# The Livelihood Vulnerability to Climate Change of Two Different Farmer Communities in Tanggamus Region, Lampung Province, Indonesia

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ABSTRACT

*The study aimed to calculate the livelihood vulnerability of organic and non-organic rice farmers' households to climate change. The sample was determined by a census comprising 60 organic and 80 non-organic rice farmers who lived in Pematang Sawa Sub-district, Tanggamus Region, Lampung Province, Indonesia. The livelihood vulnerability index (LVI) was measured based on seven main indicators: natural disaster and climate variability, agriculture profile, food security, water security, food/rice consumption, educational attainment, and income. The results showed that organic rice farmers' households were more vulnerable in terms of natural disaster and climate variability, water security, food consumption, education, and income, while non-organic rice farmers' households were more vulnerable in terms of agriculture profile and food security. Using the LVI framework approach of the Intergovernmental Panel on Climate Change (LVI-IPCC), non-organic rice farmers' households were found to be more vulnerable to climate change than organic rice farmers' households. To better observe the vulnerability of organic and non-organic rice farmers' households to climate change, future studies should be conducted in two distant locations (e.g., different regions or provinces) because different climate components could significantly influence the findings. Rice farmers' households could become less vulnerable by providing them with objective climate information that will encourage them to adopt the necessary climate change adaptation and mitigation strategies. Further support is needed in the form of resources aid programs, such as the provision of irrigation systems or pumping wells, as well as livestock aid to increase the farmers' income.*

**Keywords:** vulnerability, climate change, organic rice, Lampung Province
**JEL Classification:** Q10, Q54, Q16

## INTRODUCTION

Climate change is a long-term, continuous, and natural process. To withstand the impacts of this phenomenon, the agricultural sector requires effective adaptation and mitigation strategies, such as organic rice farming (Surmaini et al. 2011; FAO 2010). Compared to conventional rice farming, organic rice farming has been known to produce higher yields in harsh and uncertain climate situations. It reduces the emission of greenhouse gases (GHG), such as carbon dioxide and nitrous oxide (Kotschi and Mullër-Sämann 2004). This affordable practice minimizes nutrient loss and mitigates climate change by sequestering atmospheric carbon dioxide, building soil organic carbon, and reducing the use of synthetic nitrogen fertilizer. It also uses water more efficiently, allowing it to endure extreme weather events and resist risks in harvest, making agricultural land and farmers more resilient to the effects of changing climatic conditions (Mathukia et al. 2016 ). Compared to conventional rice farming systems, organic rice farming was also reported to reduce the cost of agricultural production by 28 percent.

In general, farmers' organic agricultural businesses should be based on their existing knowledge, information, and awareness on the negative effects of chemical inputs. Recently, demand for organic rice products has steadily increased because of the increasing awareness on healthy products. Farmers are shifting gradually from chemical-intensive conventional rice farming to environment-friendly organic rice farming. In Indonesia, organic rice farming became an alternative rice production system because of the economic crisis in 1997, which caused limited inorganic fertilizer and pesticide subsidies by 1998. As a result, the price of inorganic fertilizer increased. Environment-friendly agricultural technology policies were implemented following the rising price of inorganic fertilizer and to reduce the use of pesticides (Marioyono 2009).

Farmers in Pekon Tampang Tua Village, Pematang Sawa Sub-district have been used to organic farming, with production inputs such as inorganic fertilizers being expensive and scarce because their isolated area can only be reached by ships once a day. These farmers use whatever natural resources they could find as suitable fertilizer or organic pesticides such as straw, plant leaves, and animal manure. Aside from the scarcity of inorganic fertilizer and having ample natural water resources, the study area was suitable to be developed as a center of organic farming in Lampung Province.

An alternative way to study the impacts of climate change is by asking farmers directly (Suwandi et al. 2014). However, many farmers are uneducated about climate change, and their lack of awareness and information makes their households extremely vulnerable. Thus, farmers need to be well-informed about climate change and its effects on agriculture, as well as adaptation and mitigation strategies to manage the impacts of climate change (Rasmus and Misha 2010).

Lampung's economy depends heavily on its agricultural sector. It has a wide agricultural area and good agroecology for crop production, particularly rice production. As a means of anticipating and adapting to climate change, farmers in Lampung Province started cultivating organic rice in 2002, while farmers in the village of Pekon Tampang Tua in Pematang Sawa Sub-district, Tanggamus Regency began organic rice cropping in 2009.

Tanggamus Regency experienced a change of climate type from D1 (based on the data of rainfall during 1976–1990) to D2 (based on the data of rainfall in 1991–2010), which means drier climate, according to Oldeman's climate classification. Based on rainfall statistics, the monthly rainfall depth in Tanggamus Regency, particularly Pematang

Sawa Sub-district, was 45 millimeters (mm) from June to September 2012, categorized as dry months. An average rainfall of less than 100 mm indicates that during that period, Pematang Sawa Sub-district experienced drought that caused a decline in rice production. With this background, it was deemed useful to conduct a study to determine the livelihood vulnerability to climate change of organic and non-organic rice farmers' households in Tanggamus.

