Anticipate the impact of climate change at tidal swamplands through water management technology

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Abstract. Climate change significantly affects the production of agricultural commodities, including tidal swamplands. The current and future tidal swamplands have become one of the mainstay areas for agrarian commodity production due to the shrinking productive land. One of the keys to successful tidal swampland management is water management. In addition to increasing land productivity, water management can also reduce the impact of global climate change. Water management in agricultural development at tidal swampland needs to pay attention to the type of overflow, land typology, and land characteristics. Water management technology at recurrent event wetland embrace two-ways flow systems, unidirectional flow systems, one-way flow system and dam overflow conservation (SISTAK), water management for surjan, and shallow evacuation systems. The employment of this water management technologies depend upon the condition of water system within the fields. The water control era ought to enhance water first-class while mixed with different plant cultivation technological additives and it will likely be extra powerful in growing rice manufacturing at tidal swampland. This paper was a review of research results of water management technology in rice cultivation and its impact on increasing rice production.

1. Introduction
Tidal swamplands include wetlands that are affected by the ebb and flow of seawater. The potential and opportunity for increasing national food production through the utilization and optimization of swampland management are very large and prospective. The swampland has been cleared consists of tidal swampland covering an area of 1.453 million ha [1]. However, on the moment, the contribution of swampland to meals crop manufacturing, which include rice nationally continues to be meager, among 600-700 hundred thousand heaps, despite the fact that the consequences of the ability evaluation display that if optimization is carried out, it may make contributions to the manufacturing of as much as 8.55 million heaps of grain or 12 times now because of this that it contributes among 14-15% nationally [2]. Aspects of water management technology are very much needed in the development of swampland to increase the contribution of the swampland.

Rice fields in Indonesia generally have two planting seasons that are rainy season (October to March) and the dry season (April to September). Almost every 3 to 5 years, there was an extreme climate change - El Nino and La Nina - affecting rice production. The climate phenomenon in Indonesia showed a strong
influence on rice production. Extreme climates El Nino during 2007-2010 were reported to have caused a decrease in rice production by around -4.08%; on the other hand, La Nina in the same period led to an increase in production of approximately 1.78%. However, two extreme climatic conditions have reduced rice productivity by -0.50% and -0.65%, respectively [3].

The results showed that through water management, swamp that’s thought-about sub-optimal or less productive is reborn into fertile agricultural land [4]. On the tidal swamplands of overflow type A and overflow type B, farmers usually apply a two-way system. The results showed that with the application of a one-way water management system (which is equipped with sluice gates), rice yields can be increased by increasing cropping intensity and increasing productivity. Meanwhile, on recurrent event swamplands with overflow type C and, or D overflow water management with a block system, that functions to conserve water throughout the dry season, rice growth and yield may be augmented [5]. According to Syahbuddin [6], floodgates have an crucial function in water control to preserve the water wishes of plants. It can increase land productivity for various crops, especially food and horticulture, and may increase the harvest index (IP) to 300 harvests [7].

The purpose of this paper is to review the integrated water management and water management practices in rice cultivation in periodic event tidal swamplands. This paper focuses more on the technical aspects of water management in supporting rice cultivation at tidal swamplands.

2. The fluctuation of rice production at swampland of South Kalimantan due to climate change

The extreme climate change in Indonesia was a shorter interval [8]. Food crop, especially rice is the most vulnerable to extreme climate, El Nino and La Nina. During 70 years, Indonesia was hit by 18 El Nino, including three very strong, four strong and moderate, and seven weak El Nino and 15 La Nina, including four strong, five moderate, and six weak La Nina (figure 1) [9]. The extreme climate will affect rice production because during El Nino most rice fields suffered drought until puso, but during La Nina, some rice fields were flooded so that it cannot be planted. However, El Nino in swamplands could be a blessing because in swamplands become dry so that it can be planted and can lead to additional planting areas [8]. A survey in 2013 showed that extreme climate in 1970-2010 resulted in decreasing in national rice production by -0.50% (El Nino) and -0.65% (La Nina) [3].

Changes in rainfall patterns and extreme climate are very influential on rice. The vulnerability of rice plants was closely related to land use systems and soil properties, cropping patterns, soil management, water, crops, and varieties [11]. Therefore, the vulnerability of rice plants to rainfall patterns would impact on the area of planting and harvesting, yield productivity and quality. El Nino or La Nina caused 1) crop failure, decrease in planting index (PI) which leads to decreased productivity and production, 2) damage to agricultural land resources, 3) increase in frequency, area, and intensity drought, 4) increased humidity, and 5) increased intensity of plant pests [10].

