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Adaptation and Mitigation Strategies of Climate Change from Agricultural Sector in the Tabalong District (South Borneo)

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Abstract

Agriculture and climate change have a complex causal relationship. The agricultural sector produces large amounts of Green House Gases (GHG) such as CH_4*,* CO_2*, and* N_2O *which affect the climate. One of the consequences of climate change is an increase in rainfall. This has caused 2,971.51 ha of submerged and damaged rice fields in the Tabalong District. This study aims to determine the climate change adaptation and mitigation strategies of the agricultural sector in the Tabalong District. Emission measurements and mapping of the distribution of GHG emissions are shown to support strategy determination. The GHG inventory is calculated using the Indonesian Ministry of Environment and Forestry method, mapping the distribution of emissions using the geographic information system method, and determining the best adaptation and mitigation strategies using the Analytic Hierarchy Process (AHP) with Expert Choice Software. The results showed that GHG emissions from the agricultural sector of the Tabalong District until 2030 amounted to 191,384* tCO_2e */ year. There are five Sub-districts identified as the largest GHG-producing districts from the mapping of the distribution of GHG. The results of the AHP synthesis show that there are three strategies for climate change adaptation and four strategies for climate change mitigation.*

***Keyword**: Adaptation Strategies; Agricultural; Climate Change; Mitigation Strategies*

Introduction

Climate change is an implication of global warming (Susandi et al., 2010). One of the potential problems caused by climate change is an increase in climate events (Easterling et al., 2000). The increasing frequency of Extreme Climate Events (ECEs) such as heatwaves and floods has been linked to climate change (Babcock et al., 2019). Climate events in the form of floods and drought have caused crops that experience crop failure to expand (Surmaini & Runtunuwu, 2011). Tabalong District is one of 13 districts / cities in South Borneo Province, Indonesia that has felt the impact of climate change. Based on Central Bureau Statistic data, the amount of annual rainfall increased from 2,293 mm in 2010 to 3,790 mm in 2019

(BPS, 2020). The increase in rainfall resulted in the overflowing of the Tabalong River and caused an area of 2,971.51 ha of rice fields to be submerged and damaged (BPBD, 2020).

Agriculture and climate change are linked in a complicated way. The agricultural sector produces a large number of gas emissions that affect the climate. Increasing concentrations of greenhouse gases in the atmosphere have caused changes in the precipitation cycle which negatively impact the quantity, quality, and stability of agricultural production (Agovino et al., 2018). Finally, climate change affects changes in food availability, access to food, food utilization, and food security (Brown et al., 2017). Understanding the effects of climate change on food is a critical first step toward effectively addressing these issues (Fanzo et al., 2018; Thornton et al., 2014).

There are two challenges in agriculture regarding climate change, such as adapting to a varied climate and implementing a climate change mitigation strategy (Smith & Olesen, 2010). Agriculture contributes around 14% of GHG emissions on a global scale and 7% on a national scale (Purnamasari et al., 2019). The agricultural sector generates three types of GHG, including carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4). Several activities produce GHG emissions, including the application of nitrogen fertilizers and manure produce N_2O emissions, changes in land use produce CO_2 emissions (Garnett, 2011), and rice fields produce CH_4 emissions (Wihardjaka, 2015).

Therefore, an appropriate climate change adaptation and mitigation strategy are needed for the Tabalong District. Adaptation options aim to increase the stability of agricultural production while mitigation options aim to reduce GHG emissions produced by agriculture. Efforts to reduce GHG emissions are in line with Presidential Regulation Number 61 of 2011, which states that Indonesia's geographic position is very vulnerable to climate change, so it requires countermeasures through climate change mitigation. Based on the foregoing discussions, the purpose of this study is to identify the best climate change adaptation and mitigation strategies for the agricultural sector in the Tabalong District.

Literature Review

Climate change can be defined as a climate change event caused by human activities, either directly or indirectly. Human activities have caused changes in the composition of the atmosphere globally and led to changes in the variability of natural climates observed over comparable periods (UU No 32, 2009). Pendergrass et al., (2017) have compared the climate variability of the last few decades with the projected RCP8.5 for the late 21st century and found that in the global multi-model mean, the variability of rainfall increases 3–4% K - 1 globally, 4–5% K - 1 on land, and 2–4% K - 1 on oceans, and it is strongest in the period from daily to a decade. Rainfall variability increases as average rainfall and extreme rainfall occur in most models, regions, and time scales.

