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Editor Ifan Prasetya

Author comments I am Momon who is lecturer and researcher with subject in water management particularly on wetland. We want to joint for sharing knowledge and experience regarding wetland agriculture and environment

Abstract Views 823

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TITLE AND ABSTRACT

Title Option for Land and Water Management to Prevent Fire in Peat Land Areas of Sumatera, Indonesia

Abstract Investment development for oil palm plantation in Indonesia was increasing and it clear away into peat land area. Land clearing activities without considering peat ecological function may have impact on environmental degradation. The objective of this research was to study development potential of oil palm plantation at peatland by using land evaluation approach. The field survey method was observation

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The screenshot displays the JWEM submission review interface. The main content area is divided into three sections: SUBMISSION, PEER REVIEW, and EDITOR DECISION. The SUBMISSION section lists the authors (Momon Sodik Imanudin, Elisa Wildayana, M. Edi Armanto), title, section (Articles), and editor (Irfan Prasetya). The PEER REVIEW section shows a single round of review initiated on 2017-12-04. The EDITOR DECISION section indicates that the submission was accepted on 2018-01-31. A sidebar on the right contains navigation links such as 'Abstracting and Indexing', 'Publication Ethics', and 'Contact Us'. At the bottom, there is a search bar and a 'Browse By Issue' option. The browser's address bar shows the URL 'ijwem.ulm.ac.id/index.php/ijwem/author/submissionReview/160'.

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Subject: [jwem] Editor Decision

Journal of Wetlands Environmental Management (JWEM)

Sriwijaya University Momon Sodik Imanudin:

We have reached a decision regarding your submission to Journal of Wetlands Environmental Management, " OPTION FOR LAND AND WATER MANAGEMENT TO PREVENT FIRE IN PEAT LAND AREAS OF SUMATERA INDONESIA:

Our decision is: Revisions Required

Irfan Prasetya

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Reviewer C:

The manuscript entitled "OPTION FOR LAND AND WATER MANAGEMENT TO PREVENT FIRE IN PEAT LAND AREAS OF SUMATERA INDONESIA" can be accepted after some comments below has been addressed by

the authors.

1. The English should be improved.
2. The objective of the research should be described to focus with what they have done not in general such as the menagement.
3. The authors should put the objective the research in the last paragrap of Introduction. They should also the urgency of the research in this paragraph.
4. Please write Materials and Methods instead of Methodology
5. In the results and discussion, the authors mentioned a lot the characteristic of pineapple. It should be initiated in the introduction, why the plant is important to your investigation. Thus, focus in the part of results and discussion about your results and discuss them with the literature.
6. Fig 7-10, please make the y-axis outside of the line.
7. Please write only Conclussions instead of conclusion and suggestion. The format of your conclusion should be described in text and not itemized. Please make them shortly as the conclusion only describe the significant results of your work.

The authors should read the Guidline of the journal before re-submission.

Less talk, write more

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Makalah Pertama
OPTION FOR LAND AND WATER MANAGEMENT TO PREVENT
FIRE IN PEAT LAND AREAS OF SUMATERA INDONESIA

By

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ABSTRACT

Limitations of dry land has forced the investors to open peatlands for oil palm plantations. Before peatlands cultivated and managed, it is necessary to carry out land drainage to dispose of excess water. However, excessive drainage system often leads to the peatlands becoming over drained, irreversible drying and stimulating wildfire. The research aimed to develop the management operation of water management in tertiary block of oil palm plantation. A Drainmod model was used in predicting the dynamics of ground water daily for a year. Pineapple and oil palm are used as indicator plants for model adaptation in the field. Pineapple responses on shallow ground water level was also conducted in a greenhouse. The simulations using climate scenarios of normal, dry (Elnino) and wet (Lanino) conditions. The results showed that the Drainmod model is able to predict the ground water level daily for a year. Water management objective is water retention, and it should have been started since April on the Elnino condition, and in July on the Lanina condition with ground water depth of 50 cm from the ground. Pineapples are adaptive in wet conditions, where groundwater conditions are -5 cm for one month; the plants have not demonstrated physiological disorders

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Key word: land and water, peat fire, Drainmod model, pineapple, oil palm

1. INTRODUCTION

Limitations of dry land for agriculture are now making the government, private sector and farmers to open peatlands. Peatland is formed from accumulation of dead vegetation materials and its decomposition process is not perfect due to wet environmental conditions and the peatland is rich in organic materials. Peatland area in the world is estimated at about 400 million ha. Indonesia is the fourth country with the largest peatland in the world, which

is about 17.2 million ha after the Canada of about 170 million ha, the Soviet Union (150 million ha), and the United States covering 40 million ha (Euroconsult, 1984).

Peatlands in Indonesia are located and distributed mainly in Sumatra, Kalimantan and Papua. However, due to the variability of the peatland is very high in terms of the thickness, maturity and fertility of peatlands, thus not all of the peatland is suitable to be cultivated as agricultural areas. Among the 17.2 million ha of peatlands in Indonesia, only about 6 million ha can be utilized for agriculture (Agus and Subiksa, 2008). South Sumatra has a peatland area of approximately 2 million ha.

Limin (2006) stated that the depth of the peat layer burning was an average of 22.03 cm (variation between 0 to 42.3 cm), but at some points the fire layer can reach approximately 100 cm. Therefore extinguishing of peatland is very difficult and requires a lot of water. To extinguish a total area of one square meter of peatland required water as much as 200-400 liters. The influence of climate and disturbance Elnino on human activity is causing large areas of peatland in Indonesia was on fire. A major fire occurred repeatedly from 1997, 1999, 2001, 2002, 2004, 2006, and 2015. LAPAN (2015) reported that during the period 21 June until 20 October 2015, a total of 2,089,911 ha area of Indonesia was experiencing forest and land fires. The distribution of burned land is an area of 618 574 ha for peatlands and 1,471,337 ha for non-peatland forest. The fire occurred in Sumatra, Kalimantan, Papua, Sulawesi, Bali and Nusa Tenggara, Java, and the Moluccas. Especially for South Sumatra has the largest number of fire. Based on the information of the Forest Service by Terra Modis Satellite Data for 2015 the number of vulnerable and very vulnerable area burned in South Sumatra is 736,563 ha. Amount of the fires can reach over 350,000 ha. ANTARA (2015) reported that during the period 2006-2014, forest fire in the South Sumatra has caused the destruction of 1.4 million ha of peatland. Therefore, the government has made a restoration

program to 2 million ha of peatland national must be completed within a period of 5 years, and South Sumatra have priority.

The recovery effort of damaged peatlands will not be easy and simple because formation of peatlands take million years and nature conditions of peatland could not return due to a fire or any disposal surplus. However, what can be done is that how peatlands could be revegetated, so that the ecological function can be restored and peatland damage can be minimized. Reclaimed peatland restoration is much easier because drainage network has been built, but for uncultivated peatlands, it is difficult because drainage network for water system should be built first.

Restoration should also think of the benefit principle, especially for peatland area is located close to the local community, the restoration should give added value to the income of local residents. Armanto *et al* (2016) reported that field studies in the area of Talang Sepucuk OKI was found that local people (farmers) cultivate pineapples as main agricultural commodity. This condition is a potential for local crops that can be an alternative agricultural farming in the form of partnerships with large companies.

The main success key of the restoration are also dependent on water management. Water should be available in quantity, time and place (Imanudin and Bakri, 2016). Planning the water system requires data of ground water daily at least in one year. On the other hand daily observation is difficult and costly. Estimation of water level through the help of computer models (Drainmod) has been carried out for the tidal area (Imanudin *et al.*, 2010, Imanudin *et al.*, 2011). The dynamics of daily ground water level during the rainy season modeling results indicate at error levels of 1-2 cm, which the modeling results have slightly over estimate values. Reported testing of discharge water released through the drainage system shows the value of the correlation coefficient is excellent that is 0.91 (Negm *et al.*, 2016). Therefore, this paper will present the results of computer simulation models to estimate the groundwater

level. This data into useful information on network development plan of water management and control operations every month.

2. METHODOLOGY

The research was conducted in peatlands with the maturity of hemic until sapric levels. Peat depth varies from 2 m to 5 m. The research location is located in the Riding village, sub district of Pangkalan Lampam and Oil Palm Plantation Area of PT Gading Cempaka in OKI district, South Sumatra Indonesia. The land typology belongs to “*Lebak* swamp” planted with oil palm and uncultivated peatlands are dominated by swampy shrubs.

The research method is a semi-detailed survey. Field observations included peat depth and maturity, depth of the groundwater, water management network systems, land use, soil hydraulic conductivity measurements and interviews. Laboratory research was the analysis of the physical properties of soil, water and computer simulation models of Drainmod. Data input to Drainmod is data of rainfall, temperature, water channel dimensions, the values of soil hydraulic conductivity, and the water gate operating plan (Imanudin *et al.*, 2011). Scenario simulation is performed in the dynamics of ground water as a result of rainfall in dried Elnino (1997 and 2015). As a comparison it was simulated normal rainfall in 2005. Rainfall in wet conditions (Lanina) data was taken in 1999.

The Drainmod model works with fixed flow system with the concept of the water balance in the soil profile. The model was developed specifically for shallow ground water level (Negm *et al.*, 2016). Drainmod model is able to predict groundwater levels properly and has been tested for peats. Dighavan and Klove (2016) stated that the model has produced Mean Absolute Errors (MAE) of 11.29 cm and 9.09 cm, and Nash-Sutcliffe Efficiency Modeling of 0.62 to 0.64.

Tests on cold climatic conditions in peatland has generated good value (satisfactory). The dynamics of groundwater was dominantly influenced by rainwater. Therefore, on the condition of peatlands the influence of tidal land area could be eliminated. Water supply and water drainage through the channels is done by setting the floodgates. Groundwater conditions at the beginning of the simulation was made at level of -10 cm below the ground surface, the perimeter in simulation is the first tertiary (250 x 1000 m). Recorded soil physical data are soil hydraulic conductivity in three layers which are distinguished from peat maturity levels, namely sapric, hemic and fibric.

To compare the simulation results with the condition of the ground water level in the field, the ground water level was observed daily for 1 month (September 2016). To see the effect of rising water level in the channel against fluctuations in groundwater levels daily, the water level in the channel was observed by using a measuring board of pielschal.

3. RESULTS AND DISCUSSIONS

3.1. Climate Characteristics

Besides the human factor, the main trigger of fires are dry climate conditions due to decreased rainfall. If the water need for evapotranspiration is assumed to be 5 mm/day, then the water shortage has occurred in the dry climatic period in 1999, 2006 and 2015. Water is not only necessary to meet evapotranspiration, but also to keep ground water depth in order not to fall below 40 cm from the ground. Therefore, the water crisis in peatlands is longer than on dry land. Water deficit has occurred from May to November or in a period of 7 months. Meanwhile, when the condition of a normal rainfall year (2005), the analysis of the water balance in the soil indicates simply a water deficit in July-September (Figure 1), this

condition is shown in rainfall Lanina 1999. However the rainfall conditions in 1999 (Lanina) in months before and after the water has a rainfall deficit higher.

3.2. Pineapple Adaptation to Shallow Ground Water Table

Pineapple (*Ananas comosus L.*) was originally known as a garden crop, now pineapple has been cultivated as a plantation crop because the fruit has high economic value, market demand, and commodity export in the tropical countries. Pineapple has other names, namely henas, kenas, honas (in Bataknese), ganas, Danas (in Sundanese), manas (Balinese), pandang (in Makasarnese). Pineapple belongs to the family of Bromeliaceace and is planted in the ground by using roots. This pineapple is classified in the monocotyledon class and has flower arrangements contained in the stem end, growth expanded by using the side shoots that develop into branches vegetative, at the branch later produced fruit (Setiawan, 2000). Pineapple can be cultivated on the altitude 0-1,200 m above sea level and grow around the equator between 25° N/S with rainfall of 1000-2500 mm per year. Pineapple is not resistant to cold temperatures, but it is resistant to drought because pineapple has an effective water-storage cells. The fruit is sensitive to the sun's shine (flammable) and pineapple is tolerant to acid soils that have a pH of 3-5, but the optimum pH values should be in range of 5.0-6.5 and a nice pineapple can also be developed on peatlands and is still able to bear fruit as long as the ground water depths between 50-150 cm (Sunarjono, 1998).

