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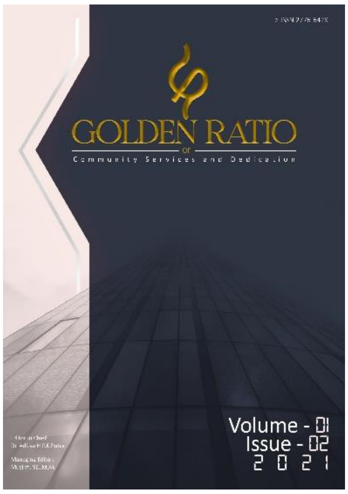

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*Corresponding author: Apiaty Kamaluddin, Universitas Pepabri, Makassar, Indonesia

E-mail: syamaty31@gmail.com

COMMUNITY SERVICE | REPORT

Level of Vulnerability and Adaptation to Climate Change Based on Rice Ecosystems

Apiaty Kamaluddin[1*], St. Hatidja[2], Hidayat Marmin[3], Lina Mariana[4]

[1,3] Faculty of Agriculture, Universitas Pepabri Makassar, Indonesia. Email: syamaty31@gmail.com[1], dayatmarmin@gmail.com[3]
[2] Department of Management, STIE AMKOP, Makassar, Indonesia. Email: hatidja@stieamkop.ac.id
[4] Politeknik LP3I Makassar, Indonesia.

Abstract: This study aims to assess farmers' vulnerability, resilience, and adaptation to climate change based on rice ecosystems. The information on vulnerability and adaptation to climate change in rice ecosystems obtained is expected to be helpful and become input for local governments and other stakeholders in making policies to support agricultural activities in regions in Indonesia, especially in the rice ecosystem. This research was conducted for six months, from February to September 2021. The assessment of farmers' vulnerability to climate change in the rice ecosystem uses three elements of exposure: outcrop, sensitivity, and adaptability. The research sample was taken from the rice production center in Takalar Regency, namely North Polombangkeng District. The study results show that the rainy zone is divided into two climates. Only a tiny part of the rice ecosystem community stated that they did not know about climate change. The impacts of climate change that respondents feel include decreased production (food crops and plantations), crop failure (puso) due to drought, and the reduced show that is the most touched by the rice ecosystem community. The cumulative index of sensitivity in the North Polmbangkeng sub-district is different. The categories are rather low class, relatively low class, and medium-class due to each sensitivity indicator's various weights and scores. Based on the value of the cumulative index of vulnerability and adaptive capacity, the three study districts range from vulnerable to very vulnerable. Lassang Village has the highest vulnerability index value (fragile) compared to the other two study districts, so it needs immediate attention.

Keywords: Climate Change, Vulnerability, Sensitivity, Adaptive Capacity, Resilience.

1. INTRODUCTION

Human activities have led to an increase in GHG emissions, leading to global warming and leading to climate change. Climate change is happening slowly but surely. In addition, climate change has an impact on all sectors of life. Climate change or seasonal variations either directly or indirectly affect people's lives. Although many people do not understand climate change or seasonal variations, those whose livelihoods are from agriculture and depend on natural resources feel the impact (Kaimuddin, 2000). As happened in the Tanadidi Farmers Group, Tamalate District, Jeneponto Regency, South Sulawesi Province, the community thinks that the dry season has become longer and the availability of water has decreased, causing agricultural yields to decline and not enough to meet household needs for one year. Historical data shows that the national production system is highly vulnerable to extreme climatic events; for example, in extreme climatic conditions (El-Nino and La-Nina years, the area and intensity of agricultural land affected by the disaster increased sharply (Kaimuddin et al., 2005). Observations in the 1994 and 1997 El-Nino years showed that the cumulative area of rice fields experiencing - relief from May to August exceeds 400 thousand ha while in standard years and La-Nina is less than 75 thousand ha. Furthermore, in 1995 La-Nina, the cumulative flood area from October to December reached 250 thousand ha, while in 1995, Normal and El-Nino years are generally less than 100 thousand ha (Boer and Alimoeso, 2002). Loss of rice production due to drought and flooding, especially in years of extreme climates, can reach 2 million tons (Boer and Las, 2003). This study aims to assess the vulnerability and adaptation of farmers to climate change based on rice ecosystems. In addition, the results of this study are also expected to be used by the general