Drought, flooding, and shifting rainfall change had reduced rice production. Research and Development of Consortium Climate Change IAARD predict climate change El Nino will expand the area of crops that are threatened with drought for lowland rice from 0.3-1.4 % to 3.1-7.8%, while area puso due to drought increased from 0.04-0.41% to 0.04-1.87%. The frequency of drought in lowland rice cultivation was three times in four years and generally increased sharply in El Nino years, while the frequency of flood ranged from 2-3 times to a sharp increase in La Nina years [11]. Increased flood intensity would indirectly affect rice production due to increased attacks by plant pests, such as brown planthoppers [12].

Research results of ISARI in 2012 [13] showed that attacks of tungro, rat, and stemborer increased when rainfall amount >200 mm. Brown planthopper attacks increased in precipitation of 100-150 mm, while blast disease increased in rainfall> 200 mm [14]. Increasing temperature would increase the speed of transpiration that scale back rice productivity, increase water consumption, accelerate fruit or seed ripening, reduce yield quality, and develop of assorted pests. The results of Tschirley’s [15] research
showed that there had been a decrease in agricultural yields of more than 20% when the temperature rose more than 4°C. The Research and Development of Consortium Climate Change [16] showed that an increase the temperature due to increased CO₂ concentration would reduce crop yields. When the paddy field conversion rate was 0.77% per year and there was no increase in planting index, then rice production at the Regency level in 2025 will decrease by 42,500-162,500 tons. Increasing temperature also affects population and pest attacks. The impact of rising sea levels on a decreased in rice production due to an increase in salinity. According to Grattan et al [17], salinity levels below 2.0 dS/m did not affect rice yield. If salinity increases above 2 dS/m then rice yield will decrease by about 10% for every 1 dS/m increase.

3. Water management technology at tidal swamplands

Water management is one of the determining factors for the success of agricultural development, especially rice in tidal swamplands concerning to optimize the utilization and conservation of land resources [18]. Water management can be defined as utilizing water appropriately to increase agricultural production. In particular, water management in tidal areas aims to supply water for plant evapotranspiration needs, remove excess water, prevent the occurrence of toxic elements (pyrite) and leaching of toxic elements and prevent land subsidence.

Water management in tidal land can be in the form of irrigation, drainage, conservation or interception. All of these can be done separately or integrated with other technical cultures as appropriate. In water management, tidal movement or overflow can be used as a source of irrigation water as well as energy (energy) to encourage the rate (acceleration) of water to enter small channels (tertiary, quarter) or plot farm land. The tidal movement of water in the tidal swamp occurs twice in one month, namely a single tide (spring tide) and a double tide (neap tide). The tidal movement of water in rivers that empties into the sea can reach up to 100 km upstream. The strength of the tidal movement of water will weaken as it is further away from the river mouth. Therefore, areas far from river mouths require a water management system with the help of a network of primary, secondary and tertiary canals so that they can enter the tide further and wider.

The principle of water management in tidal swampland must refer to the limiting conditions, these limiting conditions can be in the form of soil, water or plant factors. Soil factors include information on the pyrite layer, peat thickness, physiography and topography. Water factors include rainfall and tidal water fluctuations as well as water delivery from the upstream area of the river. Based on these data, the water level on the land can be predicted by calculating the water balance. In addition, plant factors also play an important role considering that the type and variety are the determinants or are determined by the water factor in the field.

3.1. Two-way flow system

Water management is a two-way flow system, namely the regulation of water inflow (irrigation) and outflow (drainage) from and for the farming area through the same channel (handil) so that water changes only occur in estuary areas close to river estuaries/secondaries. This is applied by farmers at the tertiary and quaternary levels on tidal swamplands type B. This system has weaknesses including the leaching and refreshment rate of incoming tidal water is less effective and limited.

3.2. One-way flow system

One-way flow system is a water regulation model in which water enters (irrigation) and discharge (drainage) through two different channels so that water changes periodically follow a one-way cycle. one-way (figure 5). This one-way water management model or system requires the existence of sluice gates (flapgates and stoplogs) at the channel estuaries. The sluice gate at the inlet is designed to open inward so
that during high tide it is pushed open so that incoming water can enter the tertiary or quaternary channel, while the sluice gate at the outlet is designed to open to the sea so that at high tide it is closed, but at low tide it opens to the outside so that water flows outward. From the plot or upstream can come out as the water recedes. This one-way water system has been widely adopted by farmers of tidal swamp land, among others, farmers of the Telang tidal swampland, Musi Banyuasin Regency (South Sumatera), Terantang, Mandastana Sub District, Barito Kuala Regency (South Kalimantan), and the Canal and Pangkoh areas, Kapuas Regency (Central Kalimantan).

