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# Analysis of the Livelihood Vulnerability Index for Rice Farmers Households Due to Climate Change in Aceh Besar District

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***Abstract***

Agriculture is highly dependent on climatic conditions for success in achieving maximum production not only influenced by superior seeds and technological mechanisms. One of the impacts that can be caused by climate change is to reduce agricultural productivity. One area or location that is affected by climate variability and the level of vulnerability and resilience can be identified is Aceh Besar district. The data obtained in this study can be analyzed quantitatively. The analytical methods used in this research are descriptive - quantitative analysis, Estimated Livelihood Index (LVI), risk analysis, and adaptation and mitigation strategies. The results showed that the vulnerability index through the calculation of LVI-IPCC in the category of vulnerability, Montasik area is more susceptible to drought; from the sensitivity category, Blang Bintang area is more sensitive to vulnerability; and from the adaptive capacity category, the Montasic region is more adaptable to climate change. The risks of climate change that are felt by farmers are in the form of decreased production, experiencing crop failure, more frequent droughts, dry agricultural land, difficult cultivated land, decreased volume of water sources, and pest outbreaks. The highest risk experienced by farmers in the Blang Bintang and Montasik areas is drought, with a percentage value of 80% in the Montasik area and 88% in the Blang Bintang area. The adaptation strategy taken by farmers to climate change is to form organic businesses, water-efficient farming, intercropping, rotating crops, planting dry-resistant varieties, and maintaining irrigation channels. The strategy mostly done by farmers in the Blang Bintang area is to do crop rotation and plant dry-resistant varieties, while in the Montasik area the farmers do more crop rotation.

***Keywords:*** *Adaptation Strategy; Exposure; Farming; Vulnerability; Weather*

## *1. Introduction*

Climate change is a change in climatic conditions indicated by changes in the average or variability of climate parameters that take place over a long period of time. Climate change from the agricultural sector is damage (degradation), agricultural infrastructure, decreased production and productivity of food crops, which can lead to threats of food vulnerability and insecurity and even poverty. This makes farmers uneasy about climate change, such as the high frequency of rain that doesn't even stop, for example in rice farming. The occurrence of drought can reduce crop production. Farmers really need climate information, but weather forecast information is inaccurate so farmers don't get this information (Lasco et al., 2011).

Table 1.Climate Weather Data in Aceh Besar District, 2016 - 2019

| No | Month | Minimum | | | | Maximum | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **2016** | **2017** | **2018** | **2019** | **2016** | **2017** | **2018** | **2019** |
| 1 | January | 23.8 | 20.1 | 21.8 | 20.4 | 32.5 | 33.4 | 33.2 | 34 |
| 2 | February | 23.6 | 21.4 | 21 | 19.2 | 32.5 | 32.4 | 21 | 34 |
| 3 | March | 23.7 | 21.2 | 22.6 | 21.6 | 33.3 | 33.4 | 33.4 | 34.8 |
| 4 | April | 24.5 | 22.6 | 22.6 | 21 | 33.7 | 34.6 | 33.8 | 35.4 |
| 5 | May | 24.4 | 23 | 23.6 | 22.2 | 33.5 | 34.5 | 34 | 36.2 |
| 6 | June | 23.6 | 23.1 | 22.2 | 22.6 | 33.8 | 35.8 | 36 | 36.4 |
| 7 | July | 23.1 | 22.4 | 22.6 | 20 | 33.5 | 37.2 | 36 | 37.2 |
| 8 | August | 23.3 | 22.4 | 22.2 | 21 | 33.5 | 36.6 | 36.2 | 35.8 |
| 9 | September | 23.5 | 22 | 21.2 | 22 | 32.6 | 34.2 | 35 | 36 |
| 10 | October | 23.5 | 19.8 | 22.5 | 21.6 | 32.3 | 36 | 33 | 33 |
| 11 | November | 23.6 | 23 | 22.8 | 22.5 | 31.4 | 33.6 | 32 | 34.1 |
| 12 | December | 23.4 | 22.4 | 22.6 | 21.7 | 30.9 | 32.4 | 32.5 | 33.4 |
| | **Average** | **23.67** | **21.95** | **22.31** | **21.32** | **32.79** | **34.51** | **33.01** | **35.03** |

Source: BPS Aceh Besar 2012 – 2018

Based on climate weather data in Aceh Besar District, 2016 - 2019. Each year the temperature increases with an average temperature increase of 1.5%. The highest temperature occurred in 2019 at 37.2 $^{0}$C. As a result of climate change, farmers suffered losses due to drought in the Aceh Besar district. This the rainfall data in Aceh Besar district are as follows.