The water requirement of pineapple ranges from 700-1000 mm per year which is achieved by the value of crop coefficient of 0.5 to 0.6 during the growing period. This condition is met if the water availability is in the depths of 0.3-0.6 m (FAO, 2015). Azevedo et al (2007) stated that the water needs of the cumulative pineapple plants is 1421mm and the need for reference evapotranspiration is 1614.9 mm. The daily requirement is highly dependent on the growth phase. In vegetative phase it decreases of 4.6 day⁻¹ mm to 3.5 mm

day-1. Therefore, the cultivation of pineapple has good prospects in the peatlands. Pineapple shows a high tolerance level of the shallow ground water table. Greenhouse test was carried out on a number of interventions that shallow ground water level depth of ground water -5 cm; -10 cm and -15 cm are still tolerant (Figure 2).

The observation of morphologically phenomena showed that pineapple can still survive with shallow ground water conditions, but pineapple is having symptoms of morphological change in the second week. Observations on the third week shows at the end of the plant leaves begin to dry (Figure 3), while the control, there is no changes in leaf morphology and pineapple grows well.

Plant morphological change is significant in the treatment depth of the groundwater -5 cm on October 20, 2016 (Figure 4), where pineapple has been treated for 70 days from the initial planting. This condition requires that the treatment be stopped to be returned to dry land conditions, so that the plant can restore growth. From the test results show that the pineapple adaptation is relatively resistant to shallow groundwater levels, pineapple can survive more than two months and the pineapple did not die. Treatment at a water depth of -15 cm relative still showed good growth. As for the depth of the groundwater treatment -5 cm, must be limited to the treatment period on 29 September 2016 the time when 50 days of treatment, the majority of pineapple leaves are still green.

The depth of groundwater is one of the important limiting factor for the cultivation of food crops in the peatlands (Imanudin *et al.*, 2016). Getting closer to the ground surface, then the root zone will be filled by water. Pelletier *et al.*, (2015) showing the condition of the ground water level reached the optimum at a depth of 60 cm for horticulture crops such as sugar beet. Meanwhile, on the condition of the ground water level is 30 cm, the soil will be saturated water closer to the surface. When this condition is too long, then the crop could experience water stress and can cause death. The study on water inundation of land have

shown if it happens more than 3 days, then the plant is very clearly undergoing physiological changes. The crop leaves will show chlorosis, like burning (Figure 5). Rachmawati and Retnaningrum (2013) states that this chlorosis symptoms occur because stagnant conditions at the time the crops will lack of oxygen supply to interfere with the process of photosynthesis and respiration. Inundation effect is also characteristic of the genotype, the status of carbohydrates before and after the inundation, the level of crop development at the time of inundation, level and duration, and degree of water turbidity.

During inundation the environment causes low CO₂ concentrations and low light causing a reduction in the ability of photosynthesis in crops. As one of the best responses of crops to waterlogging of land is switched from the metabolism of aerobic respiration to anaerobic respiration fermentation. In fact, most proteins are formed during hypoxic conditions are enzymes involved in the formation of this fermentation pathway. Because the crop cells need to maintain a continuous supply of ATP, the use of alternative electron acceptors and/or the alternative pathway is a key element to survive in waterlogged soil conditions. Plant response may also include decrease in stomata conductance and photosynthesis, and root hydraulic conductivity. These physiological changes in turn affect backup and translocation of carbohydrates (Pucciariello *et al.*, 2013).

3.3. Advance Drainmod Prediction of Groundwater in Various Climate Conditions

Estimation of the ground water level is done by using computer simulated Drainmod model. Drainmod is working on the assumption that the land receives water flow under fixed conditions (steady state condition) and is able to produce excellent correlation value of around 0.9 (Golmohammadi *et al.*, 2016). Model adaptation for the tropics has been done by Imanudin *et al* (2010) on the tidal land and produce correlation values between the water level modeling and observation in ranging of 0.8-0.9. The model produces an over estimated value

of the water condition in the dry season. The main water input is rainfall, thus it is in accordance with the conditions in the study area where the land is not influenced by tide and water level fluctuations are greatly influenced by rainfall.

Drainage design is an open channel system with the distance between the secondary channels of 250 m. Channel dimensions showed the width of 2-3 m and a depth of 2.0-2.25 m. These channels limit the plot of 25 ha. Picture of the channel is shown in Figure 6. The rainfall scenario used in the simulation are based on the climate phenomenon Elnino, Lanina and Normal. Fitria at al (2013) stated climate phenomenon Elnino events were in 1997 and 1999. Furthermore Lanina normal rainfall conditions would be used in 2005 (Hadi *et al.*, 2010). Rainfall data from the Kenten Palembang station in this period will be used in the Drainmod simulation.

The peat maturity is dominated by hemic level on the surface and on the 2 m soil depth, the peat maturity is still relatively classified as Fibric level. The values of soil hydraulic conductivity on both the maturity level of peat are respectively 3.5 m/day and 7.0 m/day. This is in line with the research results of Tahrin *et al* (2015) that the peats at a depth of 20-30 cm has a value of hydraulic conductivity ranging between 30-40 cm/hour, equivalent to 7.0-7.5 m/day.

Channel design is intended to maximize drainage, so oil palm trees can be planted. Channel conditions have not been considered for water conservation and to maintain the water level in the dry season. Therefore, the simulation will be done by looking at variations in rainfall and the potential for water retention in secondary channels, so that the water level can be increased. Drainmod simulations performed on three scenarios of climate conditions, namely Elnino conditions, Lanina and Normal. The first simulation was performed on land conditions there is no control (open system) and the second simulation is to perform control

(control drainage). The results of simulation estimation of ground water are presented as follow:

1. *Elnino dry climate conditions in 1997 and 2015*

Elnino climate phenomenon that occurred in 1997 and 2015 has led to hot weather conditions, drought due to low rainfall. Salman (2015) reported an incidence of Elnino 1997 caused drought (water deficit) from mid-year to the end of 1997. The impact is the number of crop failure due to drought and peat fires. Drainmod simulations in 1997 and 2015 have the same trend in which the depth of ground water decreased rapidly since the end of the rainy season (Figure 6). This condition is caused by precipitation that falls below normal.

Referring to the critical value of the depth of groundwater against fires is at the level of 60 cm below the ground surface, the simulation showed almost Drainmod during the period of the season is in danger. Ground water level since February under 60 cm and a peak in the dry season (June to September) is at a depth below 150 cm (Figure 7). This condition is due to precipitation of small and channel no control operations. Open drainage channel dimensions without control plus a wide and deep, making the excess land disposal. As a result of this, the dry conditions have fire occurred in 1997 and 2015.

Control of ground water level in the dry climate conditions should be done as early as possible, namely when it began to rain rarely falls. Drainmod simulation showed that the water containment should be done since April. Detention of Watergates were done, so that the ground water level remains steady 60 cm. So that the water level in the channel must be kept at least 60 cm from the ground. The simulation results of water level Elnino premises using the data of 1997 and 2015 (Figure 7) showed the same trend, so that the operation of Watergates was also similar in these climatic conditions. In theory the water can hold at a depth of 60 cm, when the water detention is done earlier. Detention is meant to increase water storage in the soil and land line. This condition is consistent with Tarin (2011) which states

that in the dry season peatland area that water shortage always occurs. To suppress this deficit will require an increase in soil water storage (pre-storage) through water retention in the channel.

2. Dynamics of Normal Climate Condition

The dynamics of ground water level in the normal rainfall conditions in 2005 can be seen in Figure 8. In an open channel conditions (free water) without experiencing over control of the land drain. Ground water level in the dry season is at a depth of 120-170 cm below the soil surface. This condition is dangerous and would highly be flammable. But with efforts to control the water level (control drainage), the water level in the dry season could ascend to a depth of 40-50 cm below the soil surface. Water detention operations began in May.

3. Condition of wet precipitation (Lanina)

Rainfall in the above normal conditions (wet) as the effect of climate phenomena Lanina was taken the data in 1999. Computer simulation model Drainmod will be done in two scenarios are simulated network conditions no control and with control. Drainmod simulation results show that the ground water level remains down ahead of the dry season and even in the dry season the water level drops beyond the critical limit (Figure 9). The condition of ground water level remains down because of spending discharge channel is too high and the system network without containment efforts. Therefore, when the canal system is not controlled, obviously it would be harmful to the ecological functions of peat. Groundwater is still down beyond the critical limit. Fires do not happen because the topsoil moist conditions due to rain instead of capillary movement of underground water. In line with the results of research Imanudin et al., (2016), that the condition of peatlands which opened the ground water level during the dry season will stay down beyond the critical limit either on normal climatic

conditions, damp, especially the condition of the lamina. Therefore, controlling the groundwater table must be done before the dry season arrives.

3.4. Adaptation models for peat restoration by multi-cropping system (pineapple palm -oil) on Estate and Industrial Plantation Forest Management

The pattern of ground water level dynamics computer simulation results Drainmod models show the ground water level is strongly influenced by rainfall, soil hydraulic conductivity, and the spacing between channels. This condition is evident from observations of groundwater level in the field (Figure 10). Ground water level in September on a wet climatic conditions indicate the condition of the safety zone, where the water table is located at a depth of 40-60 cm. In the period of September is still no rain where there 6 times (days) of rain. The influence is very large rain where rain 3 mm can raise the water level in the channel 8 cm and were able to raise the water level 9-10 cm in the area of land near and far line channels. This clearly shows the influence of fluctuations in the water level in the channel is very significant to the dynamics of groundwater levels in the area. Besides the effect of distance from the land to the channel is also very real. Groundwater conditions near the channel (0-50 m) has a ground water level 39-50 cm below the ground surface, while the position in the middle of the channel water level (100 m) the ground water level is at a depth of 79-90 m.

From this condition the dynamics of the water table in peat land area, it is clearly an effort to maintain the depth of the ground water is by conditioning the water level in the channel is at a depth of 50 cm parallel to the ground. To achieve this condition, the efforts to increase the water in the channel must be done before the rainy season ends. Operations

control water level is in line with the results of computer simulation models Drainmod. The following Table 1 is a water level control operations on the secondary channel.

Data observation of ground water level daily during the month of September in areas already opened and unopened palm plant shown in Figure 11. Lower water levels are very real where in September although there is still rain the water level drops to a depth of 80-90 cm, while on land unopened ground water level is still in the safe zone which ranges from 40-50 cm below the soil surface. The results showed that the depth of the ground water level is critical to maintain the Fire Danger Index at a safe level is at a depth of 0.6 m, and if the depth exceeds the critical value, the potential hazards of peatland fires to increase (Taufik *et al.*, 2011). In addition to the fire hazard is another environmental problem, i.e. Carbon emissions. Land cleared of oil palm plantations has the distinction of ground water was real by shrub land. This condition is consistent with research of Nusantara *et al* (2014), on the condition of the oil palm fields have 50-60 cm of ground water, the ground water level in the scrub only about 30-35 cm, and carbon emissions reached 6.701 C ton/ha/yr in the field of oil palm and 3,169 tones/ha/yr in the shrub land.

In rainy conditions or drought will slightly change the profile of ground water, is due to changes in flow direction occurs that causes the water level near the channel will be deeper. Susandi *et al* (2015), decrease in water level is due to an accelerated flow of ground water due to a reduction in peat soil moisture caused by the drying process, so that the shelf life of the water decreases.

Lower water levels in land cleared very quickly, even though the existing water level control operation. Control efforts is to detention on each primary segment in each tertiary (Figure 12). Water retention is done and distribution of water in case of overload. In operation retention system aims to maximize the water retained in line with the technique of closing the channel (canal blocking), but at the level of 20 cm from the bottom of the embankment

installed discharge pipe (sharing water), to remove excess water in case water replenishment from rainfall excess (Figure 10), this flow occurs due to the difference altitudes basic channels upstream and downstream, although the condition is rare in elnino climatic conditions. In the climatic conditions elnino more dominant water retention system, where each plot carried blocking to hold water in the channel. Wangsadipura (2005) reported a decline in groundwater levels take 120 days if it is not raining at 2.3 m spacing between channels when 500 m. For the condition of the peatland area of good channels are 500 m distance between secondary and tertiary distance between is 100 m.

To increase the added value of land use, it is the potential to do intercropping systems with pineapple (Figure 13). Adaptive pineapple on ground water table is shallow and in the dry season the wanted water level is not more than 100 cm, therefore the land can get security double, because farmers can keep these plants in order to avoid drought and fires, system control operations will be run, for large scale it is not yet done with the partnership with the company. Agricultural intercropping system on a small scale on community land. Therefore this model can be recommended to be done with the partnership with the oil palm plantation company. If the model is successful, it can support the national peatland restoration program.

