Adaptation Response of Climate Fluctuation Impact: A Study from Dry Land Farmer Community

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ABSTRACT

Climate change threatens sustainability and the environment, like food production, freshwater, and air condition, especially the dryland ecosystem. Seasonal change of the rainy season and prolonged drought put pressure on the farmer community that experienced a decrease in agriculture production and difficulty in land management. This research aims to find out the dry land farmer adaptation in overcoming climate change impact. The method used was the mixed method through observation, interview, and literature review. The majority of elder farmer respondents are 51-70 years old (46,87%), while a farmer in productive age <50 years old are (34,37%). When in detail, farmer respondents in a young age of <30 years old only 6,25%. Farmer respondents in the research location have senior high school graduate education degrees (40,62%). In 2015, an extreme drought occurred, and the total rainfall was only 1,565 mm^3, then in 2016, it increased to 3,817 mm^3. The change of annual total rainfall, which was great, reached 243%, caused some crops not to adapt well, decreasing agriculture production and farmers' income. Monoculture-based farming patterns impose production costs that continue to increase annually, while contributions to farmer incomes continue to decrease. This matter makes the income decrease from 14% in 2013 to 10,25% in 2018. Besides that, the feasibility analysis of monoculture-based farming also decreased from 4,33 to 2,7. Therefore, the implementation of a multicultural-based farming pattern is the best for adapting the climate change. The multicultural contributes to the farmer income as many as 12,12% and farming business feasibilities of 2,86.

Keywords: *Agriculture, climate fluctuation, farmers, income, plant*

INTRODUCTION

Climate change is a very worrying problem in the social and economic life of the community (Chen et al. 2020; Tang and Hailu 2020). Social and economic aspects are vulnerable to impacts and ecosystem aspects (Cockburn et al., 2018). The impact of climate change on the production sectors becomes the root of social and economic risk problems (Leisner 2020). Climate change threatens agricultural production and potentially presents problems to the sustainability of agricultural production (Challinor et al., 2014). Threats to agricultural production are caused explicitly by rainfall anomalies and frequency (Olayide & Alabi, 2018). This matter will have a broad impact because the agricultural sector fulfils local, regional, and global food needs (Fahad & Wang 2018). The pressure on crop production caused by climate change will undoubtedly raise the risk of inability to fulfil food, and food sustainability will not be achieved.

Food sustainability is based on three aspects: availability, independence, and sovereignty are very difficult to reach due to the decreasing agricultural production and climate change (Lowder & Carisma 2011; Guan et al. 2020). Climate change raises some multidimensional impacts on the agricultural sector, including limited resources of farmers community (Albers 2017), increased risk of invasive alien species of plant introduction (Runyon et al., 2012), agricultural infrastructure, land management system, and risk of harvest failure (Sitepu et al., 2019). When seen in detail, the effect of climate change on the agricultural sector can be categorized into two indicators: vulnerability and impact (Salazar-Espinoza et al., 2015). Vulnerability refers to the biological aspects affected by climate change, which caused the impairment of physiological, phenological and reproductive functions (Fenner, 1998; Paul, 2014). Otherwise, the impact disrupts physical and chemical components and social and economic (Gupta et al. 2019; Omerkhil et al., 2020).

The agricultural sector is experiencing vulnerability and climate change in biological components at some trophic levels and physical components (Sassenrath et al., 2018). Plants get a significant effect due to climate change, especially the change in seasonal patterns of longer dry seasons and shorter rainy seasons with higher intensity (Martin & Saikawa, 2017). Changes in seasonal patterns give pressure because the presence of limiting factors becomes more apparent, for example, increased soil temperatures, decreased humidity, and decreased soil carbon content (Hursh et al., 2017). The limiting factor becomes a real influence that can inhibit the rate of growth and development of plants so that it directly impacts productivity. Climate change puts more extreme pressure in specific conditions that many plants are found dead, resulting in harvest failure (Challinor et al., 2014).