Based on rainfall data in Aceh Besar Regency on average from 2016 - 2018 with a rainfall intensity of 221 m3. The decrease in rain intensity is one of the impacts of climate change. Climate change is believed to have a negative impact on various aspects of life and the development sector, especially the agricultural sector, and it is feared that it will create new problems for the sustainability of agricultural production, especially food crops. In the future, agricultural development will face several serious problems, namely: 1) decreased productivity and sloping production which of course requires technological innovation to overcome it, 2) degradation of land and water resources which results in soil sickness, decreased fertility, and pollution. 3) variability and climate change that results in flooding and drought, and 4) conversion and fragmentation of agricultural land (Surmaini, et al 2015).

Agriculture is highly dependent on climatic conditions for success in achieving maximum production not only influenced by superior seeds and technological mechanisms (Supriyanto 2012). One of the impacts that can be caused by climate change is to reduce agricultural productivity. Another thing that reduced rainfall intensity is the biggest reason for the decline in farmer yields in the dry land agricultural sector. The decrease in crop yields caused a decrease in the income of the farmers. The decline in farmer income is a short-term impact, while the long-term impact is the end of the dry land farmer profession (off-farm employment). Therefore, farmers need action of resilience or resilience in which farmers can survive and return to their original conditions.

One area or location that is affected by climate variability and the level of vulnerability and resilience that can be identified is Aceh Besar district. Aceh Besar is the largest rice producer in Aceh province. With the occurrence of climate change in Aceh Besar district, one of which was a decrease in rice production that occurred in Montasik and Blang Bintang Districts. Other sub-districts that experience closeness is Seulimum District with an area of 683 hectares, Kuta Cot Glie District with an area of 624 hectares, Indrapuri 25 hectares, Pulo Aceh covering an area of 224 hectares, Krueng Barona Jaya 16 hectares, Kuta Baro 10 hectares, Jantho 8 hectares and Lhoknga 3 hectares. Therefore, this study aims to analyze the level of vulnerability (livelihood vulnerability index) of farmer households in Montasik and Blang Bintang districts, Aceh Besar district. To measure the level of vulnerability, it can be tested using the Livelihood Index (LVI) test.

## *2. Methodology*

### 2.1 Descriptive Analysis – Quantitative

This analysis is a method used to describe the data that has been collected. The data collected were analyzed using this method so that an overview of the characteristics of the respondents and aspects related to changes due to climate variability in Aceh Besar District can be obtained.

### 2.2 Estimation of the Livelihood Index (LVI)

The estimation of the Livelihood Index (LVI) is an analysis tool to calculate the level of vulnerability of farmer households due to climate variability. Identifying vulnerability processes, prioritizing strategies to reduce vulnerability and evaluating the effectiveness of the strategies (Shah, et al., 2013). The LVI calculation in this study determines the components and sub-components in the form of exposure due to climate variability. Where each sub-component gives the same contribution to the overall index even though each main component has different sub-components. LVI in this study uses a simple approach which applies the same weight to all main components. There are four steps in adding LVI, namely:

a. Converts raw data into measurable units of data, such as percentages and ratio data.

b. Standardize each sub-component when measured using different scales.

c. Averaging the standardized scores of the main components that have been added up, giving the final score for each of the main components.

d. Combines the average scores of all major components to produce an LVI score.

**Model I**

The value of each main component is determined using the indicator numbering. It is confirmed that all the main components contribute equally to LVI (Shah et al. 2013). LVI is assigned a scale of 0 (lowest vulnerability) to 1 (highest vulnerability) (Shah et al. 2013).

**Model 2**

According to the IPCC definition, vulnerability characteristics as a function of exposure category, system sensitivity, and adaptation capacity to cope with negative impacts.

$$Index_{Sd} = \frac{Sd - smin}{Smax - Smin}$$ (Shah et al. 2013).