## METHODS

### Location, Respondents, and Time of Research

The study area was Pematang Sawa Sub-district in Tanggamus Regency, Lampung Province, Indonesia. The products in this area, which is a central production area for rainfed organic rice, are certified by the Indonesian Organic Farming Certification. Pematang Sawa Sub-district experienced drought in 2012. The respondents were selected through a census of all farmers planting organic rice. There were 60 organic rice farmers from Pekon Tampang Tua Village and 80 non-organic rice farmers from Pekon Tampang Muda Village.

## DATA ANALYSIS

The livelihood vulnerability of organic and non-organic rice farmers' households to climate change was analyzed based on the indicators developed by the Intergovernmental Panel on Climate Change (IPCC) (2007); the United Nations Development Programme (UNDP) (2007); and Hahn, Riederer, and Foster (2009). These indicators covered exposure, adaptive capacity, and sensitivity, which were modified to suit the conditions of the farmers in the study area (Table 1).

### Livelihood Vulnerability Index Approach

The livelihood vulnerability index *(LVI)* employs a weighted average approach (Sullivan, Meigh, and Fediw 2002) in which each component contributes equally to the total index despite the main components having different sub-components. The *LVI* of Hahn, Riederer, and Foster (2009) is a composite index comprising of seven major components to assess the exposure to natural disasters and climate variability, namely: food/rice consumption; education; income that affects adaptive capacity; and agriculture profile, food, and water resource characteristics that determine sensitivity to the impacts of climate change.

**Table 1. Factors contributing to LVI as per IPCC approach**

| Contributing Factors | Main Indicators |
|---|---|
| Exposure | Natural disaster and climate variability |
| Adaptive capacity | Food/rice consumption |
| | Education |
| | Income |
| Sensitivity | Agriculture profile |
| | Food security |
| | Water availability/security |

Source: Adapted from Hahn et al. (2009) with some modifications

Each of the sub-components was measured on different scales. They were standardized using the following equation (UNDP 2007):

(1)

$$Index_{sub\text{-}indicator} = \frac{S - s_{min}}{S_{max} - S_{min}}$$

*S* is the sub-indicator value for the group, while $S_{min}$ and $S_{max}$ are the minimum and maximum scores of each sub-indicator in the group under study. Inverse values of the components were taken if the relationships between the variable and vulnerability was negative.

The following equation was used to determine the average sub-indicator indices (Hahn, Riederer, and Foster 2009):

(2)

$$M_{sub\text{-}indicator} = \frac{\sum_{i=1}^{n} Index_{of\ sub\text{-}indicator}}{n}$$

$M_{sub\text{-}indicator}$ is one of the seven major indicators for the group, while n is the number of sub-indicators in each major indicator.

*LVI* is the weighted average of the seven major sub-indicators. The main-indicator indices were calculated using the following equation:

(3)

$$LVI_{main\ indicator} = \frac{\sum_{i=1}^{7} W_{Mi}\, M_{sub\text{-}indicator}}{\sum_{i=1}^{7} W_{Mi}}$$

*W* is the weighing factor of each major indicator. It is the number of sub-indicators that makes up each major indicator. The *LVI* was scaled from 0 (least vulnerable) to 0.5 (most vulnerable).

### IPCC Framework Approach for Calculating *LVI*

IPCC defines vulnerability by grouping the seven major indicators under exposure, adaptive capacity, and sensitivity (Table 1). Instead of using one weighted average as in the *LVI* approach, the weighted averages of the major sub-indicators were calculated based on the three contributing factors explained in Table 5. The following equation was used:

(4)

$$CF_{org} = \frac{\sum_{i=1}^{7} W_{Mi}\, M_{main\ indicator}}{\sum_{i=1}^{7} W_{Mi}}$$

CF is the contributing factor of e (exposure), a (adaptive capacity), and s (sensitivity). The three contributing factors were combined using the equation below. The *LVI-IPCC* was scaled from −1 (least vulnerable) to 1 (most vulnerable).

(5)

$$LVI_{IPCC} = (e_{org} - a_{org}) * s_{org}$$

## RESULTS AND DISCUSSION

### Respondents' Socio-demographic Characteristics

It is important to study the characteristics of a community of farmers to understand their capacity to adapt to climate change. In the present study, all farmers' households were interviewed to determine the household head's age, formal education, farming experience, attendance in agricultural seminars, and number of family members (Table 2). This provided information on the socio-demographic profile of the farmers' households in the study area. Longer experience in rice cultivation, more education, less number of family members, more land for cultivation, and more diverse occupations mean more knowledge and skills that could contribute to a higher adaptive capacity.