The impacts of climate change will be most pronounced in developing countries, especially in rural areas where the majority of the population is middle to low income. Adaptive capacity in developing countries is highly dependent on economic resources, social capital, awareness and training, technology, infrastructure, and institutions (Abdul-razak & Kruse, 2017). The potential impacts experienced by a community, region, or system depending on the magnitude of the exposure and the sensitivity of the units exposed. The level of vulnerability of a group of people or a system depends on the adaptive capacity of the community or the system itself and the potential impacts experienced by the community or system. Thus, efforts to reduce the vulnerability of a community or a system can be through efforts to reduce impacts or through increased adaptive capacity (Santoso et al., 2014).

Indonesia is very vulnerable to the impacts of climate change. As an archipelagic country, Indonesia is vulnerable to increasing threats from sea level rise and extreme weather events (Gregorio et al., 2017). In general, the increase in the average temperature in Indonesia's territory is estimated to be 0.5 -3.92ºC in 2100. Meanwhile, based on observational data, there has been a shift in the wet and dry months. Higher rainfall intensity and shorter rain duration occurred in northern Sumatra and Kalimantan, while lower rainfall and longer rain duration occurred in the southern part of Java and Bali (UU No 16, 2016).

The vulnerability of the community to the impacts of climate change is not only determined based on the location of the settlement, but also the level of settlement services and the extent to which local governments can cope with the impacts of climate change. Vulnerability is very complex requires a comprehensive response that links climate change adaptation and mitigation as an effort for the sustainable development of communities to increase the adaptive capacity of communities (Laukkonen et al., 2009).

“Climate Action Planning” is one of the city's top priorities to reduce greenhouse gas emissions and strengthen climate resilience, as demonstrated by the Paris Agreement (Pietrapertosa et al., 2019). The series of activities carried out to increase the ability to adapt to climate change (including climate diversity and extreme events) so that the potential damage caused by climate change can be reduced and prevented is the definition of climate change adaptation. Meanwhile, a series of activities carried out to reduce the level of greenhouse gas emissions as a form of mitigating the impacts of climate change is the definition of climate change mitigation (KLHK No 72, 2017).

Methodology

The study area in this research is the agricultural sector in Tabalong District. In determining the appropriate adaptation and mitigation strategy to be implemented, several stages must be carried out such as greenhouse gas inventory calculations, greenhouse gas emission distribution mapping, and determination of climate change adaptation and mitigation strategies.

GHG Inventory Calculation and GHG Emission Distribution Mapping

Calculation of greenhouse gases is needed as basic data for determining climate change mitigation strategies. The strategy will be adapted to previous research related to the magnitude of the reduction in greenhouse gas concentrations and the behavior of local farmers. Determination of GHG emissions from the agricultural sector in the Tabalong District is carried out using the method of the Ministry of Environment and Forestry of the Republic of Indonesia. (KLHK No 73, 2017). This includes the calculation of methane emissions from rice fields, carbon dioxide emissions from the use of urea fertilizer, carbon dioxide emissions from a lime application, and nitrous oxide emissions from soil management. The data used for the calculations were obtained from government agencies and literature. GHG emissions are calculated from 2015-2019 data. Then the data is used as baseline data for emission projections up to 2030. The obtained emission data is then presented as a map using the Geographic Information System (GIS) method.

Determination of adaptation and mitigation strategies for the agricultural sector

The method used to determine the priority of climate change adaptation and mitigation strategies is the Analytic Hierarchy Process (AHP) method with expert choice software. AHP was chosen because it is able to describe the strategy, provide an assessment by comparing the elements of the strategy decomposition results, and prioritize determining which strategy should be applied. Expert choice software was chosen to make it easier to process answers from stakeholders. There are several stages in AHP, including:

1. *Determination of criteria and alternatives*

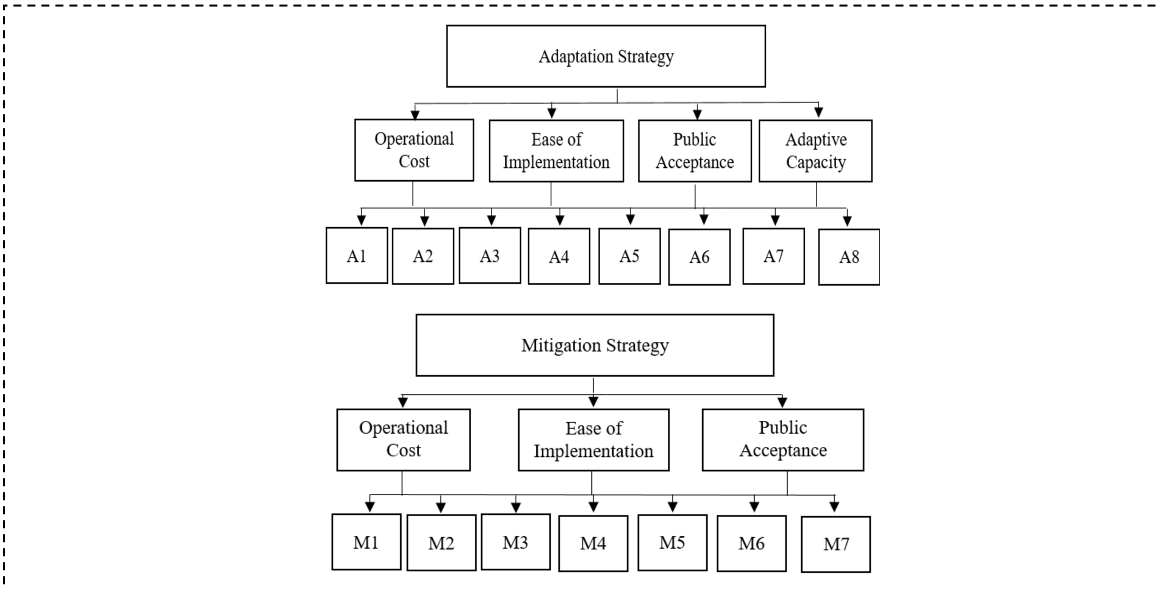
Determination of criteria and alternatives for climate change adaptation and mitigation strategies was obtained by combining literature studies and conducting field interviews with stakeholders from government agencies and farmers. The criteria are chosen based on the main considerations of stakeholders in choosing alternatives. Meanwhile, the alternative is a climate change adaptation and mitigation strategy. The literature study is used as a strategy recommendation to determine the level of greenhouse gas reduction. Field interviews were chosen to find specific strategies that are appropriate to apply, increase farmers' resilience to climate change, and to reduce greenhouse gases from the agricultural sector of Tabalong District.

There are four criteria for assessing adaptation strategies, including: operational costs, ease of implementation, public acceptance, and adaptive capacity. While for the assessment of the mitigation strategy, there are 3 criteria, including: operational costs, ease of implementation, and public acceptance. There are eight alternative climate change adaptation strategies recommended, including the use of superior seeds (A1), determination of planting calendars and cropping patterns (A2), pest and plant disease control (A3), livelihood diversification (A4), farmer insurance (A5) , providing a climate information system (A6), accelerating cultivation with agricultural tools and machines (A7), and providing flood control facilities (A8). There are seven recommended climate change mitigation strategies, including intermittent irrigation (M1), no tillage (M2), intercropping (M3), use of low emission varieties (M4), utilization of agricultural waste (M5), efficient use of fertilizers. and liming of the soil (M6), and agricultural development on non-forest land (M7).

2. *Making construction model*

Modeling is based on the critical components in the problem. Relevant criteria and decision alternatives will be arranged into a hierarchy. The first level of the hierarchy contains the objectives, while the next level represents the criteria and alternatives. From the criteria and alternative strategies for climate change adaptation and mitigation, a hierarchical model is then made, as shown in Figure 1. Furthermore, respondents' answers were analyzed using expert choice software to determine the respondent's consistency value.

Figure 1. Hierarchy Model of Climate Change Adaptation and Mitigation Strategies.



3. *Assessment criteria and alternatives*

Criteria and alternatives were assessed using pairwise comparisons. Comparisons are made based on the policy of the decision maker. The pairwise comparison process starts from the topmost level of the hierarchy shown to select criteria. Based on Saaty (1988), the best scale in expressing opinions is 1-9 as can be seen in Table 1.