Where:
Index sd = Index of sub components
Sd = Sub component value
S min = Minimum value
S max = Maximum value

After determining the value of the sub component, the next step is to determine the value of the main component, namely by using the formula:

$$Md = \frac{\sum_{i=0}^{n} index\ sdi}{n} \quad \text{(Shah et al. 2013).}$$

Where:
Md = The value of the main component for farmer household
Indexsd = Index of sub components
N = Number of sub components

The final step is to determine the LVI value of each farmer household using the formula:

$$LVId = \frac{\sum_{i=1}^{5} wmi.Mdi}{\sum_{i=1}^{5} wmi} \quad \text{(Shah et al. 2013).}$$

Where:
LVId = LVI for farmer households
wmi = Weight of the sub components
Mdi = The value of the main component for farm households

$$LVI - IPCCd = ( ed - ad ) *Sd \quad \text{(Shah et al. 2013).}$$

Where
LVI - IPCCd = LVI for farmer households declared using the IPCC vulnerability framework
e = Calculation of the exposure score (changes due to climate variability)
a = Calculation of adaptive capacity score (average weighted value of socio-demographics, social networks, and formal institutions)
s = Calculation of sensitivity score (capital, damage)

LVI – IPCCd is given a scale ranging from 0 (lowest vulnerability) to 1 (highest vulnerability) (Shah et al. 2013)

### 2.3 Risks Due to Climate Change

This analysis is carried out to calculate the risks felt by farmers' households due to climate change. Formula used:

$$Risk = \frac{Hazard\ x\ Vulnerability}{Capacity}$$

Where:
Risk = Dissolved impacts caused by climate change
Hazard = Impact / threat felt by households farmer due to change climate
Vulnerability = The level of vulnerability of farmer households due to climate change
Capacity = ability to survive due to climate change

### 2.4 Adaptation and Mitigation Strategies

Identification is carried out by asking questions about the forms and options for adaptation and mitigation carried out by rice farmers when facing drought, the efforts that can be made to overcome this drought and the obstacles faced when making these adjustments. This identification was carried out through interviews with rice farmers using a questionnaire. The results obtained are then grouped based on the choice of the same adaptation and mitigation forms and percentage based on the number of respondents. The largest percentage of each yield is the dominant type of adaptation and mitigation of each adaptation and mitigation carried out by rice farmers.

## *3. Result and Discussion*

### 3.1 Livelihood Index (LVI) Estimation

The calculation of the Livelihood Vulnerability Index can be summarized into three categories, namely exposure, adaptive capacity, and sensitivity. The exposure value is the exposure to threats that occur at the research location, namely variability such as drought and farmers' knowledge of climate change. The value of adaptive capacity is an adaptive capacity to deal with an area of threats, it can be seen from the socio-demographic and institutional side. Furthermore, the sensitivity category is an indicator of the sensitivity of an affected area which consists of food, water, health, and land ownership.

In the following, it can be seen that the categories of the main components that contribute to the vulnerability index value based on the LVI-IPCC (Livelihood Vulnerability Index – Intergovernmental Panel on Climate Change) assessment can be seen in the following table.

Table 2. Category LVI - IPCC Farmers in Blang Bintang and Montasik Districts

| **Category (Contributing Factors)** | **Main component** | **Principal Component Values** | | **Number of Sub Components per Main Component** | | **Value of Contributing Factors** | |
|---|---|---|---|---|---|---|---|
| | | **Blang Bintang** | **Montasik** | **Blang Bintang** | **Montasik** | **Blang Bintang** | **Montasik** |
| Exposure | Farmers' knowledge of climate change | 0,55 | 0,50 | 2 | 2 | 0,58 | 0,55 |
| Adaptive Capacity | General information | 0,36 | 0,57 | 2 | 2 | 0,32 | 0,32 |
| | Livelihood Strategy | 0,40 | 0,41 | 3 | 3 | | |
| | Social network | 0,28 | 0,37 | 6 | 6 | | |
| | Institutional | 0,33 | 0,25 | 2 | 2 | | |
| Sensitivity | Food | 0,42 | 0,42 | 5 | 5 | 0,42 | 0,38 |
| | Water | 0,34 | 0,49 | 4 | 4 | | |
| | Ownership | 0,68 | 0,55 | 3 | 3 | | |
| | Health | 0,86 | 0,48 | 3 | 3 | | |
| **LVI-IPCC Value Blang Bintang** | **0,11** | | | | | | |
| **Montasik** | **0,09** | | | | | | |

Source. Primary Data, 2020 (processed)

Based on the results of research data processing, it is known that the value of climate variability in Blang Bintang District has a higher value than in Montasik District. The LVI-IPCC value of Blang Bintang District was 0.11 while Montasik District got 0.99. This value means that the Blang Bintang area is more prone to climate change than the Montasic area.