Effect of decreased water level not only from fire, but also against carbon emissions. Oil palm large companies are often got international pressure due to carbon emissions. Carlson *et al* (2015) reported a very strong correlation with the depth of the ground water level and carbon loss. At a depth of 70 cm water table below the ground surface an average loss of carbon loss was of 20 t C ha/yr. This is further increased when the ground water level further down. Planting oil palm enables farmers to maintain the water level remains 50-60 cm, so in addition reduces the fire hazard is also carbon emissions.

Production of oil crops is not only influenced by the depth of the groundwater, but also the level of maturity of peat. Research shows that the more mature the higher the peat

production. At maturity level of production reached Sapric range of 19.48-22.92 MT/ha and the peat hemic ranging between 9.47- 13:37 MT/ha (Veloo et al., 2015).

4. CONCLUSIONS AND SUGGESTIONS

Study of pineapple adaptation on shallow groundwater conditions and landuse plan of Drainmod model for reclaimed peatlands planted with oil palm has produced several conclusions and suggestions, namely:

- 1) Drainmod model is able to predict the ground water level daily and is effective in designing month-control operations at the level of secondary plots. Nevertheless the value of the ground water level shows the overestimate simulation results with field data on dry conditions. This is because the condition of the water loss in the field is very high, despite the water detention is conducted, but the water level remains down beyond the critical limit.
- 2) Operation of water level control in the field is to build a water sharing system in each tertiary plot. Maintaining water level should not be dropped from 50 cm from the terrace (embankment). Therefore the drainage system should be installed on the dam surface between tertiary plots. In the dry climate conditions (Elnino), water retention system through drainage control has to be started in March-April and fully retention since May.
- 3) Potential land use by using intercropping systems of pineapples and oil palm will be able to maintain the water level closer to the root zone and will create new agribusiness. For the future the potential to do a partnership with the local farmers, so that the effort to keep the area of the fire could have been better because it involves the local community.

ACKNOWLEDGEMENTS

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REFERENCES

- ANTARA, 2015. Satu juta hektar lahan gambut Sumsel terbakar. Diunduh 2016 <http://www.antaranews.com/berita/515778/satu-juta-hektar-lahan-gambut-sumsel-terbakar>.
- Carlson, K.M, Goodman, K.L and May. C, Tobin. 2015. Modeling relationships between water table depth and peat soil carbon loss in Southeast Asian plantations. *Environ. Res. Lett.* 10 (2015) 074006. 2015 IOP Publishing Ltd.
- Dighavan, M. and Klove, B. 2016. Evaluation of Drainmod 6.1 for Hydrological Simulation of Peat Extraction Areas in Noethern Finland. *Journal Irrigation and Drainage Engineering*. Vol 142(11); November 2016.
- FAO. 2016. Crop Water Information: Pineapple http://www.fao.org/nr/water/cropinfo_pineapple.html
- Fitria, W. dan Pratama, S.M. 2013. Pengaruh Fenomena Elnino 1997 dan Lanina 1999. Terhadap Curah Hujan Biak. *Jurnal Meteorologi dan Geofisika*. Vol 14(1); 1 Mei 2013.
- Golmohammadi, G., Rudra, R.P., Shiv O. Prasher, S.O., Madani, A., Pradeep K. Goel, Mohammadi, K, 2016. Modeling the impacts of tillage practices on water table depth, drain outflow and nitrogen losses using Drainmod. *Computers and Electronics in Agriculture*, Vol 124; 73-83, June 2016,
- Hadi, Ismul A, Suwarsono, dan Herliana. 2010. Analisis Karakteristik Intensitas Curah Hujan di Kota Bengkulu. *FLUX Jurnal Ilmiah Fisika*, 7 (2). pp. 119-129. ISSN 1829-796x.
- Imanudin, M.S, Budianta, D and Bakri. 2016. El-Nino Effect on Water Management Objective in Tidal Lowland Reclamation Areas (Adaptation Model for Corn). *Proceeding the international Seminar 2nd World Irrigation Forum Chiang May, Thailand November 6-8, 2016.*
- Imanudin, M.S. dan Bakri, 2016. Model Drainase Lahan Gambut untuk Budidaya Kelapa Sawit berbasis Evaluasi Lahan. *Prosiding Seminar Nasional dan Lokakarya Pengembangan Kelapa Sawit Terpadu dan Berkelanjutan Palembang, 23 Maret 2016.* ISBN 979-587-611-2.
- Imanudin, M.S., M.E. Armanto and R.H. Susanto. 2011. Developing Seasonal Operation for Water Table Management in Tidal Lowland Reclamations Areas at South Sumatra Indonesia. *Journal of Tropical Soils*, Unila Vol. 16(3): 233-244. ISSN 0852-257X. Open access. Web-link: <http://journal.unila.ac.id/index.php/tropicalsoil> DOI: 10.5400/jts.2011.16.3.233
- Imanudin, M.S., M.E. Armanto, R.H. Susanto and S.M. Bernas. 2010. Water Status Evaluation on Tertiary Block for Developing Land Use Pattern and Water Management Strategies in Acid Sulfat Soil of Saleh Tidal Lowland Reclamation Areas of South Sumatera. *Journal of Agriculturas Science – AGRIVITA* Vol 32(3): 241-253. ISSN 0126-0537. Web-link: <http://www.agrivita.ub.ac.id/index.php/agrivita/article/view/16>

- Negm, L.M, Youssef, M.S., Checheir, G.M., and Skaggs. 2016. DRAINMOD-based tools for quantifying reductions in annual drainage flow and nitrate losses resulting from drainage water management on croplands in eastern North Carolina. *Agricultural Water Management*, Vol. 166(1); 86-100. March 2016.
- Nusantara, R.W, Sudarmadji, Sugandawaty, Tj., Djohan dan Haryono, E. 2014. Emisi CO₂ tanah akibat alih fungsi lahan hutan rawa gambut di Kalimantan Barat. *Journal Manusia dan Lingkungan* Vol. 21(3); 268-276. November 2014.
- Pelletier, V., Gallichand, J, Gumiere, S., Pepin, S., and Caron, J. 2015. Water Table Control for Increasing Yield and Saving Water in Cranberry Production. *Journal of Sustainability* 7; 10602-10619; doi:10.3390/su70810602.
- Pucciariello, C., Voesenek, L.A.C, J., Perata, P, and Sasidharan, R. 2014. Plant responses to flooding. *Front Plant Sci.* 5: 226.
- Rachmawati, D. dan Retnaningrum, E. 2013. Pengaruh tinggi dan lama penggenangan terhadap pertumbuhan kultivar sintanur dan dinamika populasi rhizobakteri pemfiksasi nitrogen non simbiosis. *Bionatura-Jurnal Ilmu-ilmu Hayati dan Fisik* Vol. 15(2); 117-125. Juli 2013.
- Rohmah, E.A., dan Saputro, T.B. 2016. Analisis Pertumbuhan Tanaman Kedelai (*Glycine max L.*) Varietas Grobogan Pada Kondisi Cekaman Genangan. *Jurnal Sains dan Seni ITS* Vol. 5(2); 2337-3520 (2301-928X Print).
- Salman, S.R. 2015. Analisis Dampak Fenomena Elnino (1997-1998) terhadap Ketersediaan Air Tanah Pulau Ambon. *Jurnal Agrologia*, Vol. 4(1); 34-40, April 2015.
- Susandi, Oksana dan Arminudin, A.T. 2015. Analisis Sifat Fisika Tanah Gambut pada Hutan Gambut di Kecamatan Tambang Kabupaten Kampar Provinsi Riau. *Jurnal Agroteknologi*, Vol. 5(2); 23-28. Februari 2015.
- Susanto, R. H. 2016. Menabur Harapan di Lahan Gambut melalui Pendekatan Multi Dimensi dalam Upaya Pencegahan Kebakaran Hutan dan Lahan untuk Kesejahteraan Masyarakat. Makalah Seminar Lahan Suboptimal, Palembang, 18 Oktober 2016.
- Tarigan, S.D. 2011. Neraca Air Lahan Gambut yang di tanami Kelapa Sawit di Kabupaten Seuyan. Kalimantan Tengah. *Jurnal Tanah Lingkungan.*, 13 (1) April 2011: 14-20.
- Taufik M., Setiawan, B.I, Prasetyo, Pandjaitan, L.B., dan Soewarso. 2011. Pengembangan Indeks Bahaya Kebakaran di HTI SBAWI Sumatera Selatan. *Jurnal Penelitian Hutan Tanaman* Vol. 8(4); 215-223. Oktober 2011.
- Wangsadipura, M. 2005. Analisis Hidraoulik Bawah Permukaan Melalui Media Gambut (Studi Kasus Lahan Perkebunan Kelapa di Guntung Riau). *Jurnal Teknik Sipil*. Vol. 12. 1 Januari 2005

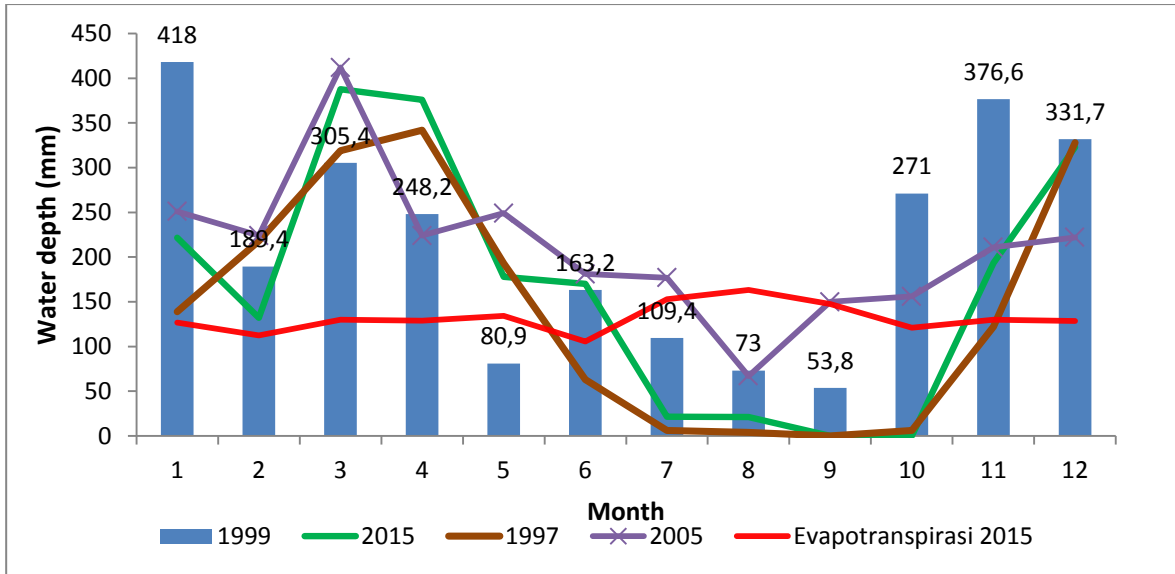


Figure 1. Comparison of rainfall Elnina 2015, 1997, Lanina 1999 with normal condition in 2005



Figure 2. Pineapple condition on the first week treatment of 10 August 2016

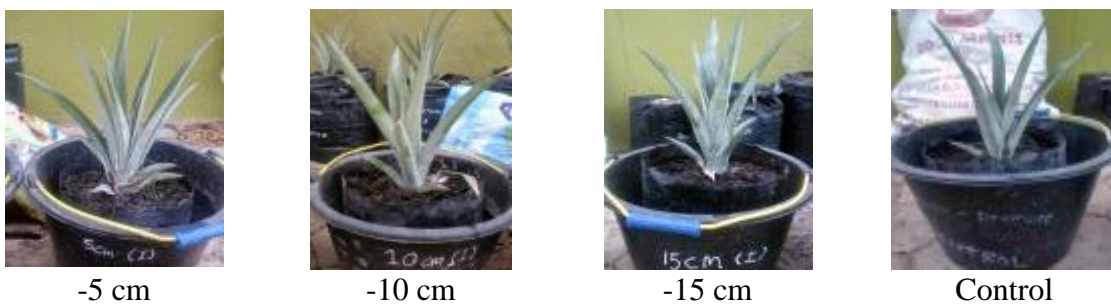


Figure 3. Pineapple condition on the third week treatment

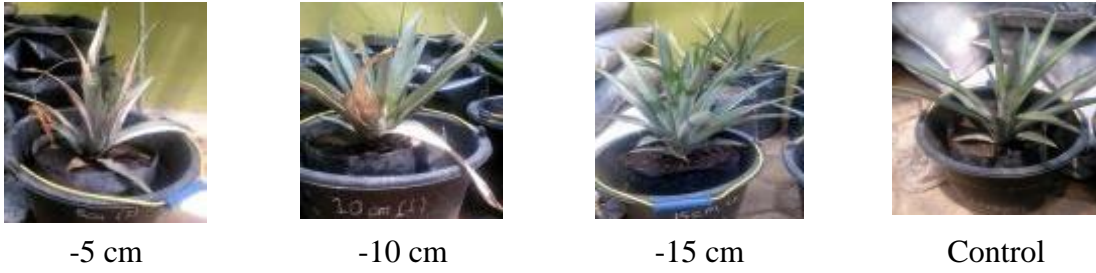


Figure 4. Pineapple morphological condition on 20 October 2016 (90 days after treatment of shallow ground water table)