The organic farming location was Pekon Tampang Tua village, which has an area of 1,083 hectares (ha) and a population of 1,149 (631 men and 518 women) and 282 households. It has an elevation of 7 meters (m)

**Table 2. Respondents' socio-demographic characteristics**

| Characteristics | Organic Farmers | | Non-organic Farmers | | Total | |
|---|---|---|---|---|---|---|
| | Number | % | Number | % | Number | % |
| Age (years) | | | | | | |
| 20–34 | 17 | 28.33 | 18 | 22.50 | 35 | 25.00 |
| 35–49 | 19 | 31.67 | 33 | 41.25 | 52 | 37.14 |
| 50–60 | 18 | 30.00 | 24 | 30.00 | 42 | 30.00 |
| >64 | 6 | 10.00 | 5 | 6.25 | 11 | 7.86 |
| Total | 60 | 100.00 | 80 | 100.00 | 140 | 100.00 |
| Formal education (years) | | | | | | |
| Uneducated | 0 | 0 | 4 | 5.00 | 4 | 2.86 |
| Elementary (1–5 years) | 17 | 28.33 | 19 | 23.75 | 36 | 25.71 |
| Elementary graduate (6 years) | 30 | 50.00 | 34 | 42.50 | 64 | 45.71 |
| Junior high school graduate (9 years) | 10 | 16.67 | 16 | 20.00 | 26 | 18.57 |
| Senior high school graduate (12 years) | 2 | 3.33 | 4 | 5.00 | 6 | 4.29 |
| College graduate (16 years) | 1 | 1.67 | 3 | 3.75 | 4 | 2.86 |
| Total | 60 | 100.00 | 80 | 100.00 | 140 | 100.00 |
| Farming experience (years) | | | | | | |
| 1–3 | 23 | 38.33 | | | | |
| 4–6 | 31 | 51.67 | | | | |
| 7–10 | 6 | 10.00 | | | | |
| 1–16 | | | 50 | 62.50 | | |
| 17–30 | | | 24 | 30.00 | | |
| 31–42 | | | 6 | 7.50 | | |
| Total | 60 | 100.00 | 80 | 100.00 | | |
| Attendance in agricultural seminars (frequency) | | | | | | |
| 1–7 | 30 | 50.00 | 66 | 82.50 | | |
| 8–14 | 24 | 40.00 | 10 | 12.50 | | |
| 15–21 | 6 | 10.00 | 4 | 5.00 | | |
| Total | 60 | 100.00 | 80 | 100.00 | | |
| Number of people in the family | | | | | | |
| 2–4 | 34 | 56.57 | 27 | 33.75 | | |
| 5–6 | 19 | 31.67 | 39 | 48.75 | | |
| 7–8 | 7 | 11.66 | 14 | 17.50 | | |
| Total | 60 | 100.00 | 80 | 100.00 | | |

above sea level. The non-organic farming location was Pekon Tampang Muda village, which had an area of 1,164 ha and a population of 1,535 people (715 men and 820 women) and 336 households. Its elevation is 5 m above sea level. All the paddy fields in both villages are rainfed, and rice is cultivated twice a year. There was no difference in organic and non-organic rice production, which had yields of 6–7 tons/ha in the wet season and 4–5 tons/ha in the dry season.

The average age of the household head in both organic and non-organic rice farmers' households was 45 years. Elementary school graduates comprise 50 percent of organic rice farmers and 42.5 percent of non-rice organic farmers. A small number of household heads completed senior high school or higher education (5% of organic rice farmers and 10% of non-organic rice farmers). In general, more educated farmers have better access to information and technologies, and are more capable to exploit these resources to adapt to climate change. Most of the household heads attended agricultural extension workshops frequently (95% of non-organic rice farmers and 90% of organic rice farmers), which enables them to gain more information on climate change and learn climate change adaptation strategies. Organic rice farmers had been cultivating rice for 1 to 10 years, with an average of 4 years. Non-organic rice farmers' rice cultivation experience averaged 15 years. On the average, organic rice farmers' households had 5 members, while non-organic rice farmers' households had 4 members. In general, farmers with more farming experience are expected to do better in paddy cultivation. The respondents in this study were relatively well-experienced farmers. Households with more family members tend to be more vulnerable to climate change since the head of the household needs to gain more income and increase crop production to provide for the family's needs.

The farmers' primary source of income was working in the agricultural business. In Pematang Sawa Sub-district, most of the farmers relied solely on agricultural jobs (73.33% of organic rice farmers and 51.25% of non-organic rice farmers), while the rest had other jobs that are non-agricultural (26.67% of organic rice farmers and 48.75% of non-organic rice farmers), such as being a civil servant, motorcycle taxi driver, vendor, laborer, and fisherman. Organic rice fields had an average size of 0.64 ha, while non-organic rice fields had an average size of 0.74 ha.

### Analysis of *LVI* of Organic and Non-organic rice farmers' households

This section discusses the maximum and minimum scores of sub-indicators and main indicators, composing the *LVI* of both groups (Table 3); and the main indicators, sub-indicators, and overall *LVI* scores of both groups (Table 4).