The main components that contribute to the vulnerability index value based on the LVI-IPCC assessment include:

**1. Exposure**

Exposure is something that causes vulnerability in an area. Exposure can be presented as a long-term change. The exposure that occurs in this study is due to climate change / climate variability. The impact that occurred in the study area was due to drought. This problem causes farmers to experience losses, this incident causes farmers to experience vulnerability due to drought climate change. If seen from the exposure value, the vulnerability value obtained for the Blang Bintang is 0.45% and Montasik is 0.53%. This means that the Montasik is more prone to drought.

**2. Sensitivity**

Sensitivity can be defined as the level of sensitivity of a system in dealing with vulnerabilities. The response of sensitivity can be positive or negative. The sensitivity in this study to farmers in the Blang Bintang area is higher than in the Montasik area. This means that the Blang Bintang area is more sensitive or more sensitive to the vulnerabilities that occur.

**3. Adaptive Capacity**

Adaptive capacity is the ability to adapt. The value of adaptive capacity in the Blang Bintang area is lower than in the Montasik area, this means that farmers in the Montasik area are more adaptable to climate change.

### 3.2 The Perceived Risks of Climate Change

Farming activities are the main source of life for farmers. Climate change will provide significant changes to agricultural business activities. In the following, we can see a table of the impacts of climate change on farmers.

Table 3. Percentage of Farmers Feeling the Impact of Climate Change in Aceh Besar District

| No. | Impact of Climate Change | Montasik District (%) | Blang Bintang District (%) |
|---|---|---|---|
| 1. | Production decreased | 75 | 80 |
| 2. | Experienced crop failure | 20 | 25 |
| 3. | More frequent drought | 80 | 88 |
| 4. | Agricultural land is getting drier | 78 | 82 |
| 5. | Agricultural land is increasingly difficult to cultivate | 75 | 79 |
| 6. | The volume of the water source decreases | 65 | 76 |
| 7. | Pest outbreaks | 78 | 80 |

Source: Primary data processed in 2020

From the table, it can be seen that the most visible impact of climate change in Montasik District is the occurrence of drought which is increasingly occurring, the same thing also happens in Blang Bintang District. Generally, farmers plant rice whose types are not suitable for water conditions and land types, this causes the death of rice plants at a young age.

### 3.3 Impact of Climate Change on Changes in Farmers' Income

In the agricultural sector, especially in the food crop subsector, it is very vulnerable to the effects of climate change. This is because food plants are seasonal crops whose condition is very sensitive to disturbances, especially to shortages and excess of water. The occurrence of climate change has caused concern for farmers about the sustainability of the rice crop. Changes in rain patterns in Aceh Besar district have caused farmers to incorrectly predict climate conditions from previous years. This situation has an impact on decreasing rice productivity. In 2017, rice productivity in Montasik District was 51,430 tons / year to 33,214 tons / year in 2018, while in Blang Bintang District, rice productivity in 2017 was 17,128 tons / year to 16,635 tons / year. This decrease causes changes in income for rice farmers, the following can be seen from the changes in income felt by farmers during climate change.

Table 4. Changes in Farmers' Income Due to Climate Change

| Category | Before Climate Change | After Climate Change | Income Change (percent) |
|---|---|---|---|
| | Average Income | Average Income | |
| Farmers in Montasik District | 11.000.000 | 8.800.000 | -20% |
| Blang Bintang District Farmers | 10.850.000 | 7.920.000 | -27% |

Source: Primary data processed in 2020

Based on the table, there is a decrease in income for farmers in Montasik District and Blang Bintang District. The change in the average income of farmers in Montasik District was 20%, while for farmers in Blang Bintang District it was 27%. Any change in income will affect household consumption. Declining income will reduce the amount of consumption, as stated by Entika Indrinawati (2015), income has a close relationship because it will determine the pattern of consumption.