Figure 5. Pineapple experience chlorosis due to inundation during 4 days



Figure 6. The open channel conditions at tertiary level every 250 m

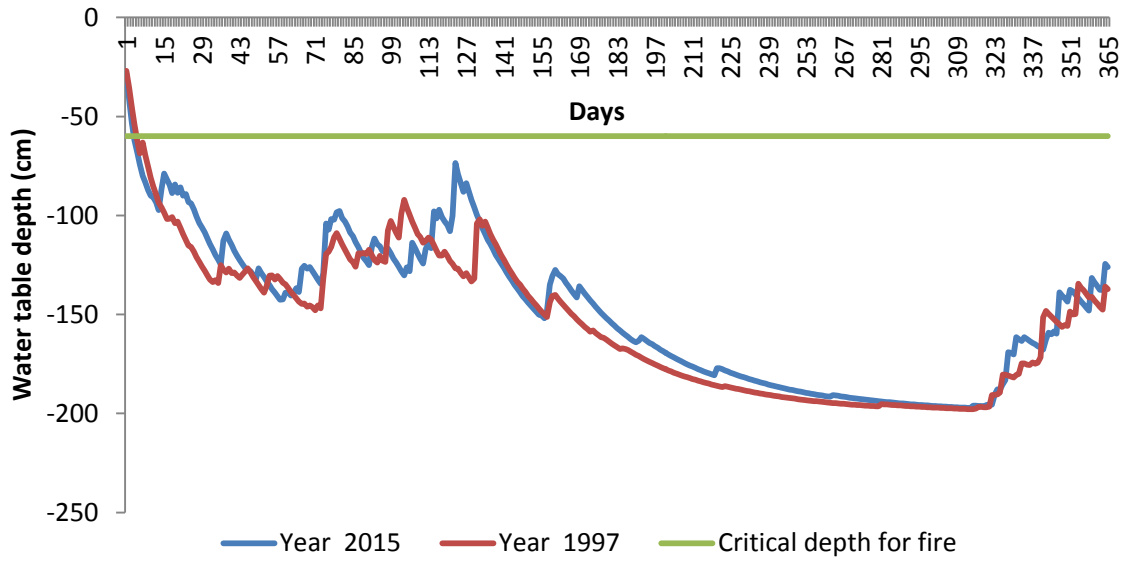


Figure 7. Dynamics of the ground water level in the dry climate conditions of Elnino 1997 and 2015

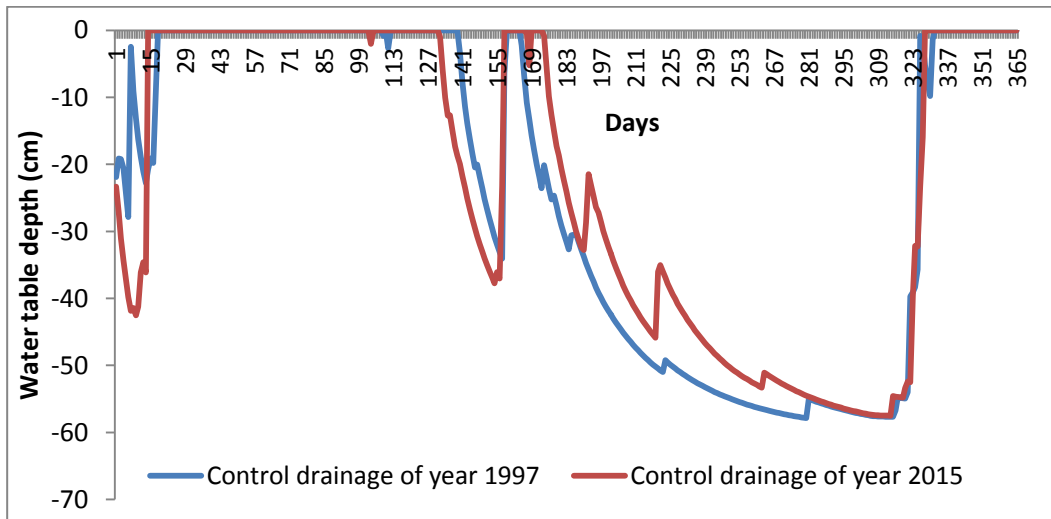


Figure 8. Influence on the Elnino door operation conditions in 1997 and 2015 on groundwater dynamics

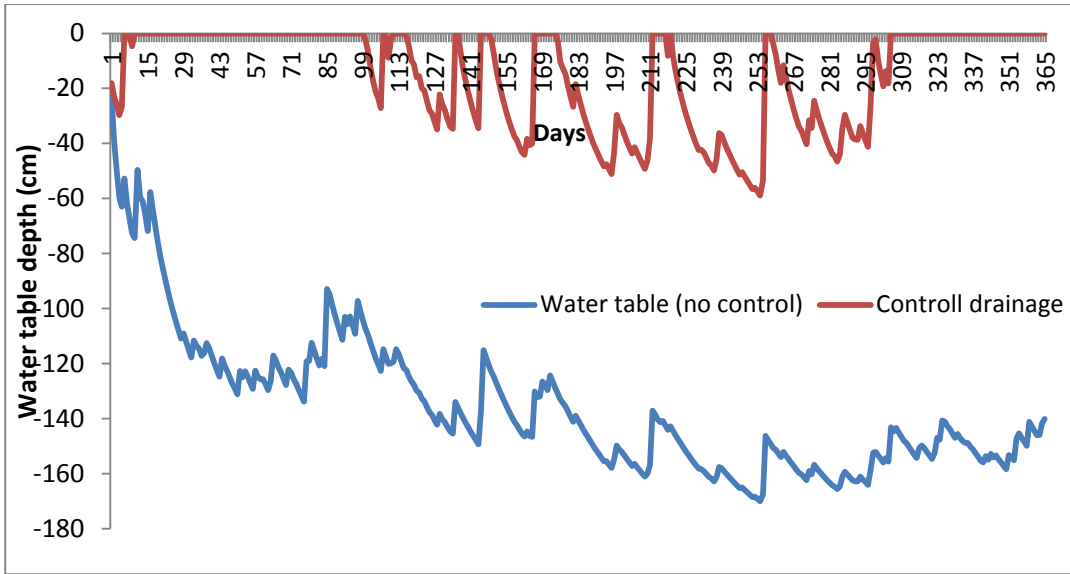


Figure 9. Dynamics of groundwater levels in the normal rainfall conditions

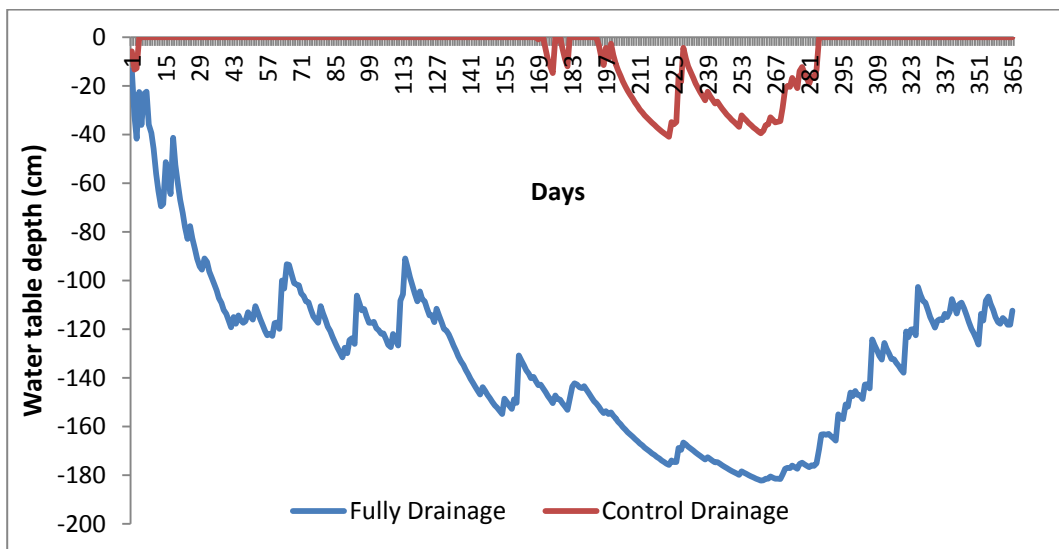


Figure 10. Dynamics of groundwater in Lanina conditions at maximum drainage conditions and under control

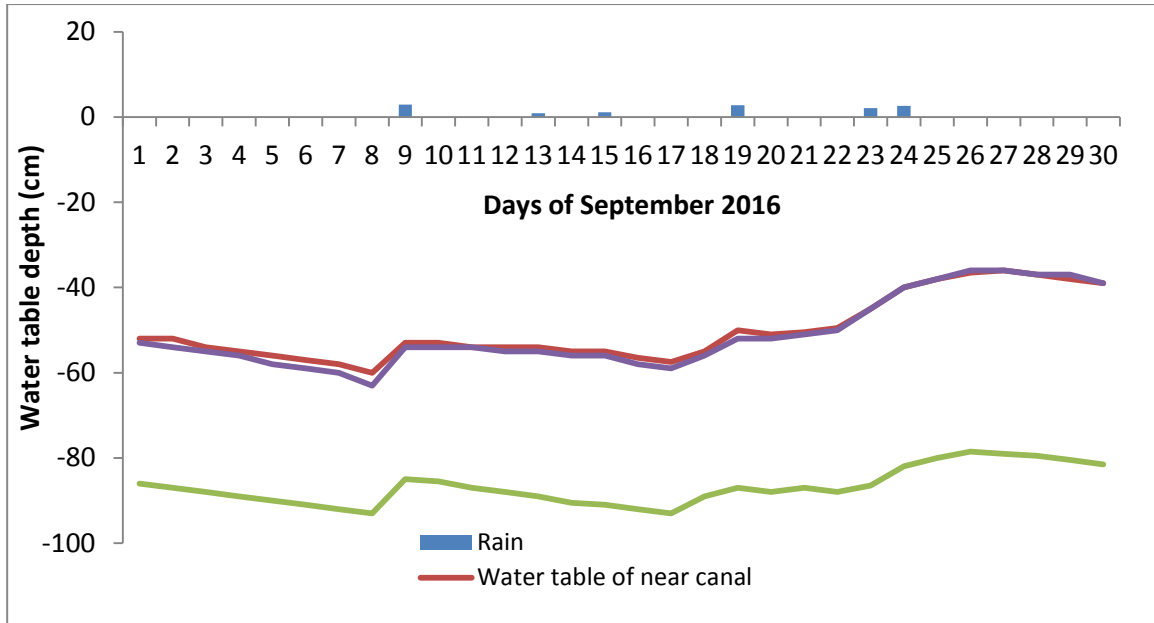


Figure 11. Dynamics of groundwater levels and precipitation in September 2016

Table 1. Water management link to the seasonal operation under three climatic conditions

Water Management Objectives	Monthly operation under various climatic condition		
	Normal	Lanino	Elnino
Drained (no operation)	January-March	January-April	January-February
Control Drainage under 50 cm	April-December	May-September	March-April
Fully Retention	-	-	May-December
Drained (no operation)	January-March	December	-