#### *Natural disaster and climate variability indicator*

Due to the adjacent location of the villages, both organic and non-organic rice farmers' households had similar natural disaster and climate variability vulnerability scores based on the number of reported floods, drought, heavy winds in the last three years, landslides, average monthly temperature, and average monthly rainfall. Pekon Tampang Tua and Pekon Tampang Muda had the same climate variability as they were only separated by a river. Most of the farmers obtained climate change information from television and the agriculture community, while only 5 percent of the total number of households obtained climate change information from an agricultural instructor. Farmers viewed weather forecasts on television as an important input in making farming decisions. The frequency of viewing weather forecasts was not evaluated. However, when climate variability was integrated into the natural disaster index, organic farmers' households were found to be more vulnerable (0.445) than non-organic rice farmers' households (0.438). Non-organic farmers' households were able to anticipate, thus, less vulnerable to climate change because they had more information and knowledge compared to organic farmers' households. As shown in Table 3, about 17 percent of organic rice farmers and 12 percent of non-organic farmers from total farmers' household was lacking in information on climate change.

**Table 3. Maximum and minimum scores of sub-indicators and main indicators composing the vulnerability index of organic and non-organic rice farmers' households**

| Main Indicators | Sub-indicators | Unit | Organic Rice Farmers' Households | Non-organic Rice Farmers' Households | Maximum Score | Minimum Score |
|---|---|---|---|---|---|---|
| Natural disaster and climate variability | Percentage of households that had no knowledge of climate change | Percentage | 17 | 12 | 100 | 0 |
| | Number of floods in the last three years | Number | 0 | 0 | 0 | 0 |
| | Number of droughts in the last three years | Number | 1 | 1 | 1 | 0 |
| | Number of heavy winds in the last three years | Number | 6 | 6 | 6 | 0 |
| | Number of landslides in the last three years | Number | 0 | 0 | 0 | 0 |
| | Average monthly temperature | Celsius | 28.0 | 28.0 | 32.65 | 22.35 |
| | Mean standard deviation of average monthly rainfall from 1976 to 2010 | Millimeter | 110.02 | 110.02 | 163.97 | 74.27 |
| Agriculture profile | Area of land employed for rice cultivation | Hectare | 0.64 | 0.74 | 3.0 | 0.12 |
| | Average crop diversification | 1/number of plants +1 | 0.3705 | 0.3382 | 1 | 0.2 |
| | Percentage of household income solely based on/ rely on agriculture | Percentage | 75 | 33 | 100 | 0 |
| | Percentage of households that cultivated only rice with no integration in animal or fish farming | Percentage | 17 | 70 | 100 | 0 |
| Food security | Percentage of households that saved crops until the next cultivating season | Percentage | 12 | 24 | 100 | 0 |
| | Percentage of households that stocked crop produce | Percentage | 100 | 100 | 100 | 0 |
| | Percentage of households that did not stock crop produce | Percentage | 0 | 0 | 0 | 0 |
| | Percentage of households that did not save seeds for the next cultivating season | Percentage | 37 | 47 | 100 | 0 |
| | Percentage of households whose food was not from family farm | Percentage | 24 | 49 | 100 | 0 |
| | Average number of households struggling to find food | Number | 0 | 0 | 0 | 0 |
| Water security | Percentage of households that reported water conflict | Percentage | 93 | 77 | 100 | 0 |
| | Percentage of households that used natural water sources for agricultural business | Percentage | 100 | 100 | 100 | 0 |
| | Percentage of households that used natural water sources for domestic needs | Percentage | 100 | 100 | 100 | 0 |
| | Average time spent to get water from natural water source | Minutes | 3.36 | 1.34 | 30 | 0.01 |
| | Average liters of water needed in each household | Liters/day | 428 | 41 | 210 | 50 |

**Table 3. Maximum and minimum scores of sub-indicators and main indicators composing the vulnerability index of organic and non-organic rice farmers' households** *(Continued)*

| Main Indicators | Sub-indicators | Unit | Organic Rice Farmers' Households | Non-organic Rice Farmers' Households | Maximum Score | Minimum Score |
|---|---|---|---|---|---|---|
| Food/rice consump-tion | Average amount of rice consumed by households per day | Kilogram | 1.56 | 1.48 | 3.00 | 0.25 |
| | Average amount of staples other than rice consumed per day | Kilogram | 0 | 0 | 0 | 0 |
| | Percentage of households that did not consume a combination of staples | Percentage | 0 | 0 | 0 | 0 |
| Education | Percentage of households that had more than a 9-year education | Percentage | 5 | 10 | 100 | 0 |
| Income | Number of household whose income was based on agricultural and non-agricultural work | Number | 1.23 | 1.52 | 3 | 1 |
| | Percentage of households that depended solely on agriculture for income | Percentage | 75 | 33 | 100 | 0 |

### *Agriculture profile indicator*

Organic rice farmers' households had a smaller index score for area of field employed. The average organic rice farming area was 0.64 ha, which was not significantly different from the average non-organic rice farming area of 0.74 ha. A larger farm size means greater adaptive capacity towards climate change, but production cost could make the farmers vulnerable. Majority of organic rice farmers' households relied solely on agricultural activities for their income, while non-organic farmers' households earned additional income by doing off-farm work in formal and informal sectors. Non-organic rice farmers' off-farm occupations also enabled them to survive during crop failure as an effect of climate change. Organic rice farmers' households' dependence on agriculture increases their vulnerability to climate change, since crop harvest failure can cause remarkable reductions in income and force them to rely on loans (Hinkel 2011).