Table 1. Paired Comparison Rating Scale

Intensity	Description
1	Both elements are equally important
3	One element is slightly more important than the other Other
5	One element is more important than the other
7	One element is definitely more absolutely important than an element other
9	One element is absolutely important than the other elements
2,4,6,8	The value between the two consideration values that are close

Source:(Saaty, 1988)

4. *Priority setting*

Determining the priority of the criteria elements can be seen as the weight or contribution of these elements to the decision-making objectives. This priority is determined based on the views of experts and interested parties on decision making, either directly (discussion) or indirectly (questionnaire). In this study, the stakeholders involved were 68 people, consisting of 48 head of farmer groups and 20 people from government agencies in Tabalong District.

5. *Consistency calculation*

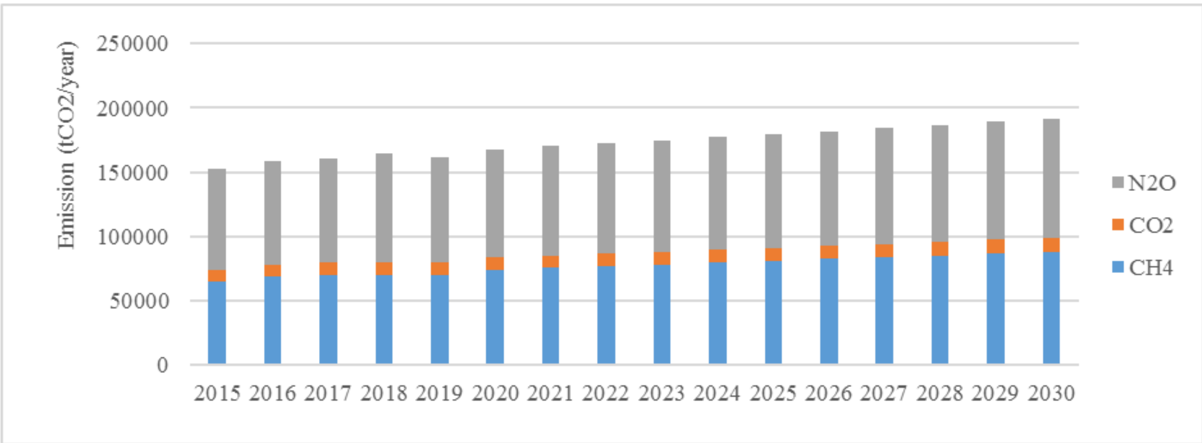
In the process of weighting the criteria values, there is a possibility of consistency from the pairwise comparisons that have been made. The consistency Ratio provides a numerical assessment of how inconsistency of an evaluation.

Result and Discussion

GHG Inventory and Mapping of GHG Emission Distribution

The implementation of an emission inventory is a continuous process because it involves continuous improvement efforts in line with the availability of data and knowledge related to GHG emissions and removals from sources. GHG emissions from 28 agricultural commodities in the Tabalong District which consist of food crops, plantation crops and horticultural crops are calculated. The results of the GHG emission inventory from the agricultural sector in the Tabalong District are presented in Figure 2.

Figure 2. GHG Emissions from Agriculture Sector in the Tabalong District.

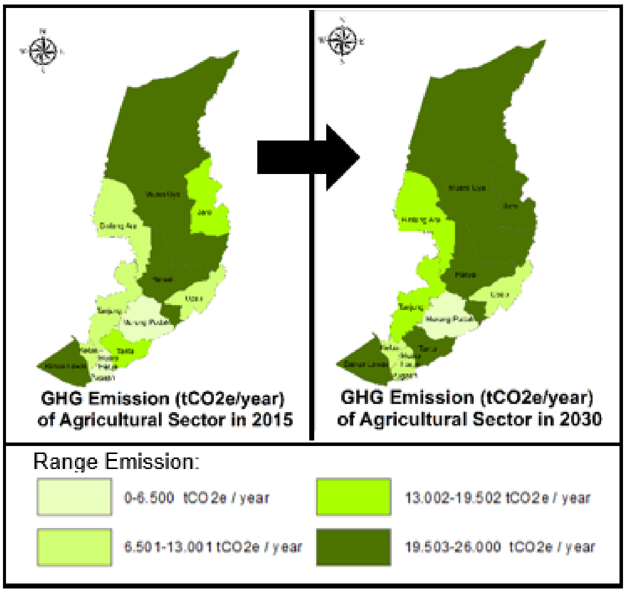


The value in Figure 2 is the conversion result of the IPCC 5th Assessment Report Global Warming Potential (GWP), namely 28 CO_2e for CH_4, 1 CO_2e for CO_2, and 265 CO_2e for N_2O (Myhre et al., 2013). From Figure 2, it can be seen that GHG emissions by 2030 for Tabalong District have increased, from 152,912 tCO_2e/ year to 191,384 tCO_2e/ year. Of the three GHGs calculated, N_2O emissions are the major GHG produced by the agricultural sector in Tabalong District.