The risk of food sustainability causes this harvest failure because the food availability will be minimal, especially in a local context (Sarkodie & Strezov, 2019). Food availability can be supplied through various cross mechanisms, for example, imports, but this reflects a problem of fulfilling food in the local context that is being disrupted or cannot fulfil the food needs (Irianto, 2016). Fundamentally, the local community's failure to fulfil food has caused a multidimensional impact, especially on social and economic aspects (Neset et al., 2019). This research is conducted to determine the dry land farmer response in overcoming the effects of climate fluctuation and determine the strategic adaptation.

RESEARCH METHOD

Equipment and Material

The equipment needed in this research is a recording device and a camera.

The material needed is an interview guideline and an observation checklist.

Method

This research was conducted using a quantitative approach and mixed-method through observation and interviews with the dry land farmer community. The observation was conducted on the dry agricultural land ecosystem in two villages, i.e. Tanjungpuro and Hadiwarno, in Ngadirojo Sub-district, Pacitan Regency, East Java Province, and the interview was conducted with the dry land agriculture owner and worker as many as 32 people. The samples of 32 people were based on purposive sampling with criteria: (1) owner and worker farmer of dryland agriculture, (2) have owned and work the land for at least ten years, and (3) head of the family.

Equation

This research was conducted in 7 months (February-September 2019). February-September was chosen as the research time as it represented the dry season (February-March 2019) and the rainy season (April-September 2019). This mechanism obtained the research data in two seasons to provide a more comprehensive and profound conclusion. Data were analyzed using the formula of agricultural income (see Formula 1), and farming feasibility analysis (see Formula 2) referred on (Soekartawi, 2006) and interpreted the result of interviewed used triangulation of data sources with the secondary data from several articles and research report.

Farm analysis:
Π = TR-TC..(1)

Description:
Π = Income,
TR = Total income,
TC = Total cost

Farming feasibility analysis:
Farming feasibility = R/C ....(2)

Description:
R = Revenue or total farming income
C = Total farming costs production

The calculation result was categorized in the criteria as follows:

a. R/C < 1, then the farming was having loss or not feasible,
b. R/C > 1, then the farming was profit or feasible,
c. R/C = 1, then the farming was in breakeven point or no profit and no loss.

RESULT AND DISCUSSION

The majority of the farmer in the research location have land for less than 0,5 hectares. Generally, almost whole respondents have an agricultural field (wetland) and also dry land. This research is focused on dry agricultural land and then followed by Table 1. In detail, Table 1 presented the dry land area owned by farmers in the research location.

Table 1. Dryland area owned by farmers

No	Dry Land Area (m^2)	Number of Farmer	Percentage (%)
1	<500	18	56,25
2	501-1.000	6	18,75
3	1.001-1.500	1	3,125
4	1.501-2.000	2	6,25
5	2.001-2.500	1	3,125
6	2.501-3.000	2	6,25
7	3.001-5.000	1	3,125
8	>5.000	1	3,125
	Total	32	100

Source: primary data, 2019

According to Table 1, it is known that all respondents have an agricultural land area of less than 1 hectare; even the majority (56.25%) only has a land area of 0.05 hectares. Limited area of the owned land is the primary factor causing the vulnerability of climate change impacts that farmers feel. This happens due to the narrower the managed land area, the more pronounced the impact of climate change is felt. The conditions in the research location are similar to those in Lesotho, and Sri Lanka in that farmers with limited land have greater vulnerability than farmers with large land (Diyawadana et al., 2017). The vulnerability arises as to the impact of the difficulty of managed land. There are no other production sources other than the narrow land, so it becomes the most significant factor inhibiting production. It will have less risk if the area of agricultural land owned is high. The owned and managed land area is inversely proportional to the difficulty of land management. It can be said that farmers with narrow land areas will be more affected due to changes in environmental conditions, including climate change. This condition is greatly influenced by the experiences and challenges faced by farmers. The longer farmers manage land, the more challenges they face and direct implications for ways or behaviours in overcoming the existing problems, also referred to as land management obstacles, in Table 2. It presents the respondent general profile.