The diversity level in terms of number of crops planted is also low with most farmers in Pekon Tampang Tua, planting only one crop other than rice. Majority of organic rice farmers' households (83%) engaged not only in rice cultivation but also in livestock rearing and fish farming, while only 30 percent of non-organic farmers' households were rearing livestock and farming fish. Livestock rearing and fish farming are important financial resources. Animals, which are some form of savings for farming households, indicate the amount of financial resources available to farmers to finance adaptation strategies (Defiesta and Rapera 2014). Overall, organic rice farmers' households were less vulnerable (0.326) in terms of agriculture profile than non-organic rice farmers' households (0.355). The agricultural diversity of organic rice farmers' households, where they were engaging not only in rice cultivation but also in livestock rearing and fish farming, mainly influenced the agriculture profile indicator.

**Table 4. Index of main indicators, sub-indicators, and overall LVI scores of both organic and non-organic rice farmers' households**

| Main Indicators | Sub-indicators | Average Index Scores (Organic) (*X*) | Average Index Scores of (Non-organic) (*Y*) | Average Index Scores of Main Indicators (Organic) (∑*X*/*n*) | Average Index Scores of Main Indicators (Non-organic) (∑*Y*/*n*) |
|---|---|---|---|---|---|
| Natural disaster and climate variability | Percentage of households that had no knowledge of climate change | 0.17 | 0.12 | 0.445 | 0.438 |
| | Number of floods in the last three years | 0 | 0 | | |
| | Number of droughts in the last three years | 1 | 1 | | |
| | Number of heavy winds in the last three years | 1 | 1 | | |
| | Number of landslides in the last three years | 0 | 0 | | |
| | Average monthly temperature | 0.548 | 0.548 | | |
| | Mean standard deviation of average monthly rainfall from 1976 to 2010 | 0.398 | 0.398 | | |
| Agriculture profile | Area of land employed for rice cultivation | 0.17 | 0.215 | 0.326 | 0.355 |
| | Average crop diversification | 0.213 | 0.173 | | |
| | Percentage of household income solely based on agriculture | 0.75 | 0.33 | | |
| | Percentage of households that cultivated only rice with no integration of animal or fish farming | 0.17 | 0.70 | | |
| Food security | Percentage of households that saved crops until the next cultivating season | 0.12 | 0.24 | 0.288 | 0.367 |
| | Percentage of households that stocked crop produce | 1.00 | 1.00 | | |
| | Percentage of households that did not stock crop produce | 0.00 | 0.00 | | |
| | Percentage of households that did not save seeds for the next cultivating season | 0.37 | 0.47 | | |
| | Percentage of households whose food was not from family farm | 0.24 | 0.49 | | |
| | Average number of households struggling to find food | 0.00 | 0.00 | | |
| Water security | Percentage of households that reported water conflict | 0.93 | 0.77 | 0.645 | 0.598 |
| | Percentage of households that used natural water sources for agricultural business | 1.00 | 1.00 | | |
| | Percentage of households that used natural water sources for domestic needs | 1.00 | 1.00 | | |
| | Average time spent to get water from natural water source | 0.1117 | 0.0443 | | |
| | Average liters of water needed in each household | 0.184 | 0.178 | | |

**Table 4. Index of main indicators, sub-indicators, and overall LVI scores of both organic and non-organic rice farmers' households** *(Continued)*

| Main Indicators | Sub-indicators | Average Index Scores (Organic) (*X*) | Average Index Scores of (Non-organic) (*Y*) | Average Index Scores of Main Indicators (Organic) (∑*X/n*) | Average Index Scores of Main Indicators (Non-organic) (∑*Y/n*) |
|---|---|---|---|---|---|
| Food/rice consumption | Average amount of rice consumed by households per day | 0.476 | 0.447 | 0.492 | 0.482 |
| | Average amount of staples other than rice consumed per day | 0.00 | 0.00 | | |
| | Percentage of households that did not consume a combination of staples | 1.00 | 1.00 | | |
| Education | Percentage of households that had more than 9-year education | 0.95 | 0.90 | 0.95 | 0.90 |
| Income | Number of households whose income was based on agricultural and non-agricultural work | 0.115 | 0.260 | 0.433 | 0.295 |
| | Percentage of households that depended solely on agriculture for income | 0.75 | 0.33 | | |
| *LVI* of organic rice farmers' households = [(0.445 x 7) + (0.326 x 4) + (0.288 x 5) + (0.645 x 5) + (0.492 x 3) + (0.95 x 1) + (0.433 x 2)]/28 = 0.45 | | | | | |
| *LVI* of non-organic rice farmers ' households = [(0.438 x 7) + (0.355 x 4) + (0.367 x 5) + (0.598 x 5) + (0.482 x 3) + (0.900 x 1) + (0.295 x 2)]/28 = 0.45 | | | | | |