N_2O is produced naturally in the soil through nitrification and denitrification processes. Nitrification is the oxidation of ammonium by aerobic microbes to nitrate. Denitrification is the reduction of nitrate by anaerobic microbes to nitrogen gas (N_2). This nitrous oxide is an intermediate gas in the denitrification reaction sequence and result from the nitrification reaction which is released from microbial cells into the soil and finally into the atmosphere. One of the main controlling factors in this reaction is the availability of inorganic N in the soil (KLHK No 73, 2017).

This data then used to map of the distribution of GHG emissions. From the mapping of the distribution of emissions, it can be seen which Sub-districts have the potential to become major GHG generates in the Tabalong District. The distribution of greenhouse gas emissions from the agricultural sector in the Tabalong District was presented in 4 coloring ranges. The map scale used is 1: 500,000. The mapping results are presented in Figure 3. From Figure 3, it can be inferred that in 2015, Banua Lawas, Muara Uya, and Haruai Sub-districts were among the largest emitters of greenhouse gases, namely in the range 19,503-26,000 tCO_2e/ year. In 2030, Tanta and Jaro Sub-districts are included in the range of GHG emitters from the agricultural sector. So, it is predicted that there will be five majors' Sub-districts that will be the priorities for implementing climate change mitigation strategy.

Figure 3. Mapping of The Distribution of GHG Emission Prediction
in The Agricultural Sector in the Tabalong District.



Determination of Climate Change Adaptation and Mitigation Strategies

Climate change adaptation and mitigation strategies are substitutes policies aimed at reducing the impacts of climate change (Tol, 2005). Climate change adaptation and mitigation strategies in Tabalong District were analyzed using the AHP method with expert choice software. The tool used in this method is a questionnaire which is then answered by stakeholders who understand well about agriculture. Respondents' answers were then processed using expert choice software. There were 68 stakeholders involved in decision making consisting of the Environment Agency, Agriculture Office, Public Works and Spatial Planning Office, Agricultural Extension Agencies, and Farmer Groups in the Tabalong District.

Determination of Climate Change Adaptation Strategy

Climate change adaptation is an effort made to increase the ability to adapt to climate change, including climate diversity and extreme events, so that the potential for damage due to climate change is reduced, opportunities posed by climate change can be utilized, and the consequences arising from climate change can be overcome (KLHK No 72, 2017). In determining the climate change adaptation strategy for the agricultural sector in Tabalong District using AHP, the first step is to determine criteria and alternatives. criteria and alternative strategies for climate change adaptation are determined based on the results of interviews with agricultural stakeholders and some literature. Direct interviews with stakeholders were conducted in order to find criteria that were considered in formulating a strategy and to find specific alternative strategies carried out by farmers in Tabalong District. There are 4 adaptation criteria recommended by stakeholders, namely operational costs, ease of implementation, community acceptance, and adaptive capacity.

Operational costs are determined as a criterion because they are directly related to the level of farmers' income. If the operational costs are greater than the revenue costs, then the farm suffers a loss. Ease of strategy implementation includes easiness in strategy counseling, implementation of product provision and implementation of strategies in the field. Public acceptance for a strategy plays an important role in strategy implementation. Generally, farmers in Tabalong District practice agriculture based on farming experience. Farmers who have been practicing farming for a long time will be more selective in determining strategies. This is done to prevent losses in farming. Adaptive capacity plays an important role in the successful implementation of the strategy. The adaptive capacity of agencies and farmers includes the capacity to provide strategic needs, funding, extension activities, and implementation of strategies in the field.

