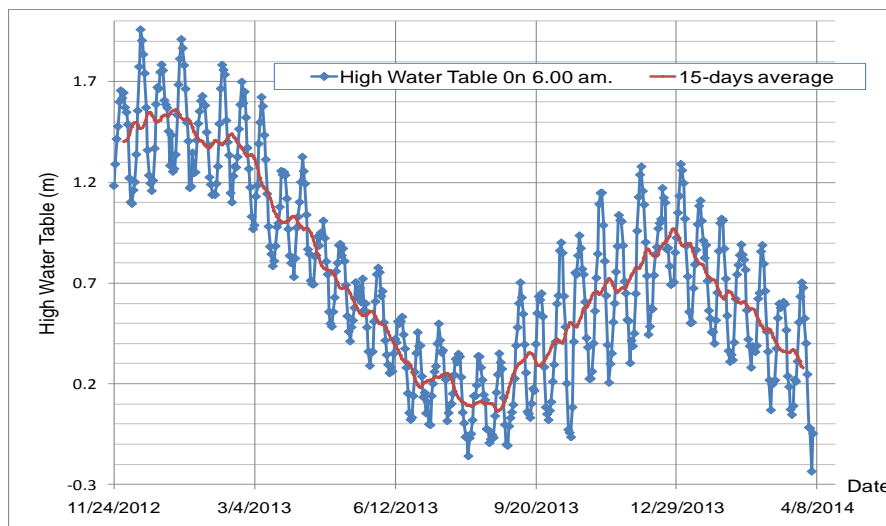


Fig. 2. Daily Sea Level High on Primer Tunnel at Pinang Luar Swampland

From measurement during 2 years, it occurred the decreasing water level in the primary channel. The mean water table level for 15 days average at 2012, the highest water level at December 27th, 2012 is 1.508 meters while the average water level at 2013 is 0.969 meters happened at December 27th, 2013. It means that decreased in the water level about 0.54 meters.

Based on observation, land that was originally planned for agriculture land, mostly was changed into palawija land. It happened because of high water table away from ground surface, so the farmers can not grow paddy. If there's no solution to solve this problem, it will become problem in food supply for people. Many land that turned into plantation land, such as palm oil plantation which many seen around Pinang Luar tidal swampland.

Based on field data, changes in characteristics of land happens because of higher water level. It cause productivity level to become lower, which saw the paddy productivity dropping to 2 ton/ hectare. Most of agricultural land still dependent to rainfall and rely tidal to water supply at agricultural area. It happens mostly at West Kalimantan tidal swampland.

Surely water storage is necessary as a solution to provide water adjusted to crop needs. With water storage, excess of water can be saved and use it when water shortage happens. In a good management, it will also give good impact to land and water management at West Kalimantan tidal swampland.

### 4.3. Reservoir at Swamp Area

The main issue that common for farmers of tidal swampland at West Kalimantan are tidal water could not reach agricultural land. This condition lead to great loss to local farmers. In this circumstances it is needed to build reservoir for water storage to ensure water reaching agriculture land during dry seasons. In the land with lower elevation and bordered by the river it will be needed to install water retaining embankment [20]. In this way water that flow into the land can be controlled.

Embankment can also be used for road. The width of the embankment should be sufficient to be used for development land transportation for today and the future. The minimum width of the road was built 6 meters wide [20]. Soil to build the embankment can be taken from the excavation where the reservoir built. So in higher water level condition especially on rainy season, the embankment can serve to retain water and reservoir can supply fresh water to people who live around it on dry season.

Due to limited land, reservoir does not necessarily built in large area, it may be constructed by utilizing primary and secondary channels in long storage form. The whole system of water management is fresh water long storage. Fresh water storage that can be used for water or drinking water is better collected firstly in fresh water ponds around peoples settlement.

Channels dimension for long storage can be build by following criteria [20];

1. Needs of piles to build embankment by considering compaction the embankment naturally, settlement section of embankment foundation (original ground level that piled by embankment)
2. Dimension of channels excavation also can be planned according to needs of fresh water volume during dry season with lost of waters.
3. Dimension of hydrolic to remove excess water.