Table 2. General profile of land owner and worker farmers' age

No	Age (years)	Number of Farmers	Percentage (%)
1	<30	2	6,25
2	31-50	9	28,125
3	51-70	15	46,87
4	>71	6	18,75
Total		32	100

Source: primary data, 2019

According to Table 2, it is known that the majority of farmer respondents (46.87%) are elder (51-70 years old). At the same time, farmer respondents in productive age of <50 years old are only (34,37%). When sorted again, farmer respondents in a young age of <30 years old are only (6,25%). It means that work as a farmer tends to be dominated by old age and that young people rarely work as farmers. Working as a farmer is not the type of work desired. This condition has implications for the decreasing number of farmer workers in the future, so the risk of agricultural land being abandoned or not managed can become a natural phenomenon. This finding strengthens the Susilowati (2016) research that the development of the agricultural sector is under threat of unsustainability due to the low number of young farmers, but elderly farmers continue to increase.

The low youth worker in the agricultural sector indicates that working as a farmer is not attractive. Youth worker thinks that working in the agricultural sector is related with low income and low social status. It is caused by the main factor that farmers have a low exchange rate. The farmer exchange rate is one of the parameters to see that working as a farmer is profitable or not and indicators of the farmer welfare (Director Food and Agriculture National Planning Agency, 2013). However, it needs to be understood that the low farmer exchange rate is triggered by some matters based on Pambudi research (2019) which are (1) land management difficulties, especially planting preparation, (2) high potential for attack by plant pests (OPT), (3) the risk of harvest failure as a result of climate change, (4) rainy season and an uncertain dry season, (5) fluctuations in seed and fertilizer price, (6) the low selling price of the harvest, and (7) low quantity and quality of harvests.

Various obstacles faced by farmers can be solved if the fundamental problems are identified, like a soil type, dry and rainy season, and the anomaly. A comprehensive and holistic understanding of existing problems becomes the primary foundation for finding solutions transforming problems into challenges to be overcome. The understanding of this problem is influenced by the level of education and agriculture management practices. According to the research of Susanti et al. (2016), the level of education has a positive influence on agricultural production. It means that the higher the farmer education, the ability to manage agricultural land and the ability to face and overcome various agricultural problems/obstacles can be conducted well. Therefore, generally, farmers with a high education will be more accessible in solving problems and obstacles in farming. Table 3 is presented the data on farmer education in the research location.

Table 3. General profile of land owner and worker farmer education

No	Education	Number of Farmers	Percentage (%)
1	Not Graduated from Elementary School	5	15,6
2	Elementary School	10	31,3
3	Junior High School	4	12,5
4	Senior High School	13	40,6
5	Diploma	0	0,0
6	Graduate Program	0	0,0
Total		32	100,0

Source: primary data, 2019

According to Table 3, it is known that the majority of farmer respondents in the research location were high school graduates (40,625%). In general, all farmer respondents are high school graduates, and farmers with higher education levels are not found. This condition is in line with Susilowati (2016) research that the worker in agriculture is dominated by people with a lower level of educational background. This finding also strengthens the research of Widyawati & Pujiyono (2013), which stated that low levels of education are a limiting factor for accessing employment, so deciding to become a farmer is the easiest rational choice. This phenomenon is also in line with the results of research from the Ministry of Agriculture (2016) that the number of workers in the agricultural sector, especially in village areas, shows a decreasing trend. Low educational level is related to the ability to understand a problem holistically and analyzed a series of phenomena that occur.

One of the factors causing the decrease in young labour is the migration of people from the village to the city. The decision of young workers to migrate from village to city is very rational, due to the condition of agricultural land is increasingly challenging to be managed and not economical. This finding supports the previous research of Adu et al. (2018) that the productive youth workforce tends to leave the homeland based on the agricultural sector. The migration flow is accelerated by the worsening impact of climate change, which makes the land more challenging to manage. In 2015 migration from Pacitan to Surabaya was 348 people, Madiun was 199 people, Kediri 297 people, Sidoarjo was 68 people, and Pasuruan 83 people (Central Bureau of Statistic East Java, 2016). One of the problems in agricultural land management is due to the very high dependence on climatic conditions, so farmers do not have resilience in the event of a climate anomaly (shifting of the rainy season and dry season).