The criteria and alternatives are then arranged into a hierarchy, as shown in Figure 1. After that, the criteria and alternatives are assessed by stakeholders using pairwise comparisons. The answers from the respondents are then input into the expert choice software. In the AHP method, the pairwise comparison analysis process starts from the topmost hierarchy, namely the selection of adaptation strategy criteria. The results of data processing using expert choice software show that the percentage of respondents' choices for the adaptation strategy criteria are public acceptance of 31.9%, ease of implementation 24.4%, operating costs 22.5%, and adaptive capacity 21.1%. These results indicate that all stakeholders agree that the main priority in choosing a strategy is based on public acceptance. The last criterion is shown from the adaptive capacity. Stakeholders agree that public acceptance is a top priority in strategy selection. It is intended that farmers in the area are willing to implement adaptation strategies and disseminate technical information about these strategies to other farmers.

Pairwise comparison analysis was then carried out on alternative climate change adaptation strategies. There are eight adaptation strategies that are recommended as alternative climate change adaptation strategies, including: the use of superior seeds (A1), determination of planting calendars and cropping patterns (A2), pest and plant disease control (A3), livelihood diversification (A4), farmer insurance (A5), providing a climate information system (A6), accelerating cultivation with agricultural tools and machines (A7), and providing flood control facilities (A8).

All Strategies are chosen based on four predetermined criteria, such as operational costs, ease of implementation, public acceptance, and adaptive capacity. The results of the analysis are presented in Table 2. The consistency of stakeholder choices calculated using the Analytic Hierarchy Process (AHP) method with expert choice software. The results show that the inconsistency ratio of the stakeholders involved is 0.00. This means that these stakeholders are consistent in responding to the criteria and elements of alternative climate change adaptation strategies.

Table 2. The Result of Adaptation Strategy Priorities

Alternative	Weight	Rank
Using superior seeds	0.167	1
Controlling pests and plant diseases	0.154	2
Acceleration of cultivation with agricultural machinery and tools	0.134	3
Determining the cropping calendar and cropping patterns	0.129	4
Livelihood diversification	0.114	5
Provision of flood control facilities	0.108	6
Provision of climate information systems	0.107	7
Farmer insurance	0.087	8

Table 2 shows the ranking of each climate change adaptation strategy. Of the eight adaptation strategies, there are three main strategies that are recommended to be implemented in Tabalong District, namely: the use of superior seeds, controlling plant pests and diseases, and accelerating cultivation with agricultural tools and machines. These strategies were chosen because they are specific strategies that have been applied by most farmers in Tabalong District. In addition, the determination is based on an agreement with agricultural stakeholders and has relevance in its implementation. For example, the use of superior seeds is not yet fully resistant to pests and plant diseases. Therefore, the implementation of pest and plant disease control is still needed. Superior seeds are recommended as one of the adaptation strategies, because rice farmers in Tabalong District have used them. Superior seeds are tolerant of soaking up to 7-15 days, with a high yield potential of 4.5-5.0 tons/ha. (Balitbang, 2015). Based on the results of interviews with farmers, the most common types of superior seeds used by rice farmers in Tabalong Regency is the Ciherang variety and Mekongga.

Pests and plant diseases that attack agricultural commodities in Tabalong Regency include: rats, stem borer, blast, Tapping Panel Dryness (TPD) and white root fungus. Steps to control plant pests and diseases that have been carried out are using pesticides and herbicides. In addition to using chemicals to control pests, farmers in Jaro District, Tabalong Regency use natural pest control technology, namely *Mina Padi*. *Mina padi* is a form of intercropping in rice cultivation which is integrated with fish cultivation (Lantarsih, 2012). The *Mina Padi* system provides two advantages for farmers, namely reducing pesticide costs and increasing income from harvesting fish (Rahman & Taufik, 2018).

Another strategic priority is the acceleration of cultivation with agricultural tools and machines. This strategy is also related to the use of superior seeds such as land preparation, maintenance, and post-harvest. In the land preparation stage, various agricultural tools and machines are using from traditional equipment such as “tajak” to modern equipment such as tractors. At the maintenance stage of agricultural equipment and machinery, water pumps are commonly used. Meanwhile, at the post-harvest stage, the agricultural tools and machines used can be in the form of mini-mills, rice thresher machines, and rice mills. Farmers used to use mini combination harvester to speed up the rice harvesting process. After harvesting, a thresher is commonly used to help shed grain from the stem. After threshing, the next step is to mill the grain using a rice milling machine. Before grinding, farmers used to dry the unhulled rice first. This step is taken so that processed rice is not easily damaged.