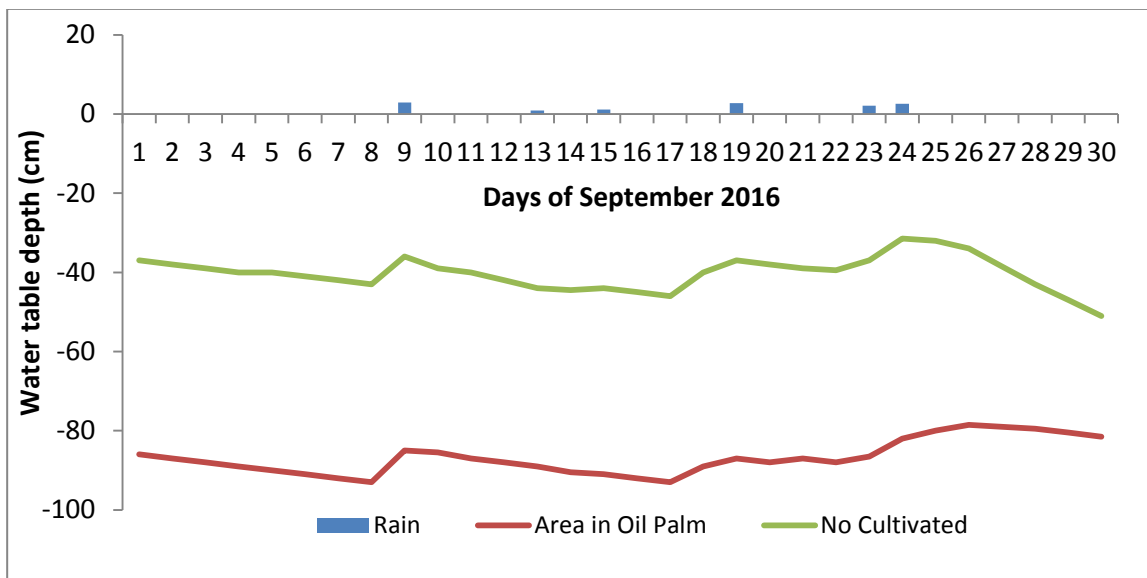


Figure 12. Dynamics of the ground water level in the uncultivated peatlands



Figure 13. Control of ground water level through water retention in the channel with the water system based on different topography



Figure 14. Growth of pineapple intercropping with oil palm on local society lands

15 Januari 2018	Penyerahan Artikel
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FINAL MAKALAH

OPTION FOR LAND AND WATER MANAGEMENT TO PREVENT FIRE IN PEAT LAND AREAS OF SUMATERA INDONESIA

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ABSTRACT

Limitations of dry land have forced the investors to open peatlands for oil palm plantations. Before peatlands cultivated and managed, it is necessary to carry out land drainage to dispose of excess water. However, excessive drainage system often leads to the peatlands becoming over drained, irreversible drying and stimulating wildfire. The research aimed to develop the management operation of water management in tertiary block of oil palm plantation. A Drainmod model was used in predicting the dynamics of ground water daily for a year. Pineapple and oil palm are used as indicator plants for model adaptation in the field. Pineapple responses on shallow ground water level were also conducted in a greenhouse. The simulations using climate scenarios of normal, dry (Elnino) and wet (Lanino) conditions. The results showed that the Drainmod model is able to predict the ground water level daily for a year. Water management objective is water retention, and it should have been started since April on the Elnino condition, and in July on the Lanina condition with ground water depth of 50 cm from the ground. Pineapples are adaptive in wet conditions, where groundwater conditions are -5 cm for one month; the plants have not demonstrated physiological disorders

Keywords: land and water, peat fire, Drainmod model, pineapple, oil palm

INTRODUCTION

Limitations of dry land for agriculture are now making the government, private sector and farmers to open peatlands. Peatland is formed from accumulation of dead vegetation materials and its decomposition process is not perfect due to wet environmental conditions and the peatland is rich in organic materials. Peatland area in the world is estimated at about 400 million ha. Indonesia is the fourth country with the largest peatland in the world, which is about 17.2 million ha after the Canada of about 170 million ha, the Soviet Union (150 million ha), and the United States covering 40 million ha (Euroconsult, 1984).

Peatlands in Indonesia are located and distributed mainly in Sumatra, Kalimantan and Papua. However, due to the variability of the peatland is very high in terms of the thickness, maturity and fertility of peatlands,

thus not all of the peatland is suitable to be cultivated as agricultural areas. Among the 17.2 million ha of peatlands in Indonesia, only about 6 million ha can be utilized for agriculture (Agus and Subiksa, 2008). South Sumatra has a peatland area of approximately 2 million ha.

Limin (2006) stated that the depth of the peat layer burning was an average of 22.03 cm (variation between 0 to 42.3 cm), but at some points the fire layer can reach approximately 100 cm. Therefore, extinguishing of peatland is very difficult and requires a lot of water. To extinguish a total area of one square meter of peatland required water as much as 200-400 liters. The influence of climate and disturbance Elnino on human activity is causing large areas of peatland in Indonesia was on fire. A major fire occurred repeatedly from 1997, 1999, 2001, 2002, 2004, 2006, and 2015. LAPAN (2015) reported that during the period 21 June until 20 October 2015, a total of 2,089,911 ha area of Indonesia was experiencing forest and land fires. The distribution of burned land is

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an area of 618,574 ha for peatlands and 1,471,337 ha for non-peatland forest. The fire occurred in Sumatra, Kalimantan, Papua, Sulawesi, Bali and Nusa Tenggara, Java, and the Moluccas. Especially for South Sumatra has the largest number of fire. Based on the information of the Forest Service by Terra Modis Satellite Data for 2015 the number of vulnerable and very vulnerable area burned in South Sumatra is 736,563 ha. Amount of the fires can reach over 350,000 ha. ANTARA (2015) reported that during the period 2006-2014, forest fire in the South Sumatra has caused the destruction of 1.4 million ha of peatland. Therefore, the government has made a restoration program to 2 million ha of peatland national must be completed within a period of 5 years, and South Sumatra have priority.

The recovery effort of damaged peatlands will not be easy and simple because formation of peatlands take million years and nature conditions of peatland could not return due to a fire or any disposal surplus. However, what can be done is that how peatlands could be revegetated, so that the ecological function can be restored and peatland damage can be minimized. Reclaimed peatland restoration is much easier because drainage network has been built, but for uncultivated peatlands, it is difficult because drainage network for water system should be built first.

Restoration should also think of the benefit principle, especially for peatland area is located close to the local community, the restoration should give added value to the income of local residents. Armanto et al. (2016) reported that field studies in the area of Talang Sepucuk OKI were found that local people (farmers) cultivate pineapples as main agricultural commodity. This condition is a potential for local crops that can be an alternative agricultural farming in the form of partnerships with large companies.

The main success key of the restoration is also dependent on water management. Water should be available in quantity, time and place (Imanudin and Bakri, 2016). Planning the water system requires data of ground water daily at least in one year. On the other

hand daily observation is difficult and costly. Estimation of water level through the help of computer models (Drainmod) has been carried out for the tidal area (Imanudin et al., 2010, Imanudin et al., 2011). The dynamics of daily ground water level during the rainy season modeling results indicate at error levels of 1-2 cm, which the modeling results have slightly over estimate values. Reported testing of discharge water released through the drainage system shows the value of the correlation coefficient is excellent that is 0.91 (Negm et al., 2016). Therefore, this paper will present the results of computer simulation models to estimate the groundwater level. This data is useful information on network development plan of water management and control operations every month.

MATERIALS AND METHODS

The research was conducted in peatlands with the maturity of hemic until sapric levels. Peat depth varies from 2 m to 5 m. The research location is located in the Riding village, sub district of Pangkalan Lampam and Oil Palm Plantation Area of PT Gading Cempaka in OKI district, South Sumatra Indonesia. The land typology belongs to “*Lebak swamp*” planted with oil palm and uncultivated peatlands are dominated by swampy shrubs.

The research method is a semi-detailed survey. Field observations included peat depth and maturity, depth of the groundwater, water management network systems, land use, soil hydraulic conductivity measurements and interviews. Laboratory research was the analysis of the physical properties of soil, water and computer simulation models of Drainmod. Data input to Drainmod is data of rainfall, temperature, water channel dimensions, the values of soil hydraulic conductivity, and the water gate operating plan (Imanudin et al., 2011). Scenario simulation is performed in the dynamics of ground water as a result of rainfall in dried Elnino (1997 and 2015). As a comparison it was simulated normal rainfall in 2005. Rainfall in wet conditions (Lanina) data was taken in 1999.

The Drainmod model works with fixed flow system with the concept of the water balance in the soil profile. The model was developed specifically for shallow ground water level (Negm et al., 2016). Drainmod model is able to predict groundwater levels properly and has been tested for peats. Dighavan and Klove (2016) stated that the model has produced Mean Absolute Errors (MAE) of 11.29 cm and 9.09 cm, and Nash-Sutcliffe Efficiency Modeling of 0.62 to 0.64.

Tests on cold climatic conditions in peatland have generated good value (satisfactory). The dynamics of groundwater was dominantly influenced by rainwater. Therefore, on the condition of peatlands the influence of tidal land area could be eliminated. Water supply and water drainage through the channels is done by setting the floodgates. Groundwater conditions at the beginning of the simulation were made at level of -10 cm below the ground surface, the perimeter in simulation is the first tertiary (250 × 1000 m). Recorded soil physical data are soil hydraulic conductivity in three layers which are distinguished from peat maturity levels, namely sapric, hemic and fibric.

To compare the simulation results with the condition of the ground water level in the field, the ground water level was observed daily for 1 month (September 2016). To see

the effect of rising water level in the channel against fluctuations in groundwater levels daily, the water level in the channel was observed by using a measuring board of pielschal.

RESULTS AND DISCUSSIONS

Climate Characteristics

Besides the human factor, the main triggers of fires are dry climate conditions due to decreased rainfall. If the water need for evapotranspiration is assumed to be 5 mm/day, then the water shortage has occurred in the dry climatic period in 1999, 2006 and 2015. Water is not only necessary to meet evapotranspiration, but also to keep ground water depth in order not to fall below 40 cm from the ground. Therefore, the water crisis in peatlands is longer than on dry land. Water deficit has occurred from May to November or in a period of 7 months. Meanwhile, when the condition of a normal rainfall year (2005), the analysis of the water balance in the soil indicates simply a water deficit in July-September (Figure 1), this condition is shown in rainfall Lanina 1999. However the rainfall conditions in 1999 (Lanina) in months before and after the water has a rainfall deficit higher.

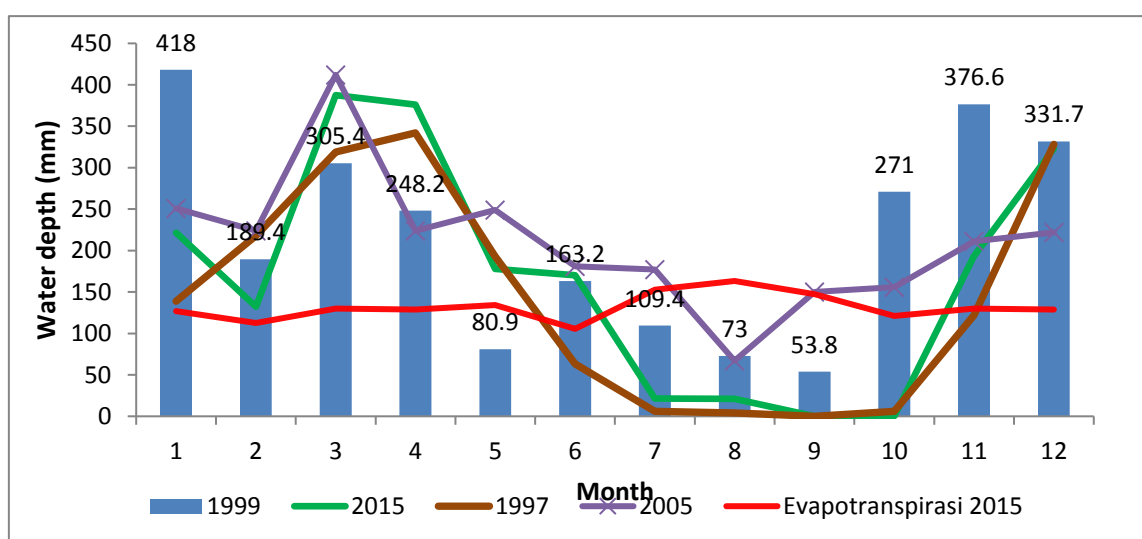


Figure 1. Comparison of rainfall Elnina 2015, 1997, Lanina 1999 with normal condition in 2005

Pineapple Adaptation to Shallow Ground Water Table

Pineapple (*Ananas comosus L.*) was originally known as a garden crop, now pineapple has been cultivated as a plantation crop because the fruit has high economic value, market demand, and commodity export in the tropical countries. Pineapple has other names, namely henas, kenas, honas (in Bataknese), ganas, Danas (in Sundanese), manas (Balinese), pandang (in Makasarnese). Pineapple belongs to the family of Bromeliaceae and is planted in the ground by using roots. This pineapple is classified in the monocotyledon class and has flower arrangements contained in the stem end, growth expanded by using the side shoots that develop into branches vegetative, at the branch later produced fruit (Setiawan, 2000). Pineapple can be cultivated on the altitude 0-1,200 m above sea level and grow around the equator between 25° N/S with rainfall of 1000-2500 mm per year. Pineapple is not resistant to cold temperatures, but it is resistant to drought because pineapple has an effective water-storage cells. The fruit is sensitive to the sun's shine (flammable) and

pineapple is tolerant to acid soils that have a pH of 3-5, but the optimum pH values should be in range of 5.0-6.5 and a nice pineapple can also be developed on peatlands and is still able to bear fruit as long as the ground water depths between 50-150 cm (Sunarjono, 1998).