The shifting season is the delay of the rainy season. Typically, the rainy season starts in October, but the rainy season starts in December during research. Farmers delay for the paddy planted 2-3 months. This is similar to Ashok & Sasikala (2012) research, which stated that technology is indispensable for climate anomaly interventions to increase farmer resilience. However, if technology has not yet been presented, harvest failure continues to spread. As the results of Montle & Teweldemedhin (2014) research, some technologies can be applied to increase farmer resilience by making engineering or design irrigation channels. At the research location, farmers deliberately leave the land unmanaged until the rainy season comes (emphasizing) as the response to climate anomalies. The finding in this research is consistent with the study Galbreath et al. (2016), which stated that community understanding is very relevant to the efforts made to overcome obstacles in facing the impacts of climate change. In this research, farmers with higher education can apply more adaptive agricultural systems, multicultural and selecting type of plant according to ecological characteristics (sweet potato, red beans, long bean, and cassava).

The farmer chooses the emphasis because there are no technological interventions that can be applied to overcome these problems. Farmers in the research location are classified as conventional farmers who still have a dependence on environmental conditions, especially climate. Farmer dependence on climate in North Ghana as research Etwire et al. (2013) that dry land farmer is very vulnerable to the climate anomaly and non-existing technology to manipulate the climate becomes an inhibiting factor in obtaining maximum harvest. The condition is getting worse by the unmanaged land by farmers because it is considered in vain and does not provide harvests. Therefore, if an anomaly is a prolonged dry season, then the agricultural land in the research location is left unmanaged as in North Ghana.

On the other hand, if it rains very heavily and causes flooding, agricultural land will also experience harvest failure. The conditions at this research location are consistent with Balana et al. (2020). The agricultural vulnerability now faces the climate anomaly problem: the prolonged dry season or heavy rainfall and cause the flood. One way to overcome this is to map annual rainfall levels (see Figure 1). The annual rainfall interval can be identified as a basis for selecting appropriate (adaptive) plant species through mapping.

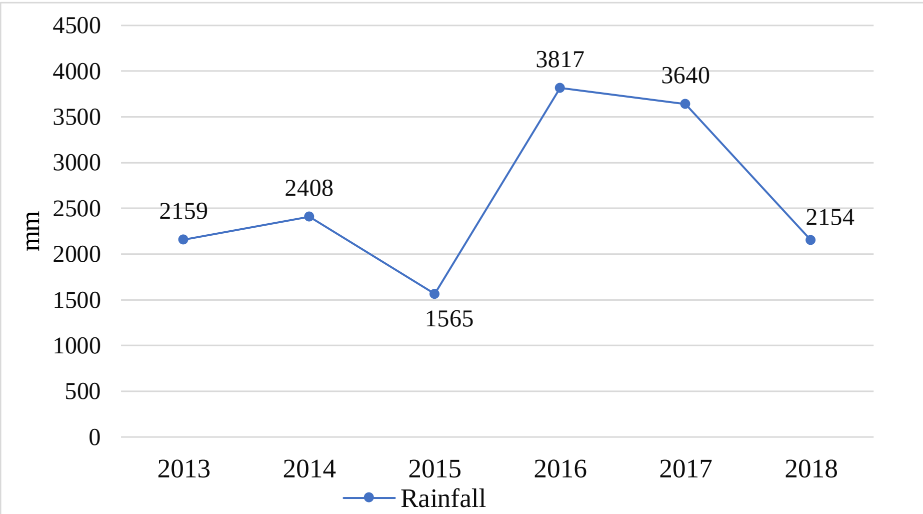

Figure 1. Rainfall in Ngadirojo Sub-district in 2013-2018 (mm)
Source: (Central Bureau of Statistic Agency Pacitan Regency, 2017)

According to Figure 1, it is known that the annual rainfall at the research location is very fluctuating. The annual rainfall interval can also be high because, in 2015, the rainfall was only 1,565 $mm^{3,}$ then in 2016, it increased to 3,817 mm^3. Increased rainfall that occurs even more than 100% means that the intensity of annual rainfall is greatly influenced by macro factors, such as climate, wind direction, type of wind, and others. Because these conditions are natural phenomena that humans cannot control, farmers must apply adaptive farming patterns toward environmental conditions change. Inability to adapt to climatic conditions will decrease production and income, so working in the agricultural sector is no longer profitable. This is consistent with the Olayide & Alabi (2018) research that rainfall often becomes an inhibiting factor in agricultural cultivation and is difficult to control by humans.