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public as a learning process. Advice and understanding of regional characteristics related to rainfall patterns and signs of extreme climatic phenomena so that agricultural activities can be adapted to these conditions.

2. Theoretical Framework

The study took a case study of farmers in rice production centers in South Sulawesi, namely Sidrap, Pinrang, and Wajo Regencies, South Sulawesi Province. The location is determined by the purposive sampling method. First, the area is selected by strata or regional typology (district, sub-district, and village). Then, for each stratum, a minimum of two sites were selected, which were considered representative of the ecological conditions in each stratum. In comparison, the time of the study was carried out for six months (May - October 2018). Assessment of community/lowland rice farmers' vulnerability to climate change uses the function of three components, namely outcrop, sensitivity, and adaptability (IPCC 2001; O'Brien et al. 2004; Metzeger et al. 2006 in Forner 2006). To calculate the index of the element of vulnerability (outcrop, sensitivity, and abilities of adaptation) is performed by the formula, K = Wi / Xi, where K = index, Wi = The weight indicator to-I, and Xi = score indicator to-I. Meanwhile, the determination of the vulnerability index is done by reducing the results of the number of outcrop and sensitivity indices with the adaptability index. It can be written or formulated as follows:

$$k = (\sum_{ie=1}^{n}(w_{ie} x\, x_{ie}) + \sum_{is=1}^{n}(w_{is} x\, x_{is})) - (\sum_{iac=1}^{n}(w_{iac} x\, x_{iac}))$$

Information:
K = vulnerability index,
Wie = the weight of the i-th indicator on the outcrop, Xie = the score of the i-th indicator on the outcrop,
Wis = the weight of the i-th indicator on the sensitivity, Xis = the score of the i-th indicator on the sensitivity,
Wiac = Weight of the i-th indicator on adaptability, and
Xiac = score of the i-th indicator on adaptability.

3. Activity Implementation Method

3.1 Perception of Climate Change

70% of respondents in Takalar Regency feel that there is a climate change in their area. Based on the perception of respondents climate change, it shows that almost all groups of respondents have known about climate change; only a tiny part stated that they do not know. There are two groups of perceptions, and the first one explains that climate change is very pronounced, especially in ten years Final. They compare the phenomenon of changes in air temperature that is getting hotter, rainfall is very high at certain times, but at other times, it is sporadic. The second group assumes that climate change is expected as an extraordinary event is natural, claiming climate change is natural. Respondents' indicators of climate change indicate that the phenomenon of climate change that is felt or known by the respondent is almost the same as the respondent's understanding of climate change. The wonders of climate change include: Changes in air temperature or the weather is getting hotter; Uncertain rainfall; Changes/shifts in seasonal patterns; The frequency and intensity of natural disasters are getting more significant; It is increasingly difficult to obtain clean water; Solid winds/storms and increasing waves; Increased intensity of pest attacks. The impacts of climate change felt by respondents include: Decrease in production (food crops and plantations); failure Crop (puso) due to floods and drought damage Material to property affected by floods/landslides and the intensity of ARI and diarrhea increased. The decline in production is the most felt impact by respondents. This causes the income of respondents to decline so that it will have implications for their purchasing power and welfare. There is a tendency to decrease production in lowland rice cultivation due to shifts in the planting season (forward/backward). Adaptation efforts that have been made include: Changes in varieties/seeds resistant to weather and pests; Changes/adjustments to cropping time/schedule; Planting trees (reforestation) in critical land areas; Build and repair irrigation canals; Use and development of organic fertilizer. The local government initiated efforts to adapt to climate change, starting from the district to the village level, has only taken incidental anticipation programs. There is a potential for the higher vulnerability that has not been matched by capacity

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building (communities do not have any preparation. To face the changes that occur, they are resigned).