The water requirement of pineapple ranges from 700-1000 mm per year which is achieved by the value of crop coefficient of 0.5 to 0.6 during the growing period. This condition is met if the water availability is in the depths of 0.3-0.6 m (FAO, 2015). Azevedo et al. (2007) stated that the water needs of the cumulative pineapple plants are 1,421 mm and the need for reference evapotranspiration is 1,614.9 mm. The daily requirement is highly dependent on the growth phase. In vegetative phase it decreases of 4.6 day⁻¹ mm to 3.5 mm day⁻¹. Therefore, the cultivation of pineapple has good prospects in the peatlands. Pineapple shows a high tolerance level of the shallow ground water table. Greenhouse test was carried out on a number of interventions that shallow ground water level depth of ground water -5 cm; -10 cm and -15 cm are still tolerant (Figure 2).

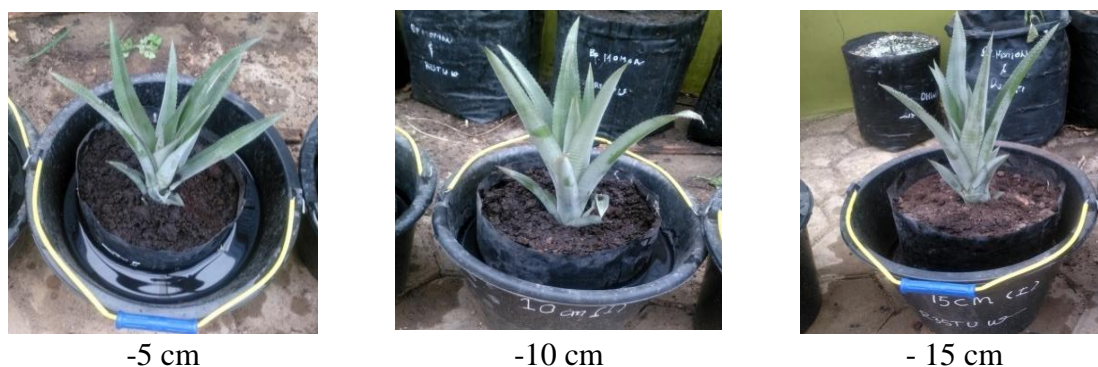


Figure 2. Pineapple condition on the first week treatment of 10 August 2016

The observation of morphologically phenomena showed that pineapple can still survive with shallow ground water conditions, but pineapple is having symptoms of morphological change in the second week.

Observations on the third week showed at the end of the plant leaves begin to dry (Figure 3), while the control, there is no changes in leaf morphology and pineapple grows well.

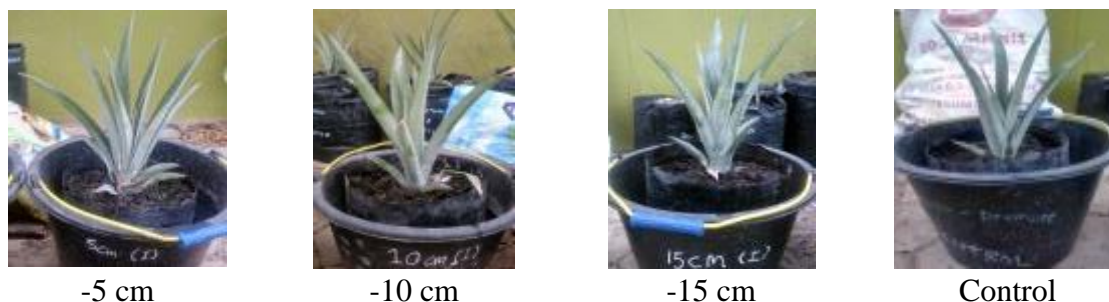


Figure 3. Pineapple condition on the third week treatment

Plant morphological change is significant in the treatment depth of the groundwater -5 cm on October 20, 2016 (Figure 4), where pineapple has been treated for 70 days from the initial planting. This condition requires that the treatment be stopped to be returned to dry land conditions, so that the plant can restore growth. From the test results show that the pineapple adaptation is relatively resistant to shallow groundwater

levels, pineapple can survive more than two months and the pineapple did not die. Treatment at a water depth of -15 cm relative still showed good growth. As for the depth of the groundwater treatment -5 cm, must be limited to the treatment period on 29 September 2016 the time when 50 days of treatment, the majority of pineapple leaves are still green.



Figure 4. Pineapple morphological condition on 20 October 2016 (90 days after treatment of shallow ground water table)

The depth of groundwater is one of the important limiting factors for the cultivation of food crops in the peatlands (Imanudin et al., 2016). Getting closer to the ground surface, then the root zone will be filled by water. Pelletier et al., (2015) showing the condition of the ground water level reached the optimum at a depth of 60 cm for horticulture crops such as sugar beet. Meanwhile, on the condition of the ground water level is 30 cm, the soil will be saturated water closer to the surface. When this condition is too long, then the crop could experience water stress and can cause death. The study on water inundation of land has

shown if it happens more than 3 days, then the plant is very clearly undergoing physiological changes. The crop leaves will show chlorosis, like burning (Figure 5). Rachmawati and Retnaningrum (2013) states that this chlorosis symptom occurs because stagnant conditions at the time the crops will lack of oxygen supply to interfere with the process of photosynthesis and respiration. Inundation effect is also characteristic of the genotype, the status of carbohydrates before and after the inundation, the level of crop development at the time of inundation, level and duration, and degree of water turbidity.



Figure 5. Pineapple experience chlorosis due to inundation during 4 days

During inundation the environment causes low CO₂ concentrations and low light causing a reduction in the ability of photosynthesis in crops. As one of the best responses of crops to waterlogging of land is switched from the metabolism of aerobic respiration to anaerobic respiration fermentation. In fact, most proteins are formed during hypoxic conditions are enzymes involved in the formation of this fermentation pathway. Because the crop cells need to maintain a continuous supply of ATP, the use of alternative electron acceptors and/or the alternative pathway is a key element to survive in waterlogged soil conditions. Plant response may also include decrease in stomata conductance and photosynthesis, and root hydraulic conductivity. These physiological changes in turn affect backup and translocation of carbohydrates (Pucciariello et al., 2013).

Advance Drainmod Prediction of Groundwater in Various Climate Conditions

Estimation of the ground water level is done by using computer simulated Drainmod model. Drainmod is working on the assumption that the land receives water flow under fixed conditions (steady state condition) and is able to produce excellent

correlation value of around 0.9 (Golmohammadi et al., 2016). Model adaptation for the tropics has been done by Imanudin et al. (2010) on the tidal land and produce correlation values between the water level modeling and observation in ranging of 0.8-0.9. The model produces an over estimated value of the water condition in the dry season. The main water input is rainfall, thus it is in accordance with the conditions in the study area where the land is not influenced by tide and water level fluctuations are greatly influenced by rainfall.

Drainage design is an open channel system with the distance between the secondary channels of 250 m. Channel dimensions showed the width of 2-3 m and a depth of 2.0-2.25 m. These channels limit the plot of 25 ha. Picture of the channel is shown in Figure 6. The rainfall scenarios used in the simulation are based on the climate phenomenon Elnino, Lanina and Normal. Fitria at al. (2013) stated climate phenomenon Elnino events were in 1997 and 1999. Furthermore Lanina normal rainfall conditions would be used in 2005 (Hadi et al., 2010). Rainfall data from the Kenten Palembang station in this period will be used in the Drainmod simulation.



Figure 6. The open channel conditions at tertiary level every 250 m

The peat maturity is dominated by hemic level on the surface and on the 2 m soil depth, the peat maturity is still relatively classified as Fibric level. The values of soil hydraulic conductivity on both the maturity level of peat are respectively 3.5 m/day and 7.0 m/day. This is in line with the research results of Tahrin et al. (2015) that the peats at a depth of 20-30 cm has a value of hydraulic conductivity ranging between 30-40 cm/hour, equivalent to 7.0-7.5 m/day.

Channel design is intended to maximize drainage, so oil palm trees can be planted. Channel conditions have not been considered for water conservation and to maintain the water level in the dry season. Therefore, the simulation will be done by looking at variations in rainfall and the potential for water retention in secondary channels, so that the water level can be increased. Drainmod simulations performed on three scenarios of climate conditions, namely Elnino conditions, Lanina and Normal. The first simulation was performed on land conditions there is no control (open system) and the second simulation is to perform control (control drainage). The results of simulation estimation of ground water are presented as follow:

1. Elnino dry climate conditions in 1997 and 2015

Elnino climate phenomenon that occurred in 1997 and 2015 has led to hot weather conditions, drought due to low rainfall. Salman (2015) reported an incidence of Elnino 1997 caused drought (water deficit) from mid-year to the end of 1997. The impact is the number of crop failure due to drought and peat fires. Drainmod simulations in 1997 and 2015 have the same trend in which the depth of ground water decreased rapidly since the end of the rainy season (Figure 6). This condition is caused by precipitation that falls below normal.

Referring to the critical value of the depth of groundwater against fires is at the level of 60 cm below the ground surface, the simulation showed almost Drainmod during the period of the season is in danger. Ground water level since February under 60 cm and a peak in the dry season (June to September) is at a depth below 150 cm (Figure 7). This condition is due to precipitation of small and channels no control operations. Open drainage channel dimensions without control plus a wide and deep, making the excess land disposal. As a result of this, the dry conditions have fire occurred in 1997 and 2015.

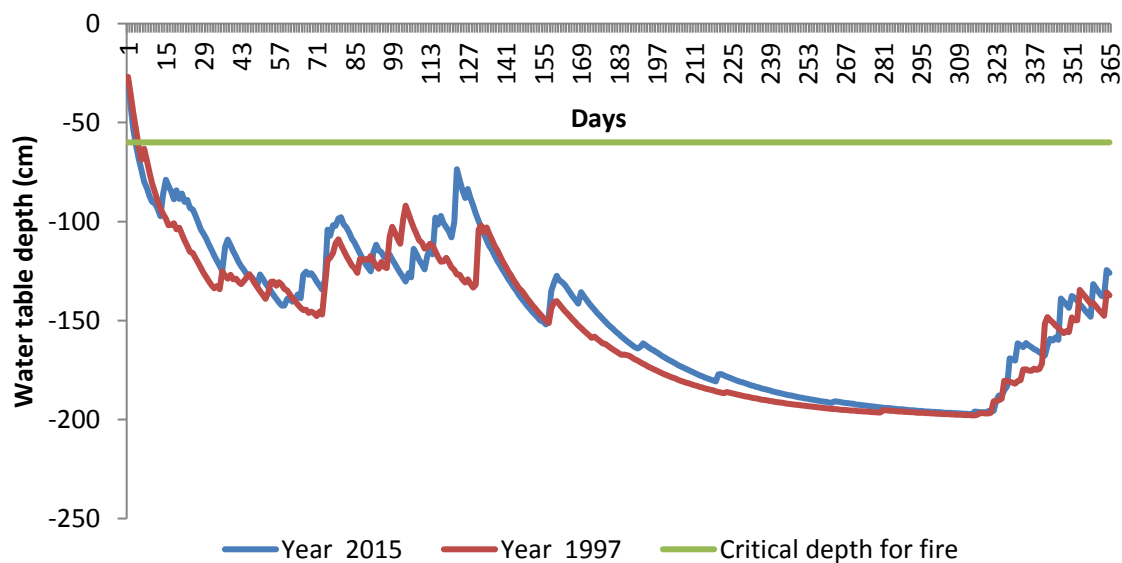


Figure 7. Dynamics of the ground water level in the dry climate conditions of Elnino 1997 and 2015

Control of ground water level in the dry climate conditions should be done as early as possible, namely when it began to rain rarely falls. Drainmod simulation showed that the water containment should be done since April. Detention of Watergates was done, so that the ground water level remains steady 60 cm. So that the water level in the channel must be kept at least 60 cm from the ground. The simulation results of water level Elnino premises using the data of 1997 and 2015 (Figure 7) showed the same trend, so that the operation of Watergates was also similar in these climatic conditions. In theory the water can hold at a depth of 60 cm, when the water detention is done earlier. Detention is meant to increase water storage in the soil and land line. This condition is consistent with Tarin (2011) which states that in the dry season peatland area that water shortage always

occurs. To suppress this deficit will require an increase in soil water storage (pre-storage) through water retention in the channel.