Determination of Climate Change Mitigation Strategy

Climate change mitigation is a series of activities carried out in an effort to reduce greenhouse gas emissions as a form of efforts to mitigate the impacts of climate change (KLHK No 72, 2017). In determining climate change mitigation strategies for the agricultural sector in Tabalong District using AHP, the first step is to determine criteria and alternatives. Criteria and alternative climate change mitigation strategies are determined based on the results of greenhouse gas calculations, interviews with agricultural stakeholders, and supporting literature. Direct interviews with stakeholders were conducted to find criteria to be considered in formulating strategies and to find specific alternative strategies carried out by farmers in Tabalong District to reduce greenhouse gases produced by the agricultural sector. There are 3 mitigaton criteria recommended by stakeholders, namely operational costs, ease of implementation, and public acceptance.

Operational costs are set as a criterion because they are directly related to farmers' income levels. If the operational costs are greater than the cost of income, the farming business suffers a loss. Ease of strategy implementation includes easiness in strategy counseling, product provision implementation and strategy implementation in the field. Public acceptance of a strategy plays an important role in strategy implementation. Generally, farmers in Tabalong District farm based on experience. Farmers who have been farming for a long time will be more selective in determining strategies. This is done to prevent losses in farming.

The criteria and alternatives are then arranged into a hierarchy, as shown in figure 1. After that, the criteria and alternatives are assessed by stakeholders using pairwise comparisons. The answers from the respondents are then input into the expert choice software. In the AHP method, the pairwise comparison analysis process starts from the topmost hierarchy, namely the selection of mitigation strategy criteria. The results of data processing using expert choice software show that the percentage of respondents' choices for the mitigation strategy criteria are public acceptance of 43.6%, ease of implementation 30.5%, and operating costs 26.0%. These results indicate that all stakeholders agree that the main priority in choosing a strategy is based on public acceptance and the last criterion is operational costs. Stakeholders agree that public acceptance is a top priority in strategy selection. This result is not much different from the ranking for climate change mitigation strategies, because the majority of respondents think that with the acceptance of a strategy by the public, the implementation of the mitigation strategy can be sustainable and disseminated to other farmers.

Pairwise comparison analysis was then carried out on alternative climate change mitigation strategies. There are seven mitigation strategies recommended as an alternative to climate change mitigation strategies.

Strategies are chosen based on three predetermined criteria such as operational costs, ease of implementation, and public acceptance. The analysis results showed in Table 3. The consistency of stakeholder choices calculated using the Analytic Hierarchy Process (AHP) method with expert choice software. The results show that the inconsistency ratio of the stakeholders involved is 0.00. This means that these stakeholders are consistent in responding to the criteria and elements of alternative climate change mitigation strategies.

Table 3. The Result of Mitigation Strategy Priorities

Alternative	Weight	Rank
Efficient use of fertilizers and liming soil	0.198	1
Utilization of agricultural waste	0.179	2
Intercropping pattern	0.136	3
Using low emission varieties	0.130	4
No-tillage	0.129	5
Agricultural development on non-forest land	0.124	6
Intermittent irrigation	0.103	7

Table 3 shows the rankings for each climate change mitigation strategy. Of the seven strategies, four main strategies for mitigating climate change were selected as recommendations for appropriate strategies to be implemented in Tabalong District, such as efficient use of fertilizers and liming of soil, utilization of agricultural waste, intercropping patterns, and the use of low-emission varieties. The determination of the 4 main strategies was the result of discussions with stakeholders who stated that the strategies had been implemented by most of the farmers in Tabalong District. Also, the chosen strategy is based on consideration of the public acceptance criteria. Public acceptance criteria are priority criteria for climate change mitigation strategies.

The first priority strategy is the efficient use of fertilizers and liming of soil. The use of organic and inorganic fertilizers increases the levels of N_2O released by the soil (Subagyono and Surmaini, 2007). Efficient use of fertilizers is needed to reduce N_2O emissions from fertilizer use. The efficiency of using fertilizers can be increased through education regarding the correct fertilizer dosage. The efficiency of fertilizer use can be increased through education and monitoring by agricultural extension workers regarding the correct dose of fertilizer. The correct dose of fertilizer for each sub-district in Tabalong District can be seen in the dose book issued by the Agricultural Research and Development Agency issued by the Ministry of Agriculture. The Agricultural Research and Development Agency has proposed a new formulation as a substitute for NPK 15-15-15, namely NPK 15-10-12. With the reduction of P and K nutrient formulas, it is hoped that the fertilization dose will be more effective, efficient, economical and environmentally friendly. In addition to the efficient use of fertilizers, applying lime to the soil can reduce carbon dioxide emissions from the soil. Provision of ameliorants such as dolomite can reduce CO_2 emissions by 8.9% (Sopiawati et al., 2014).