3.2 Vulnerability Indicator

The Outcrop (exposure) indicator used for the outcrop parameter, namely the area of rice fields. The wider the rice field in an area will affect production and productivity, which will give a lower vulnerability value than areas with narrower rice fields. The determination of the paddy field index is based on the percentage of paddy field area to the area in each district. Then the percentage of each district is fractionated with the district with the highest percentage of paddy field area to obtain the indicator fraction of paddy field area of one district against another so that the fraction value is between zero and one (0 - 1). A value of one (1) means that the area has the highest percentage of paddy field area compared to other regions. In contrast, the fraction value is close to zero, meaning the lowest percentage of the paddy field area. Because only one indicator is used to obtain the indicator value of the paddy field area, then the rice field area fraction is multiplied by the weight of the rice field area indicator, which is 1.0. Table 1 shows the index value of the outcrop of rice fields in Sidrap, Pinrang, and Wajo districts in 2009. It appears that the average value of the index of the outcrop of rice fields in the three districts as rice production centers of South Sulawesi is 0.88. The high index value of the relative rice field area of Wajo Regency is because the proportion of rice field area is the widest compared to the other two districts.

Table 1. Index of Rice Field Outcrop In Sidrap, Pinrang And Wajo Regencies.

No	District	Rice Field Area (ha)	Percentage of rice field area (%)	Rice field index
1	Sidrap	46,984	23,95	0,68
2	Pinrang	85,259	34,02	0,97
3	Wajo	87,975	35,10	1,00
Average Total			31,02	0,88

3.3 Sensitivity

Poverty Sensitivity Index (IKK) The Determination of the poverty sensitivity index is based on the percentage of the number of poor people to the total population in each district. Then the portion of each community is fractionated with the section with the highest rate of poor people to get the poverty indicator fraction of one neighborhood against another so that a fraction value is obtained between zero and one (0 - 1). The value of one (1) means the area has the highest percentage of poor people compared to other regions, while the fraction value is close to zero, meaning that the rate of poor people is the lowest. To obtain the poverty indicator value, the poverty fraction value is multiplied by the poverty indicator weight, which is 0.4. Thus, the area with the highest poverty fraction has an index value equal to 0.4. The higher the percentage of poor people in a district, the higher the value of the poverty fraction, the higher the poverty indicator value of the area, so the more vulnerable the location is. The poorer the population, the more limited their access to economic resources, so this group will be more difficult if there is an extreme climate change. Table 2 shows the poverty vulnerability index value of Sidrap, Pinrang, and Wajo districts in 2009. It can be seen from Table 2 that the average value of the poverty vulnerability index of the three districts as rice production centers of South Sulawesi is 0.36. The high relative IKK value of the Wajo Regency is because it is highest compared to the other two regencies in terms of the proportion of the number of poor people to the total population.

Table 2. Poverty sensitivity index in Sidrap, Pinrang and Wajo Districts

No	District	Total population poor (people)	Percentage of poor people (%)	Poor Vulnerability Index (IRPM)
1	Sidrap	19,1	7,64	0,30
2	Pinrang	33,3	9,65	0,38
3	Wajo	38,3	10,16	0,40
Average Total			9,15	0,36

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3.4 Rainfed Land Sensitivity Index (IKLTH)