By utilizing long storage reservoir, it can keep amounts of water needed. Water needs for irrigation can be calculated based on water for crops plus percolation and land management minus effective rainfall. If plant pattern that to be planned is paddy-paddy-maize, then the amount of water needed for irrigation from beginning of growing season on November is 7.32 mm/ days or 73.2 m<sup>3</sup>/days/ha.

Noticing the network system at Pinang Luar swampland and satellite photo Figure 3, it can be d escribed that:

1. Pinang Luar swamp area is located on the edge of Punggur Besar river.
2. It has length about 1088 meters of primary channels and 8533 meters of total channel length with width average of 20 meters.
3. The availability of monthly rainfall (Figure 1) then building a the reservoir is very possible to save rainwater.

From this field condition it can be formulated the concept of reservoir development with some following alternatives:

1. Build reservoir upstream agricultural land (network system), by making dam to keep fresh water from upstream of Punggur Besar river, Pinang Luar swamp area, shown in Figure 3(c), perspective shown in Figure 4(a).
2. Making pool or ponds around agricultural land for rain water storage or fresh water from river at high tide and close the pool when it low tide, shown in Figure 3(b), perspective shown in Figure 4(b).
3. Utilizing primary and secondary channel as long storage, shown in Figure 3(a), by making dam like embankment with alternating between irrigated areas tapping laterally, perspective shown in Figure 4(c).
- 4.



(a) (Long Storage in the channel) (b) Ponds around agricultural areas  
(c) Reservoir upstream  
network system (d) Border network system

**Fig. 3 Network system of Pinang Luar Swamp Area at Punggur Besar River [21]**



#### 4.4. Control Gate

In order so tidal can be controlled it is needed to install gate control and water gate control. This gate also control the water level so it is at level as wanted by crops and it can grow optimally. Irrigation and drainage at tidal swampland this time utilizing the movement of sea tide. It is less favorable on dry season, because supply fresh water from upstream decreased during dry season. So water from the sea flow into the land when high tide condition happens. While on low tide water will be towards into the sea and could possibly be overdrain. To overcome this problem, it necessary build the gate control to control water that flow in or out from channels that has function as long storage.



4(a) Perspective of Reservoir



4(b) Perspective of Ponds

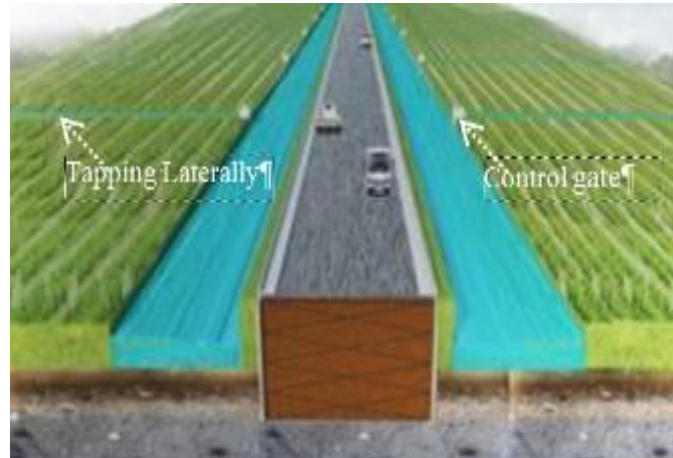


Fig. 4(c) Perspective of Long Storage

## V. CONCLUSION

From the above description, a concept can be made that:

1. Swampland in Pinang Luar has high rainfall potential, the monthly rainfall average is 267 mm and annual rainfall average is 3,147 mm. The amount of monthly rainfall with a probability of 80% greater when compared to evapotranspiration that occurs in a year (except in February and August).
2. With rainfall potential and land condition, then the swampland Pinang Luar is very possible to build reservoir as a water storage in order for irrigation needs.

Further research should be done to get detail of planning, the research can be about land characteristics or physical properties of soil at Pinang Luar swamp area.

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