The second priority strategy is the utilization of agricultural waste. The utilization of agricultural waste is a carbon mitigation technology by slowing down the conversion of carbon into atmospheric CO_2 gas (Munandar et al., 2014). The utilization of agricultural waste can reduce CO_2 emissions by 0.33 tCO_2/ha/year and N_2O emissions by 0.02 tCO_2/ha/year (Smith et al., 2008). In the Tabalong District, agricultural waste such as straw has been used for animal feed. In addition, harvested waste can be used as organic fertilizer. Straw contains the element silica. Silica is absorbed by rice plants in amounts exceeding the absorption of K and N elements (Si>K>N) and plays an important role in improving plant health and resistance to disease attacks, especially blast and brown planthopper pests (Karyaningsih, 2012).

The third priority strategy is intercropping patterns. The intercropping pattern is planting more than one crop at the same time or in one crop period in the same place. The intercropping pattern was carried out to increase the total production and reduce the risk of crop failure (Balitbang, 2018) and can be used to increase the usefulness of organic fertilizers and useful microbes (Balitbang, 2011). The application of intercropping patterns in agriculture can reduce N_2O emissions by 1.2 kg N_2O/ha/year (Evers et al., 2010). This method has been applied by several farmers in Tabalong District. Usually farmers plant various horticultural crops such as tomatoes and chilies among rubber plantations.The goal is to get more than one harvest of several types of crops on the same plot of land in one year. Farmers apply multiple cropping systems at once to reduce the risk of crop failure and obtain total yields of high economic value.

The fourth priority strategy is Using low emission varieties. Using low emission varieties can reduce CH_4 emissions by 10-66%. The characteristics of low emission varieties are early maturity, effective use of photosynthesis, a small number of tillers, and have a strong root oxidation capacity (Najamuddin, 2014). The best rice variety in reducing GHG emissions in swamps is Punggur. While the one with the highest GHG contribution is Martapura. The Batanghari variety contributes the lowest GHG emissions compared to Punggur, Air Tenggulang, and Banyuasin on lowland swamps (Balitbang, 2015). Based on the calculation of GHG predictions, if the strategies are implemented simultaneously until 2030, it can reduce GHG emissions by up to 19%.

Conclusion

Tabalong District is one of the areas in South Kalimantan that is affected by climate change. One of the impacts was the flood which caused 2,971.51 ha of rice fields to be submerged and damaged. In addition, agriculture also produces several greenhouse gas emissions such as carbon dioxide, nitrous oxide, and methane. The calculation of greenhouse gases as the basis for determining climate change mitigation strategies has been achieved. GHG emissions generated by the agricultural sector in the Tabalong District until 2030 are 191,384 tCO2e/year, with details of CH4 emissions of 87,990 tCO2e/year, CO2 emissions of 10,829 tCO2e/year, and N2O emissions of 92,565 tCO2e/year. CH4 emissions have resulted from rice fields, carbon dioxide emissions from urea fertilizer and lime application to the soil, and nitrous oxide emissions from soil management. From the mapping of the distribution of GHG, it is known that in 2030, 5 Sub-districts are included in the range of the highest GHG emission contributors to the agricultural sector in the Tabalong District, namely the Sub-districts of Banua Lawas, Tanta, Haruai, Jaro, and Muara Uya. This sub-district will be a top priority in implementing climate change adaptation and mitigation strategies.

To reduce greenhouse gases and increase farmers' resilience to climate change, the selection of climate change adaptation and mitigation strategies has been carried out based on the opinion of agricultural stakeholders. The results of the analysis using the AHP method with expert choice software show that there are three climate change adaptation strategies that are the priority of stakeholders, such as the use of superior seeds, controlling pests and plant diseases, and accelerating cultivation with agricultural tools and machines. Meanwhile, for climate change mitigation strategies, there are four main priorities such as the efficiency of fertilizer use and liming, utilization of agricultural waste, intercropping patterns, and using low emission varieties. Based on the calculation of GHG predictions, if the strategy is implemented simultaneously until 2030, it can reduce GHG emissions by up to 19%.

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