The rainfed land index is determined based on the percentage of the area of rainfed rice fields to the site of rice fields in each district. Then the rate of each community is fractionated by the section with the percentage of rainfed rice area to get the indicator fraction of rainfed land of one regency against another. The fraction value is between zero and one (0 - 1). A value of one (1) means that the area has the highest percentage of rainfed compared to other regions, while the value of the fraction is close to zero, meaning that the rate of the rainfed area is the lowest. To obtain the value indicator of rainfed rice fields, the value of the rice field fraction is multiplied by the weight of the indicator weight of rainfed rice fields, which is 0.3. Thus, for areas with a fraction of rainfed rice fields, the index value is equal to 0.3. The higher the percentage of the rainfed rice area in a district, the higher the value of the area fraction of rainfed rice fields, the higher the indicator value for rainfed rice fields in the area, so that the site is more vulnerable. The more comprehensive the rainfed rice fields, the lower the production and productivity due to extreme climate events, the more limited their access to economic resources. This group will be increasingly difficult if there is a powerful climate change.

Table 3. Sensitivity index value of rainfed rice fields in Sidrap, Pinrang and Wajo Regencies.

No	District	Area of rainfed rice fields (ha)	Percentage of rainfed rice field area (%)	Sensitivity index of rainfed rice fields (IRSTH)
1	Sidrap	4.450	9,47	0,04
2	Pinrang	3.250	3,81	0,02
3	Wajo	61.413	69,81	0,30
	Average Total	73.406	27,70	0,12

3.5 Population Density Sensitivity Index (IKKP)

Population density or density is the number of people per unit area, usually in units of people per km2. This population density indicates the availability of space per one resident. The greater the density can cause the environment's carrying capacity to be heavier. The pressure on the environment will be even more significant so that the quality of the domain will worsen. This condition can make the community more vulnerable to changes and environmental quality. The higher population density, of course, requires higher service facilities, such as housing, clean water, health, and education. The population density sensitivity index (IKKP) is based on the population density of the study district. A fraction is performed on the area with the highest density so that the fraction value is 0-1. To get the IKKP deal, the value of each fraction is multiplied by a weighting of 0.3. The IKKP values for each district are presented in Table 4.

Tabel 4. Sensitivity Index Value of Population Density of Sidrap, Pinrang and Wajo

District	Population Density Sensitivity Index
Sidrap	0,0019
Pinrang	0,0025
Wajo	0,0021
Average Mean	0,0022

3.6 Adaptability Capacity

Adaptability is determined by three indicators, namely: (i) Education Capacity Index (IKP), where the IKP is an accumulation of two variables, namely the level of community education and educational facilities, (ii) Economic Capacity Index (IKE). Where the IKE value is based on income (GDP) per capita, income per capita shows the purchasing power of the people in meeting their daily needs. The higher the value, the greater the purchasing power of the people so that the greater the capacity of the community in anticipating the impacts of climate change and (iii) the index Health Capacity (IKKes), where the IKKes is based on two main components, namely the health facility capacity indicator (IKFK) and the medical personnel capacity indicator (IKTM). The IKP, IKE, and IKKes indicator values are presented in Table 5.

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Table 5. IKP, IKE and IKKes Indicator Values in Sidrap, Pinrang and Wajo Districts

District	IKP	IKE	IKKes
Sidrap	0,17	0,077	0,090
Pinrang	0,15	0,087	0,065
Wajo	0,15	0,083	0,084

3.7 Adaptability Strategy

From the survey results of community vulnerability to climate change in the three study districts, it can be seen that climate change is global. Still, the level of exposure of natural systems and communities differs locally. In addition, the survey results show that the study area is vulnerable to climate change. This condition will affect the level of community vulnerability in the three districts. People who are more sensitive and have lower adaptability will be more vulnerable, and vice versa. To deal with climate change, mitigation and adaptation efforts are needed. Mitigation efforts are human efforts to prevent climate change by reducing its sources (IPCC, 2001). These efforts include: saving electrical energy, reducing the use of motorized vehicles, stopping logging and forest burning, and urging the use of renewable energy such as solar, water, and wind that are environmentally friendly.