***Food security indicator***

None of the farmers in the study area were reported to be struggling to find adequate food for their families. Among the households that stored crops, only 12 percent of organic rice farmers' households and 24 percent of non-organic rice farmers' households reported insufficient amount of food reserve until the next cultivating season. The average food reserve of organic rice farmers' households was enough for 787 days, while that of non-organic rice farmers' households was enough for 553 days. Majority of organic rice farmers' households (76%) primarily obtained food from their personal farms, while non-organic farmers (51%) obtained their food mostly from crops planted in rented farms. Majority of organic rice farmers' households (63%) and non-organic rice farmers' households (53%) had an adequate stock of seeds for the next cultivating season. The seeds in stock, which came from the best production harvest, weighed 50–200 kilograms (kg). The vulnerability index for food security had six sub-indicators. The calculation revealed that organic rice farmers' households were less vulnerable than non-organic rice farmers' households because the former had a higher amount of seed stock and food reserves, which were sufficient until the next cultivating season. The variable that had dominant effect on this component was the number of households that depend only on their family farm for food. Should their crops fail, they will not have sufficient food for their household and need to purchase food elsewhere. Purchasing food is a sign of vulnerability.

***Water security indicator***

Vulnerability due to water is directly related to rainfall variability. Rainfall deficits can dramatically reduce crop yields, livestock numbers, and productivity. The fluctuations in yearly rainfall, as well as within a monsoon season, govern the yield of crops (Ashok and Sasikala 2012). The index of vulnerability to water had five sub-components. Majority of organic rice farmers (93%) and non-organic rice farmers (77%) reported having water conflict, especially in the dry season, because both villages had no irrigation system for the rice fields and relied solely on rainfall. Pekon Tampang Tua village had natural springs, but due to its inaccessible location, organic rice farmers needed to walk and hike for 100 to 400 m to reach the mountain springs. They spent more time to collect water than non-organic rice farmers because Pekon Tampang Muda village had easily accessible natural springs. The average daily water consumption of organic and non-organic rice farmers' households were 426 and 415 liters, respectively. The *LVI* calculation revealed that organic rice farmers' households had a higher vulnerability than non-organic rice farmers' households in terms of water because the former consumed more water and required more time to collect water. However, for both groups, the problems with water were primarily caused by the location of the water source and not by farming practices.

***Food/rice consumption indicator***

Organic rice farmers' households (0.492) were more vulnerable to climate change in terms of food/rice consumption compared to non-organic rice farmers' households (0.482). The average daily rice consumption of organic and non-organic rice farmers' households was 1.57 kg/day and 1.48 kg/day, respectively. High rice consumption implies that organic rice farmers' households needed to increase their production. This makes them vulnerable to climate change because should there be a crisis in rice production due to draught or other natural disaster, the households would not be able to meet their domestic needs.

***Income (financial) indicator***

Financial resources as an indicator of adaptive capacity has two sub-indicators that represent the households' ownership and access to financial resources. Better financial standing signifies a greater ability to finance adaptation strategies and recovery mechanisms to climate change risks. The sub-indicator that had a dominant influence on this main indicator was the percentage of households that depended solely on agriculture for income. Non-organic rice farmers' households had a significantly higher income from agricultural and non-agricultural work than organic rice farmers' households. Besides working in the agricultural sector, majority of non-organic rice farmers' households (67%) had more than one additional off-farm source of income, while majority of organic rice farmers' households (75%) mostly relied on agriculture for income generation.

***Educational background indicator***

Based on formal education backgrounds, ≤10 percent household heads were high school or college graduates (5% of organic rice farmers and 10% of non-organic rice farmers). Organic rice farmers' households had a higher vulnerability score. On the average, respondents had nine years of formal education (see Table 1), which is equivalent to the third year of secondary education in the country. In general, more educated farmers had better access to information and technologies, and were more capable to exploit these resources to adapt to climate change. Therefore, given that only 5 percent of organic rice farmers completed secondary or higher education, their households were more vulnerable to climate change.