2. Dynamics of Normal Climate Condition

The dynamics of ground water level in the normal rainfall conditions in 2005 can be seen in Figure 8. In an open channel conditions (free water) without experiencing over control of the land drain. Ground water level in the dry season is at a depth of 120-170 cm below the soil surface. This condition is dangerous and would highly be flammable. But with efforts to control the water level (control drainage), the water level in the dry season could ascend to a depth of 40-50 cm below the soil surface. Water detention operations began in May.

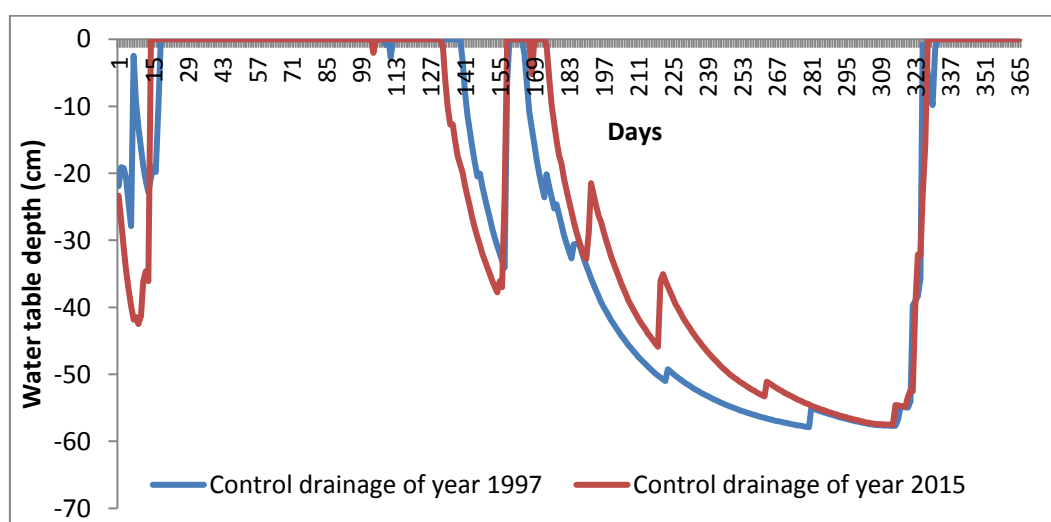


Figure 8. Influence on the Elnino door operation conditions in 1997 and 2015 on groundwater dynamics

3. Condition of wet precipitation (Lanina)

Rainfall in the above normal conditions (wet) as the effect of climate phenomena Lanina was taken the data in 1999. Computer simulation model Drainmod will be done in two scenarios are simulated network conditions no control and with control. Drainmod simulation results show that the ground water level remains down ahead of the dry season and even in the dry season the water level drops beyond the critical limit

(Figure 9). The condition of ground water level remains down because of spending discharge channel is too high and the system network without containment efforts.

Therefore, when the canal system is not controlled, obviously it would be harmful to the ecological functions of peat. Groundwater is still down beyond the critical limit. Fires do not happen because the topsoil moist conditions due to rain instead of capillary movement of underground water. In line with the results of research Imanudin et al. (2016),

that the condition of peatlands which opened the ground water level during the dry season will stay down beyond the critical limit either on normal climatic conditions, damp,

especially the condition of the lamina. Therefore, controlling the groundwater table must be done before the dry season arrives.

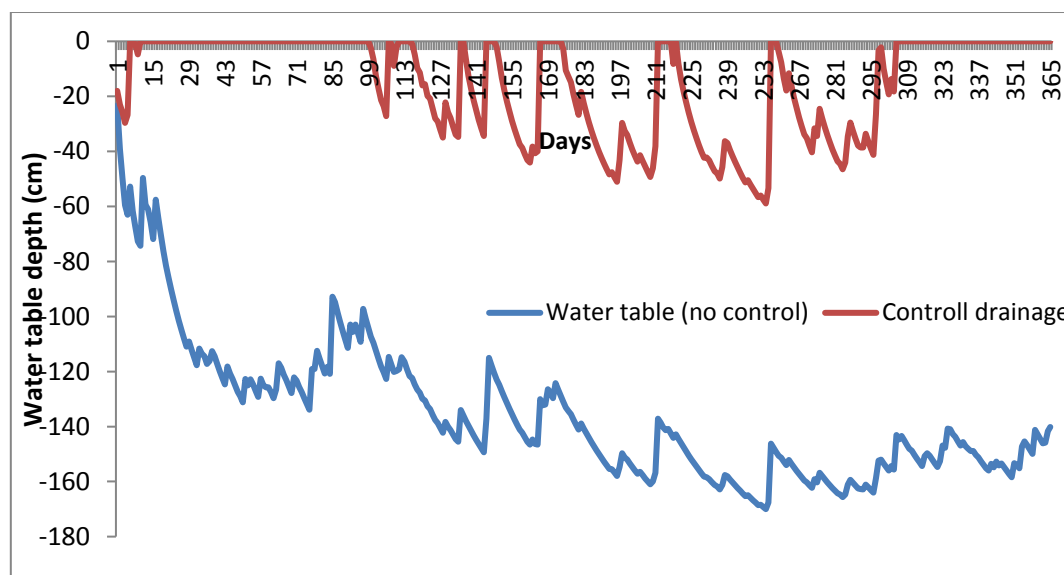


Figure 9. Dynamics of groundwater levels in the normal rainfall conditions

Adaptation models for peat restoration by multi-cropping system (pineapple palm -oil) on Estate and Industrial Plantation Forest Management

The pattern of ground water level dynamics computer simulation results Drainmod models show the ground water level is strongly influenced by rainfall, soil hydraulic conductivity, and the spacing between channels. This condition is evident from observations of groundwater level in the field (Figure 10). Ground water level in September on a wet climatic condition indicates the condition of the safety zone, where the water table is located at a depth of 40-60 cm. In the period of September is still

no rain where there 6 times (days) of rain. The influence is very large rain where rain 3 mm can raise the water level in the channel 8 cm and was able to raise the water level 9-10 cm in the area of land near and far line channels. This clearly shows the influence of fluctuations in the water level in the channel is very significant to the dynamics of groundwater levels in the area. Besides the effect of distance from the land to the channel is also very real. Groundwater conditions near the channel (0-50 m) has a ground water level 39-50 cm below the ground surface, while the position in the middle of the channel water level (100 m) the ground water level is at a depth of 79-90 m.

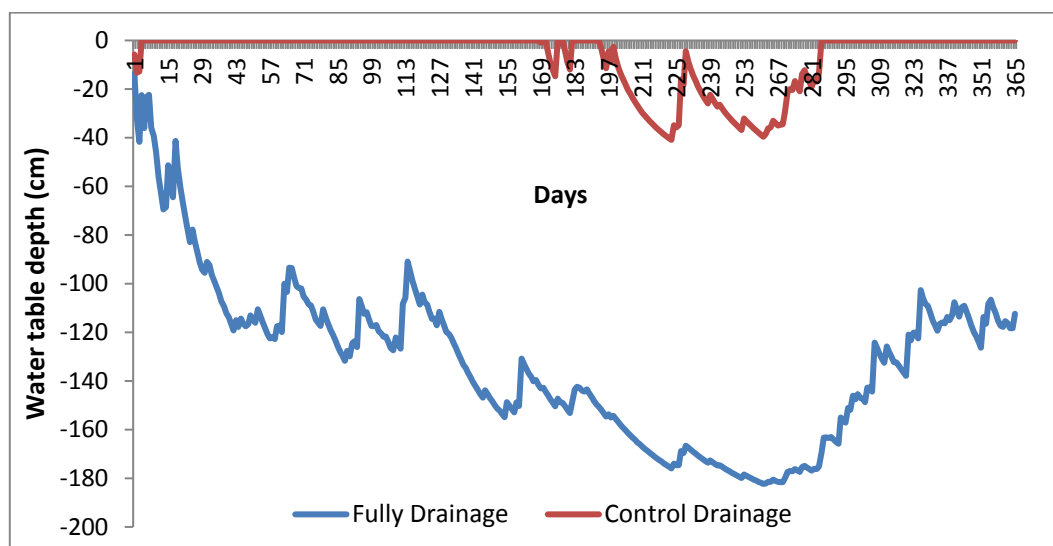


Figure 10. Dynamics of groundwater in Lanina conditions at maximum drainage conditions and under control

From this condition the dynamics of the water table in peat land area, it is clearly an effort to maintain the depth of the ground water is by conditioning the water level in the channel is at a depth of 50 cm parallel to the ground. To achieve this condition, the efforts

to increase the water in the channel must be done before the rainy season ends. Operations control water level is in line with the results of computer simulation models Drainmod. The following Table 1 is a water level control operations on the secondary channel.

Table 1. Water management link to the seasonal operation under three climatic conditions

Water Management Objectives	Monthly operation under various climatic condition		
	Normal	Lanino	Elnino
Drained (no operation)	January-March	January-April	January-February
Control Drainage under 50 cm	April-December	May-September	March-April
Fully Retention	-	-	May-December
Drained (no operation)	January-March	December	-

Data observation of ground water level daily during the month of September in areas already opened and unopened palm plant shown in Figure 11. Lower water levels are very real where in September although there is still rain the water level drops to a depth of 80-90 cm, while on land unopened ground water level is still in the safe zone which ranges from 40-50 cm below the soil surface. The results showed that the depth of the ground water level is critical to maintain the Fire Danger Index at a safe level is at a depth of 0.6 m, and if the depth exceeds the critical

value, the potential hazards of peatland fires to increase (Taufik et al., 2011). In addition to the fire hazard is another environmental problem, i.e. Carbon emissions. Land cleared of oil palm plantations has the distinction of ground water was real by shrub land. This condition is consistent with research of Nusantara et al. (2014), on the condition of the oil palm fields have 50-60 cm of ground water, the ground water level in the scrub only about 30-35 cm, and carbon emissions reached 6.701 C ton/ha/yr in the field of oil palm and 3,169 tones/ha/yr in the shrub land.

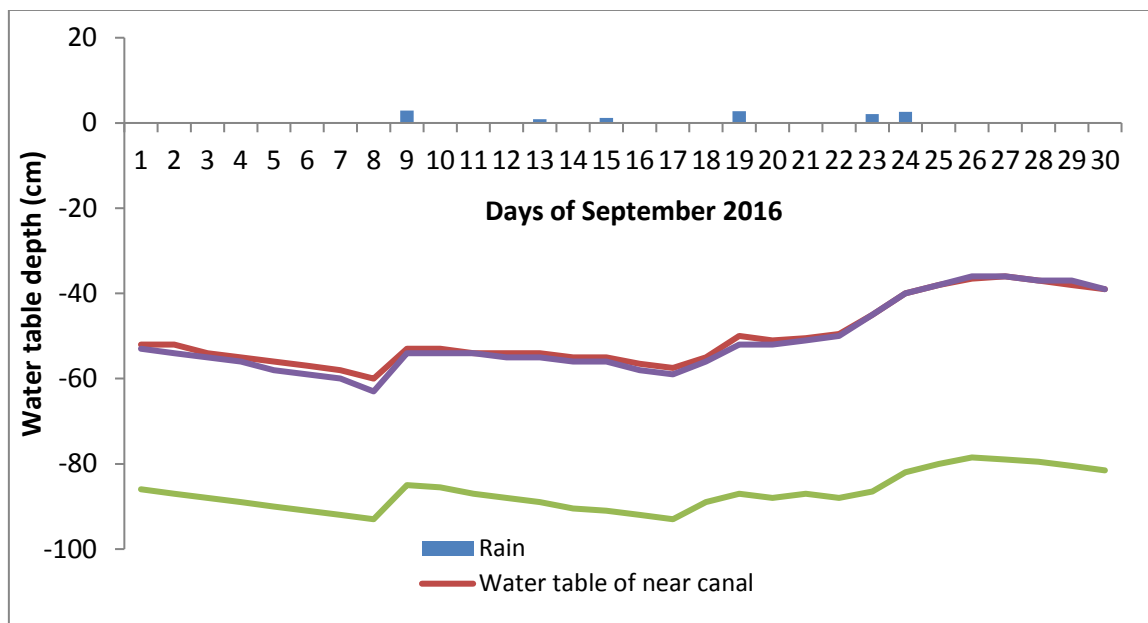


Figure 11. Dynamics of groundwater levels and precipitation in September 2016

In rainy conditions or drought will slightly change the profile of ground water, is due to changes in flow direction occurs that causes the water level near the channel will be deeper. Susandi et al. (2015), decrease in water level is due to an accelerated flow of ground water due to a reduction in peat soil moisture caused by the drying process, so that the shelf life of the water decreases.