Adaptation to climate change is the ability of a system to adapt to climate change. The trick is to reduce the damage caused, take advantage, or overcome difference with all its consequences (Sarakusumah, 2012). Adaptation to climate change is one way of adjusting that is carried out spontaneously or planned to react to climate change (Murdiyarso in Surakusumah, 2012). Adaptation to climate change can reduce the impact of climate change and increase the effects of benefits. Adaptation strategies to climate change can provide both short-term and long-term benefits. Barriers that often occur are in the implementation process and the effectiveness of adaptation. The cause of these obstacles is because the adaptability of each region, country, and the socio-economic group is different (Sarakusumah, 2012). Meanwhile, mitigation is an effort to suppress the causes of climate change. Examples are greenhouse gases and others to reduce or prevent climate change risk. Mitigation efforts carried out in Indonesia in the energy sector, for example, can be carried out by implementing energy efficiency and conservation, optimizing the use of renewable energy, efficient use of petroleum energy through reducing subsidies and optimizing energy substitutes for petroleum, and the use of nuclear power (Sarakusumah, 2012). The survey results show that climate change, especially rainfall, greatly influences hydrological conditions. According to Singgih (2000); Pawitan (2002); Fakhruddin (2003); Asdak (2007) states that changes in the quantity or imbalance of hydrological conditions in An area affects the level of vulnerability of the community in that area. Therefore, it is necessary to adapt efforts to the impacts of climate change in the future. The hydrological balance is not only influenced by climate change but also by topography and land use. Of the three elements, land use is one element that humans can control. The land use in the three districts changes every year. Changes in land use almost certainly follow a pattern from forest use types to agriculture, plantations, and settlements in line with the development of urban areas (Pawitan 2002).

The rice ecosystem-based adaptation strategy provides multiple benefits for humans and nature, including protecting against extreme natural disasters (floods and droughts), reducing casualties, and reducing economic losses due to climate change. The rice ecosystem-based adaptation strategy increases the community's ability to cope with the impacts of climate change and contributes to the long-term viability of sustainable development efforts. In addition, adaptation strategies based on rice ecosystems are an important and cost-effective problem solver to design a future with inevitable climate change. Rice ecosystem-based adaptation strategies can be carried out through management activities and timing and cropping patterns. The agricultural sector releases greenhouse gas emissions into the atmosphere in significant amounts, namely CO2, CH4, and N2O (Paustian et al. in Surmaini, 2004). At the world level, the agricultural sector accounted for around 14% of emissions in 2000, the highest levels of which came from fertilizers, livestock, paddy fields, livestock waste, and the burning of agricultural residues (WRI in Surmaini, 2004). Indonesia's agricultural sector in 2005, according to the US-EPA in Surmaini (2004), reached 141 million tons of carbon equivalent (Mt CO2e). Indonesia, compared to other countries such as the United States, Brazil, China, and Indonesia in the same year, emissions from the Indonesian agricultural sector are still low or negligible. From these data, it can be concluded that there is a need for adaptation and mitigation efforts in the farming industry to overcome climate change.

So far, Indonesian agriculture, especially lowland rice, is only seasonal agriculture with no crop rotation every year. Soil needs time to recover before replanting can be carried out. People in Indonesia still have adherent principles. The purpose of the follower principle is that when a person

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or other group carries out an investment that turns out to be profitable, the community immediately follows it. This principle has a weakness: people who follow other parties in the planting process tend not to understand the planting rules. As a result, the soil and plants are not good because of the excessive use of chemical fertilizers and no cropping cycle. Another consequence is soil erosion. Adaptation efforts in the agricultural sector are to look at daily weather conditions. What plants can be planted according to the weather experienced? When the planting process has been adapted to weather and land conditions, it is likely that the crop yields obtained are of high quality and do not produce excessive emissions that cause climate change. This adaptation process has the disadvantage of being carried out depending on the weather experienced every day. This uncertainty makes the adaptation process not run well. The process to overcome climate change which is the best alternative is the mitigation process. The mitigation process in the agricultural sector is seen as the most effective because mitigation itself is a process to prevent climate change. So far, agriculture uses chemical fertilizers, which cause water pollution and soil erosion. The mitigation process in the agricultural sector consists of various ways. There are two examples of agriculture that need to be applied to mitigate climate change, namely:

(1) Organic Agriculture. Organic agriculture does not use agricultural chemicals (without pesticides and synthetic fertilizers), fertilizers that are operated using animal manure. Organic farming also uses natural methods such as crop rotation and products obtained from nature, such as organic pesticides, to control crops.
(2) Integrated Agriculture. Optimizing environmental quality and economic benefits in agriculture using conventional and organic farming methods. An example is that the soil is given compost and animal manure and added with synthetic fertilizers. In addition, it combines biological, cultural, and mechanical pest control practices with the use of synthetic and natural pesticides.

Organic farming has excellent benefits for the community, but it is still experiencing obstacles in practice. The block lies in the preparation of procuring complex organic agricultural products and the increasing number of organic claims on the market, which are often referred to as trade fraud practices in the name of organic products. Both consumers and organic farmers suffer losses. (Zulfiyah, 2013). The adaptation and mitigation process in the agricultural sector aims to address climate change as one of sustainable development. The method of adaptation and mitigation following the principles of sustainable development is sustainable development using an integrative approach. This process is considered appropriate because it prioritizes the relationship between humans and nature. Humans influence nature in ways that are beneficial or destructive. The adaptation and mitigation process is deemed relevant to make the best use of nature without destroying nature. The community is the central aspect to launch the adaptation and mitigation process in agriculture to overcome climate change. The programs provided are suitable for the community and nature. However, often people still do not understand how the program is carried out. Therefore, there needs to be training and skills for the community so that its implementation can run smoothly. It is beneficial for society economically, and climate change can be reduced or overcome.

4. Findings

The perception of the rice ecosystem community that they have known about climate change, only a tiny part stated that they did not know. The impacts of climate change felt by respondents include: decreased production (food crops and plantations), crop failure (puso) due to floods and droughts, material damage to property affected by floods/landslides, and increased intensity of ARI and diarrheal diseases, and decreased production is a significant impact. Most felt by the people of the rice ecosystem. The community's sensitivity to climate change in Sidrap, Pinrang, and Wajo districts is different. The cumulative sensitivity index of Sidrap, Pinrang and Wajo Districts was 0.342 (slightly low class), 0.403 (slightly low class), and 0.702 (medium class). The difference in the sensitivity index of the community is due to the different weights and scores of each sensitivity indicator. The sensitivity indicators are the poverty sensitivity index, rain-free land sensitivity index, and population density sensitivity index. The adaptation capacity of the community to climate change in Sidrap, Pinrang, and Wajo districts is different. The cumulative index of adaptive capacity of Sidrap, Pinrang, and Wajo districts is 0.337, 0.317, and 0.302, respectively, but the criteria for the three sections are the same, which is relatively low. The difference in the community's adaptive capacity index is due to each indicator's different weights and scores of adaptation capacity. The hands of adaptive capacity are education capacity index, economic capacity index, and health capacity index. Indicators outcrop (expo-sure), sensitivity(sensitivity), and adaptive capacity(adaptation capacity)still need to be developed further so that the value of vulnerability is more accurate and adaptation options more comprehensive. An adaptation strategy that is also important to implement is the sustainable management of forest ecosystems. Procedures can be precise, efficient, and effective if the root problems that have occurred so far can be resolved or minimized as small as possible. To reduce this, it can be done in various ways, including:

(1) Rearranging the policies or regulations that have been issued so far.
(2) Aligning the perception of ecosystem management in a multi-stakeholder and multi-sectoral manner.
(3) Giving forest sovereignty to the community.
(4) Involving local wisdom.

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