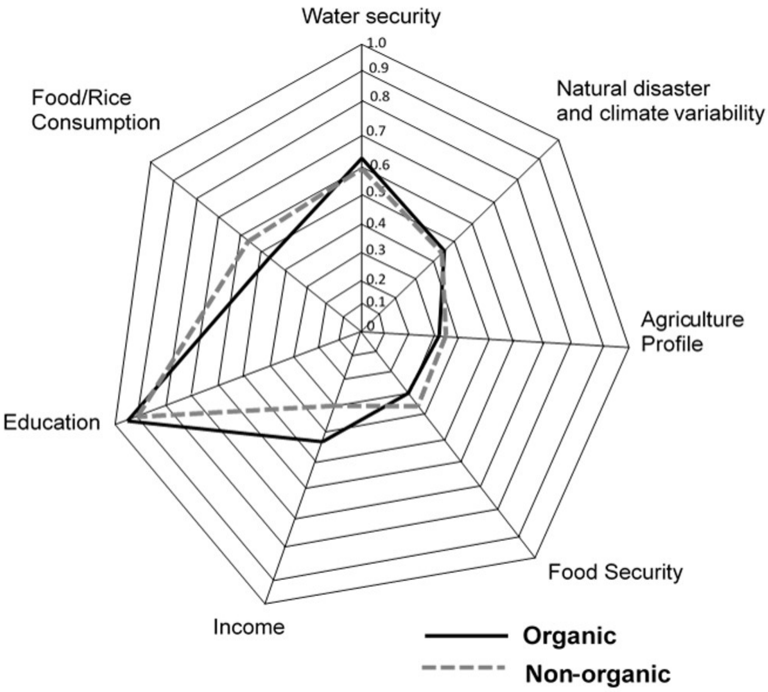
Based on the seven major indicators, both organic and non-organic rice farmers' households had the same *LVI* (0.45). It indicated that organic and non-organic rice farmers' households were both considered as moderately vulnerable to climate, due to the *LVI* score approaching 0.5.

The major vulnerability indicators presented in Figure 1 provide information on which household characteristics contribute most to climate change vulnerability in each study group. The scale range of the spidergram was from 0 (low vulnerability) to 1 (high vulnerability), with an interval of 0.1. Seven main indicators, namely, natural disaster and climate variability, agriculture profile, water security, food/rice consumption, education, and income highly contributed to the *LVI* score of organic rice farmers' households toward climate change. Two main indicators, agriculture profile and food security, highly contributed to the vulnerability of non-organic rice farmers' households towards climate change. The limitations of the overall *LVI* approach were associated with the use of indicators and indices that simplify a complex reality, with no efficient and coherent method to validate indices comprised of disparate indicators (Vincent 2007). Since sub-indicators are integrated as one major indicator value, the indexing approach does not include deviations between study populations. Furthermore, the selection and determination of sub-indicators from less to more vulnerable follows a normative judgment (Vincent 2007).

### Contribution of *LVI-IPCC* to organic and non-organic rice farmers' households

The *LVI–IPCC* analysis yielded different *LVI* scores (Table 5). Figure 2 shows a vulnerability triangle that plots the scores

**Figure 1. The vulnerability spidergram of LVI main indicators of both organic and non-organic rice farmers' households**



of contributing factors for exposure, adaptive capacity, and sensitivity. Based on Table 5 and Figure 2, organic rice farmers' households may be slightly more exposed (0.445) to climate change than non-organic rice farmers' households (0.438). Exposure can be interpreted as the external stress factors to the system of interest, such as changes in climate variability including extreme weather events or the rate of shifts in mean climate conditions (IPCC 2001).

Based on the main indicators—food security, agriculture profile, and water security—the non-organic rice farmers' households were more sensitive to climate change (0.441) compared to organic rice farmers' households (0.417). Sensitivity describes the farmers' environmental conditions, which could worsen the hazard, ameliorate the hazard, or trigger an impact. It is determined by the degree to which a system is modified or affected by an internal or external disturbance or set of disturbances (Gallopin 2003).

Based on the main indicators—food/rice consumption, education, and income—organic rice farmers' households (0.549) had higher adaptive capacity than non-organic rice farmers' households (0.489). Adaptive capacity represents the potential to implement adaptation measures that help avert potential impacts and shows the ability of a farmer's household to adjust to climate change, including climate variability and extremes; moderate potential damages; or take advantage of opportunities, cope with the consequences, and recover from shock. It can also reflect the ability of communities and individuals to adjust to change. The adaptive capacity of individuals or any social group is dependent on their access to and control over resources (IPCC 2001).

Overall, based on the *LVI-IPCC* contribution score, the organic rice farmers' households (−0.04324) were less vulnerable to climate change than non-organic rice farmers' households (−0.02263). However, organic rice farmers' households were more

**Figure 2. The vulnerability triangle diagram of both organic and non-organic ricefarmers' households to the effect of climate change in Tanggamus region**