Lower water levels in land cleared very quickly, even though the existing water level controls operation. Control efforts are to detention on each primary segment in each tertiary (Figure 12). Water retention is done and distribution of water in case of overload. In operation retention system aims to maximize the water retained in line with the technique of closing the channel (canal

blocking), but at the level of 20 cm from the bottom of the embankment installed discharge pipe (sharing water), to remove excess water in case water replenishment from rainfall excess (Figure 10), this flow occurs due to the difference altitudes basic channels upstream and downstream, although the condition is rare in elnino climatic conditions. In the climatic conditions elnino more dominant water retention system, where each plot carried blocking to hold water in the channel. Wangsadipura (2005) reported a decline in groundwater levels take 120 days if it is not raining at 2.3 m spacing between channels when 500 m. For the condition of the peatland area of good channels are 500 m distance between secondary and tertiary distance between is 100 m.

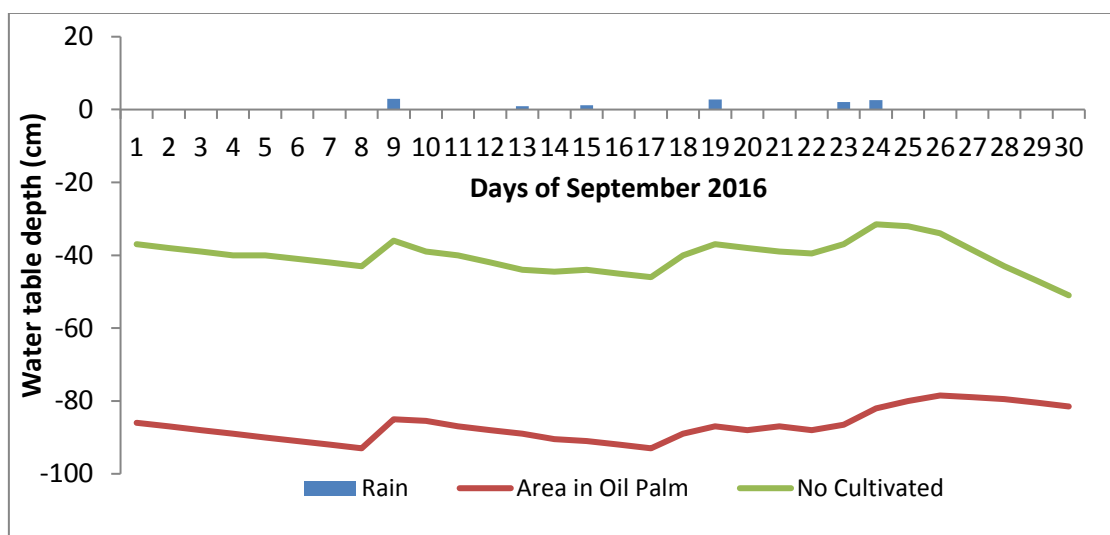


Figure 12. Dynamics of the ground water level in the uncultivated peatlands

To increase the added value of land use, it is the potential to do intercropping systems with pineapple (Figure 13). Adaptive pineapple on ground water table is shallow and in the dry season the wanted water level is not more than 100 cm, therefore the land can get security double, because farmers can keep these plants in order to avoid drought and fires, system control operations will be

run, for large scale it is not conducted with the partnership with the company yet. Agricultural intercropping system on a small scale on community land. Therefore this model can be recommended to be done with the partnership with the oil palm plantation company. If the model is successful, it can support the national peatland restoration program.



Figure 13. Control of ground water level through water retention in the channel with the water system based on different topography

Effect of decreased water level is not only from fire, but also against carbon emissions. Oil palm large companies are often got international pressure due to carbon emissions. Carlson et al. (2015) reported a very strong correlation with the depth of the ground water level and carbon loss. At a depth of 70 cm water table below the ground

surface an average loss of carbon loss was of 20 t C ha/yr. This is further increased when the ground water level further down. Planting oil palm enables farmers to maintain the water level remains 50-60 cm, so in addition reduces the fire hazard is also carbon emissions (Table 14).

Production of oil crops is not only influenced by the depth of the groundwater, but also the level of maturity of peat. Research shows that the more mature the

higher the peat production. At maturity level of production reached Sapric range of 19.48-22.92 MT/ha and the peat hemic ranging from 9.47 to 13.37 MT/ha (Veloo et al., 2015).



Figure 14. Growth of pineapple intercropping with oil palm on local society lands

CONCLUSIONS

Study of pineapple adaptation on shallow groundwater conditions and landuse plan of Drainmod model for reclaimed peatlands planted with oil palm has produced several conclusions and suggestions, namely:

- 1) Drainmod model is able to predict the ground water level daily and is effective in designing month-control operations at the level of secondary plots. Nevertheless the value of the ground water level shows the overestimate simulation results with field data on dry conditions. This is because the condition of the water loss in the field is very high, despite the water detention is conducted, but the water level remains down beyond the critical limit.
- 2) Operation of water level control in the field is to build a water sharing system in each tertiary plot. Maintaining water level should not be dropped from 50 cm from the terrace (embankment). Therefore the drainage system should be installed on the dam surface between tertiary plots. In the dry climate conditions (Elnino), water retention system through drainage control has to be started in March-April and fully retention since May.
- 3) Potential land use by using intercropping systems of pineapples and oil palm will be able to maintain the water level closer to

the root zone and will create new agribusiness. For the future the potential to do a partnership with the local farmers, so that the effort to keep the area of the fire could have been better because it involves the local community.

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REFERENCES

- ANTARA, 2015. Satu juta hektar lahan gambut Sumsel terbakar. Diunduh 2016 <http://www.antaraneews.com/berita/515778/satu-juta-hektar-lahan-gambut-sumsel-terbakar>.
- Carlson KM, Goodman KL, May C, Tobin. 2015. Modeling relationships between water table depth and peat soil carbon loss in Southeast Asian plantations. *Environ. Res. Lett.* 10 IOP Publishing Ltd.

- Dighavan M, Klove B. 2016. Evaluation of Drainmod 6.1 for Hydrological Simulation of Peat Extraction Areas in Noethern Finland. *Journal Irrigation and Drainage Engineering*. 142(11).
- FAO. 2016. Crop Water Information: Pineapple
http://www.fao.org/nr/water/cropinfo_pineapple.html
- Fitria, W. dan Pratama, S.M. 2013. Pengaruh Fenomena Elnino 1997 dan Lanina 1999. Terhadap Curah Hujan Biak. *Jurnal Meteorologi dan Geofisika*. 14(1)
- Golmohammadi G, Rudra RP, Shiv O, Prasher SO, Madani A, Goel PK, Mohammadi K. 2016. Modeling the impacts of tillage practices on water table depth, drain outflow and nitrogen losses using Drainmod. *Computers and Electronics in Agriculture*, 124: 73-83
- Hadi, Ismul A, Suwarsono, Herliana. 2010. Analisis Karakteristik Intensitas Curah Hujan di Kota Bengkulu. *FLUX Jurnal Ilmiah Fisika*, 7(2): 119-129.
- Imanudin MS, Budianta D, Bakri. 2016. El-Nino Effect on Water Management Objective in Tidal Lowland Reclamation Areas (Adaptation Model for Corn). In Proceeding the international Seminar 2nd World Irrigation Forum Chiang May, Thailand November 6-8, 2016.
- Imanudin MS, Bakri. 2016. Model Drainase Lahan Gambut untuk Budidaya Kelapa Sawit berbasis Evaluasi Lahan. Prosiding Seminar Nasional dan Lokakarya Pengembangan Kelapa Sawit Terpadu dan Berkelanjutan Palembang, 23 Maret 2016. ISBN 979-587-611-2.
- Imanudin MS, Armanto ME, Susanto RH. 2011. Developing Seasonal Operation for Water Table Management in Tidal Lowland Reclamations Areas at South Sumatra Indonesia. *Journal of Tropical Soils, Unila*. 16(3): 233-244.
<http://journal.unila.ac.id/index.php/tropicalsoil>. doi: 10.5400/jts.2011.16.3.233
- Imanudin MS, Armanto ME, Susanto RH, Bernas SM. 2010. Water Status Evaluation on Tertiary Block for Developing Land Use Pattern and Water Management Strategies in Acid Sulfat Soil of Saleh Tidal Lowland Reclamation Areas of South Sumatera. *Journal of Agriculturas Science-AGRIVITA*. 32(3): 241-253.
<http://www.agrivita.ub.ac.id/index.php/agrivita/article/view/16>
- Negm LM, Youssef MS, Checheir GM, Skaggs. 2016. DRAINMOD-based tools for quantifying reductions in annual drainage flow and nitrate losses resulting from drainage water management on croplands in eastern North Carolina. *Agricultural Water Management*, 166(1): 86-100.
- Nusantara RW, Sudarmadji, Sugandawaty Tj, Djohan, Haryono E. 2014. Emisi CO2 tanah akibat alih fungsi lahan hutan rawa gambut di Kalimantan Barat. *Journal Manusia dan Lingkungan* 21(3); 268-276.
- Pelletier V, Gallichand J, Gumiere S, Pepin S, Caron J. 2015. Water Table Control for Increasing Yield and Saving Water in Cranberry Production. *Journal of Sustainability* 7: 10602-10619.
<http://dx.doi.org/10.3390/su70810602>.
- Pucciariello C, Voesenek LACJ, Perata P, Sasidharan R. 2014. Plant responses to flooding. *Front Plant Science*, 5: 226.
- Rachmawati D, Retnaningrum E. 2013. Pengaruh tinggi dan lama penggenangan terhadap pertumbuhan kultivar sintanur dan dinamika populasi rhizobakteri pemfiksasi nitrogen non simbiosis. *Bionatura-Jurnal Ilmu-ilmu Hayati dan Fisik*. 15(2): 117-125.
- Rohmah EA, Saputro TB. 2016. Analisis Pertumbuhan Tanaman Kedelai (*Glycine max L.*) Varietas Grobogan Pada Kondisi Cekaman Genangan. *Jurnal Sains dan Seni ITS*, 5(2): 2337-3520.

- Salman SR. 2015. Analisis Dampak Fenomena Elnino (1997-1998) terhadap Ketersediaan Air Tanah Pulau Ambon. *Jurnal Agrologia*. 4(1): 34-40.
- Susandi, Oksana, Arminudin AT. 2015. Analisis Sifat Fisika Tanah Gambut pada Hutan Gambut di Kecamatan Tambang Kabupaten Kampar Provinsi Riau. *Jurnal Agroteknologi*, 5(2): 23-28.
- Susanto RH. 2016. Menabur Harapan di Lahan Gambut melalui Pendekatan Multi Dimensi dalam Upaya Pencegahan Kebakaran Hutan dan Lahan untuk Kesejahteraan Masyarakat. *Makalah Seminar Lahan Suboptimal*, Palembang, 18 Oktober 2016.
- Tarigan SD. 2011. Neraca Air Lahan Gambut yang di tanami Kelapa Sawit di Kabupaten Seuyan. Kalimantan Tengah. *Jurnal Tanah Lingkungan*, 13:(1) 14-20.
- Taufik M, Setiawan BI, Prasetyo, Pandjaitan LB, Soewarso. 2011. Pengembangan Indeks Bahaya Kebakaran di HTI SBAWI Sumatera Selatan. *Jurnal Penelitian Hutan Tanaman*, 8(4): 215-223.
- Wangsadipura M. 2005. Analisis Hidraoulik Bawah Permukaan Melalui Media Gambut (Studi Kasus Lahan Perkebunan Kelapa di Guntung Riau). *Jurnal Teknik Sivil*. 12.