Efforts are being made to make the one-way flow system effective, so that the quaternary channel is equipped with one-way swing doors according to the direction of drainage and irrigation of the rice fields. Controlling the water level of the rice field plots is carried out through plastic culverts.

The application of a one-way flow system is suitable for tidal swamps of the Adan B overflow type. This system creates water circulation in one direction, both surface water and underground water due to differences in water level from the tertiary channel. Irrigation and drainage. Water that enters through the irrigation canal into the plot of land is channeled out through the drainage channel. Furthermore, in the quarter channel, a water level control door (stoplog) is installed which can be opened and closed manually according to its needs. The application of a unidirectional flow system, additionally to facilitating the activity of harmful elements, conjointly permits the event of assorted cropping patterns as long because it is amid a water management system at the tertiary level that's appropriate for the kind of overflow and a small water management system at the land plot level [19].

![Figure 1. Illustration of a one-way flow system water system (Source: ISARI [20]).](image)

**3.3. Dam overflow**

In tidal swampland type C or D overflow, the tidal water cannot overflow the farm land, so it is also called indirect tidal land. Tidal water enters through seepage only, the main water source is rainfall. In this type of land overflow C or D, there is intensive daily drainage so that during the dry season or before the dry season the ground water level can drop to > 1 m so that the cultivated plants experience water stress. In an
effort to keep the groundwater level high, a dam (stoplog gate) can be made at each secondary or tertiary channel estuary.

So the dam overflow is a water management system by making sluice gates at the mouth of the channel limited to the height of the land so that the groundwater level can be maintained in accordance with the needs of the cultivated plants. For example, for rice at the limit < 50 cm from the surface. This block system is geared towards or suitable for tidal swampland type C or D. An illustration of the block system for tidal swampland type C or D is presented in figure 6.

3.4. One-way flow system and conservation dam
In the unidirectional water system in comparatively high swamp areas with overflow kind} or on the point of overflow type C (overflow type B/C, it's necessary to mix or integrate STASA with the block so the water within the tertiary canal isn't utterly drained). at low tide, particularly throughout the dry season, this water management system is named one-way water management and conservation dam.

![Figure 2. Illustration dam overflow system (Source: ISARI [20]).](image)

![Figure 3. (left) inlet, (right) outlet (Source: Noor et al. [21]).](image)
3.5. Water management for surjan

Water management for the surjan pattern is in principle the same as water management for rice fields. In this system, a wall (mound) is made, that is, the ground is elevated (figure 4). The area where the land is taken for masonry is called a sunken bed. The depth of taboo is adjusted to soil conditions, especially the depth of pyrite. The height of the wall is adjusted to the depth of the puddle, especially at high tide. In tabukan (sunken beds for rice fields) is suggested to create a worm channel or kemalir, that is associated exceedingly/in a very) channel of concerning twenty cm and a breadth of 20-25 cm which is created around a rice field plot with an interval of six m to twelve m to scrub out nephrotoxic compounds that interfere with plants, particularly rice plants (figure 5).

![Figure 4. The rice-field model on tidal swampland [22].](image)

3.6. Shallow drainage system

This system is different from water management in the pattern of rice fields and paddy fields/surjans, tidal water is attempted not to inundate the planting area. For this reason, tertiary canals are arranged in such a way that they only function as drainage channels and opens at low tide. In the planting area, shallow drainage canals are made which will function as drains. The illustration of the channel network in the shallow control system is presented in figure 6. This shallow control system can be applied if the pyrite layer is not too shallow, in figure 10 it can be seen that on the farm land a control channel is made around the land to maintain the groundwater level.

![Figure 5. Shape and cross-section of the kemalir channel [22].](image)
4. Conclusion
Climate change significantly affects the crops production through the influence of water systems. Through proper water management, swamp land that is considered sub-optimal or less productive can be converted into productive agricultural land. However, in the development of farming in tidal swamp land, it is necessary to pay attention to the type of overflow and typology as well as land characteristics. In increasing land productivity, it is necessary to support amelioration and fertilization technology according to the commodity.

By implementing water management technologies corresponding to two-way water systems, unidirectional water systems, block systems, one-way water systems and conservation blocks (SISTAK), water management for surjans, shallow emptying systems and water quality enhancements that are integrated with technology components. On the opposite hand, periodic event swamp is often used as agricultural land to support food security, production diversification, agro-industry development and employment.

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