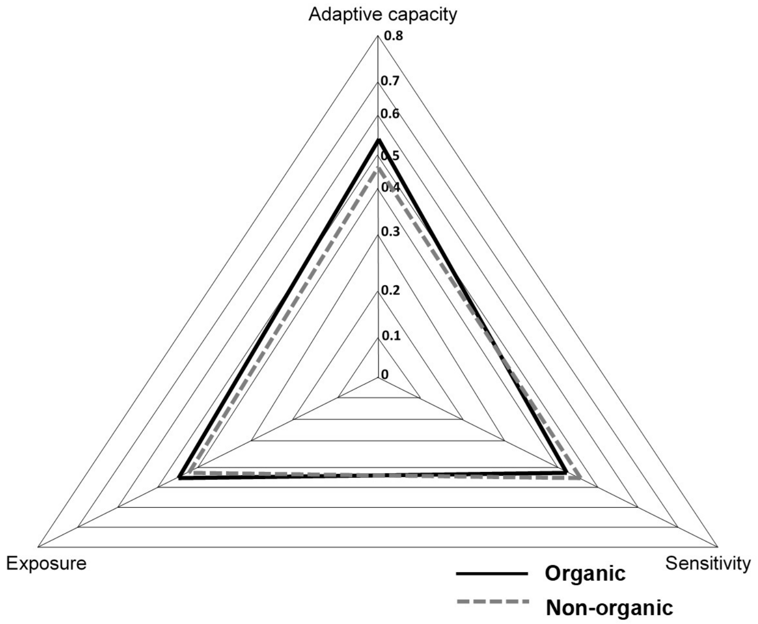


**Table 5. Calculation of LVI-IPCC contributing factors for organic and non-organic farmers' households**

| Contributing Factor | Main Indicators | Main Indicator Value ($X$) | Number of Sub-indicators ($n$) | Contributing Factor Value $\sum(X_i \times n_i)/\sum n$ | LVI-IPCC of Organic Farmers' households |
|---|---|---|---|---|---|
| Organic Farmers | | | | | |
| Adaptive capacity | Food consumption | 0.492 | 3 | 0.549 | (0.445 – 0.549) x 0.418 = -0.043 |
| | Education | 0.95 | 1 | | |
| | Income | 0.433 | 2 | | |
| Sensitivity | Food security | 0.288 | 6 | 0.418 | |
| | Agriculture profile | 0.326 | 4 | | |
| | Water security | 0.645 | 5 | | |
| Exposure | Natural disaster and climate variability | 0.445 | 7 | 0.445 | |
| Non-organic Farmers | | | | | |
| Adaptive capacity | Food consumption | 0.482 | 3 | 0.489 | (0.438 – 0,489) x 0.441 = -0.022 |
| | Education | 0.90 | 1 | | |
| | Income | 0.295 | 2 | | |
| Sensitivity | Food security | 0.367 | 6 | 0.441 | |
| | Agriculture profile | 0.355 | 4 | | |
| | Water security | 0.598 | 5 | | |
| Exposure | Natural disaster and climate variability | 0.438 | 7 | 0.438 | |

exposed to climate change due to the influence of main indicators, such as food/rice consumption, agriculture profile, and food security, which reduced the *LVI-IPCC* score. Both groups had the same medium vulnerability to climate change because their *LVI-IPCC* contribution index was between −1 and +1.

## CONCLUSION AND POLICY IMPLICATIONS

The study results showed that organic rice farmers' households were more exposed to climate change impacts than non-organic rice farmers' households. Organic rice farmers lacked information and knowledge on climate change. To lower the risks associated with climate change, organic farmers should monitor the weather forecast and attend agricultural seminars frequently to broaden their knowledge on climate variability.

On the other hand, non-organic rice farmers' households were more sensitive to climate change because they had bigger farm sizes, lacked food and seed reserves, farm ownership status, and low diversification in agricultural business compared to organic farmers. Therefore, to cope with the impacts of climate change, non-organic farmers' households should increase rice production by adding irrigation systems; preparing agriculture/staple stocks; and diversifying to plant, animal, and fish farming. Based on the indicators of food/rice consumption, education, and income, organic rice farmers' households had a higher adaptive capacity than non-organic rice farmers' households. Some strategies that were adopted to anticipate climate change were revenue diversification (on-farm and off-farm jobs), such as driving a motorcycle taxi, working as a laborer, fishing, or making furniture; consuming different combinations of staple foods, such as cassava and corn; and empowering other family members to earn additional income.

Using the overall *LVI* approach, the estimation of the vulnerability of both organic and non-organic rice farmers' households to the effects of climate change revealed a high vulnerability (0.45). However, using the *LVI-IPCC* framework approach, the estimation revealed that non-organic rice farmers' households were more vulnerable to climate change than organic rice farmers' households. Aside from the strategies mentioned above, farmers that practice conventional systems of rice cultivation should change their method to organic farming, which is more environment-friendly and has low production cost. Given the increasing popularity of healthy and organic products, a shift to organic farming will result in greater demand for products and better market prices.

Finally, the *LVI* approach should be tested on a larger scale, such as the livelihood comparison between organic and non-organic farmers' households in different regions or provinces with a higher number of respondents, to better understand the effects of climate change, adaptation strategies, and risks of rice cultivation methods at the national level. Overall, the *LVI* is expected to serve as a useful tool for development planners, government officials, and agriculture instructors to evaluate livelihood vulnerability to climate change in the communities in which they work, and to develop programs and agricultural policy to strengthen the most vulnerable sectors.

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