### 3.4 Farming Adaptation Strategy to Climate Change

Various agricultural system efforts are required in building agriculture that is resistant to both structural and non-structural characteristics. Boer (2008) states that structural efforts include adapting improvements in the construction of facilities and infrastructure, such as repairing drainage channels, reservoirs and irrigation, building flood control, developing harvest technology, while non-structural efforts include increasing the planting index in certain areas, repair or introduction of varieties that are more resilient to climate change, development of water-saving technology, strengthening knowledge of agricultural extension agents on climate, and increasing climate information and information on risk management.

Even though the forms or types vary, the target of adaptation to climate change in principle is to minimize vulnerability, build resilience, and develop the ability to take advantage of beneficial opportunities. Climate change has impacted human life and ecosystems. Adaptation also needs to be done in order to avoid the phenomenon of climate change. The level of adaptation carried out here depends on the success of mitigation activities. Communities can adapt by making preparations to face some of the risks from climate change.

Adaptation strategies, especially in farming are needed to reduce the losses caused by climate change. The following table will present data on adaptation strategies carried out by farm households in the Montasik and Blang Bintang areas. Adaptation strategy in farming is important because agriculture is the main source of livelihood for farm households.

Table 5. Percentage of Farmers Implementing Adaptation Strategies for Businesses to Climate Change in Aceh Besar District.

| No. | Adaptation Strategy | Montasik District | Blang Bintang District |
|---|---|---|---|
| 1. | Organic / semi organic business | 70% | 82% |
| 2. | Water saving farming | 15% | 34% |
| 3. | Intercropping farming | 67% | 80% |
| 4. | Perform crop rotation | 90% | 84% |
| 5. | Plant dry-resistant varieties | 80% | 84% |
| 6. | Also maintain irrigation channels | 50% | 70% |

From the table it can be seen that organic and semi-organic farming is carried out by many farmers. The first adaptation is to reduce the use of chemical fertilizers and pesticides in farming. Farmers tend to use a lot of manure produced by their own livestock as the main fertilizer and add organic matter in the form of rotting straw to the fields. This adaptation is implemented aimed at maintaining the quality of soil fertility for the long term.

The application of water-efficient farming in the two regions is still very few, even though this farming system can help farmers to maintain plant growth, especially rice, to continue to produce maximum production with less water requirements such as the SRI cultivation system (Op Rice Intensification System). From the research results, it can be seen that farmers in the Blang Bintang area do more water-efficient farming compared to farmers in the Montasik area. This is because the application of water-efficient farming is mostly carried out in rice farming with the SRI system with irrigation water management, while farmers in the Montasik area grow more rain fed rice. Intercropping farming has been developed in both regions. Intercropping cultivation is an adaptation effort to minimize losses caused by climate change. More crop rotation adaptation strategies are carried out in Montasik District.

## *Conclusions and Recommendations*

The vulnerability index obtained from the LVI-IPCC calculation results in the vulnerability category, it was found that the Montasik area was more susceptible to drought, from the sensitivity category it was found that the Blang Bintang area was more sensitive to vulnerability, and from the adaptive capacity category it was found that the Montasik area was more adaptable to climate change. The risks of climate change that are felt by farmers are decreased production, experiencing crop failure, more frequent droughts, drier agricultural land, difficult cultivated land, decreased volume of water sources, and pest outbreaks. The highest risk experienced by farmers in the Blang Bintang and Montasik areas is drought, with a percentage value of 80% in the Montasik area and 88% in the Blang Bintang area. The adaptation strategy carried out by farmers to climate change is by doing business in the form of organic, water-efficient farming, intercropping, doing crop rotation, planting dry-resistant varieties, and maintaining irrigation channels. The strategy mostly done by farmers in the Blang Bintang area is to do crop rotation and plant dry-resistant varieties, while in the Montasik area the farmers do more crop rotation.

There needs to be a government role in providing knowledge and information to farmers about climate change so that farmers understand climate change and the appropriate adaptation strategies that must be carried out. There is a need for deeper research in each village using the Livelihood Vulnerability Index (LVI) method, so that the government can prepare everything in the face of vulnerability and resilience.

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