The beneficial concept interpreted by farmer respondents is that they can still cultivate agricultural land with physical and material capabilities, and the harvests can fulfil the needs. This beneficial interpretation can be different from the farming profit concept in general, which must be based on the calculation of production costs as a deduction variable from the sale value of the harvest. However, because most farmers in the research location only manage one or two plots of land with a size <500 m2, the harvest is generally only consumed for family needs. Thus, farmers negate profit and loss in economic calculations but emphasize providing food for their families (family food independence).

Family food independence becomes the most important thing for farmers in the research location to ensure the adequacy of daily foods. Therefore, they will save their harvest (rice, peanuts, green beans, etc.). The research location also develops local wisdom. When a farmer is harvesting, a portion of the harvest will be given to his neighbours. The local wisdom has been developed for generations and continues to be preserved as part of a positive culture. The culture of giving the harvest makes food security in the community better because those who do not grow a food crop can still enjoy it. This is consistent with Waha et al. (2018), which stated that diversification of food crops as a cultivation commodity is one of the best choices for increasing food security. Here, Figure 2 is shown the dominant types of plants cultivated by dry land farmers in the research location.

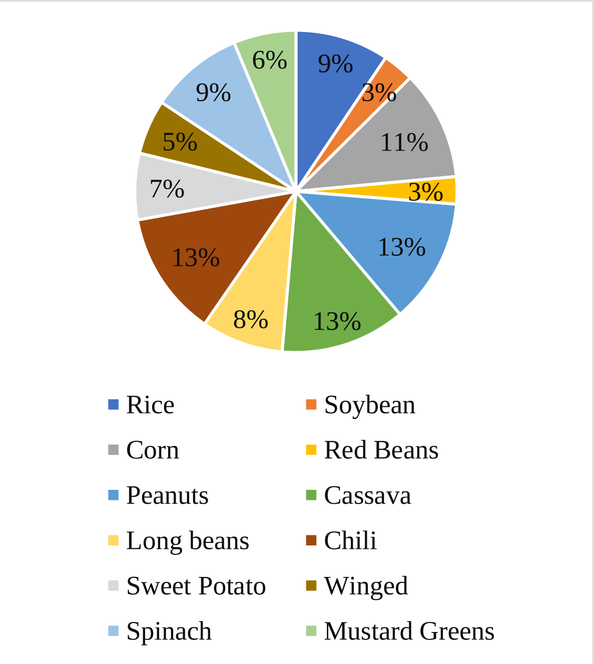

Figure 2. Types of crop that dry land farmer cultivates
Source: primary data, 2019

According to Figure 2, it can be seen that farmers in the research location have a tendency to plant food crops and vegetables. These crops cultivated include rice and food crops as substitutes for rice (corn, sweet potato, and cassava). In general, the types of plants that are cultivated are water-tolerant types. This means that the choice of plant species is by climatic conditions that continue to experience fluctuations as Lesnikowski et al. (2013) that plant species selection is essential for climate change adaptation efforts in the agricultural sector. If seen from this side, farmers have adopted an adaptive agricultural pattern to climate change. However, it needs to be further examined how the cropping patterns applied to ensure agricultural production in quantity and quality are also optimal.

Optimization of agricultural production cannot be separated from selecting suitable plant species with ecological characteristics and climatic conditions. Ecological characteristics are generally correlated with microclimate and largely determine the growth and development of cultivated agricultural commodities. The research location in Pacitan Regency is generally dominated by dry agricultural land and rain-fed rice fields. The characteristics of dry land and rain-fed rice field need to be managed in a certain way, both in the pattern of planting and the choice of plant species. Moreover, an area's biological and physical conditions significantly affect the suitability of adaptation forms Soares et al. (2012). Here, Figure 3 shows the production data of agricultural commodities is displayed at the research location

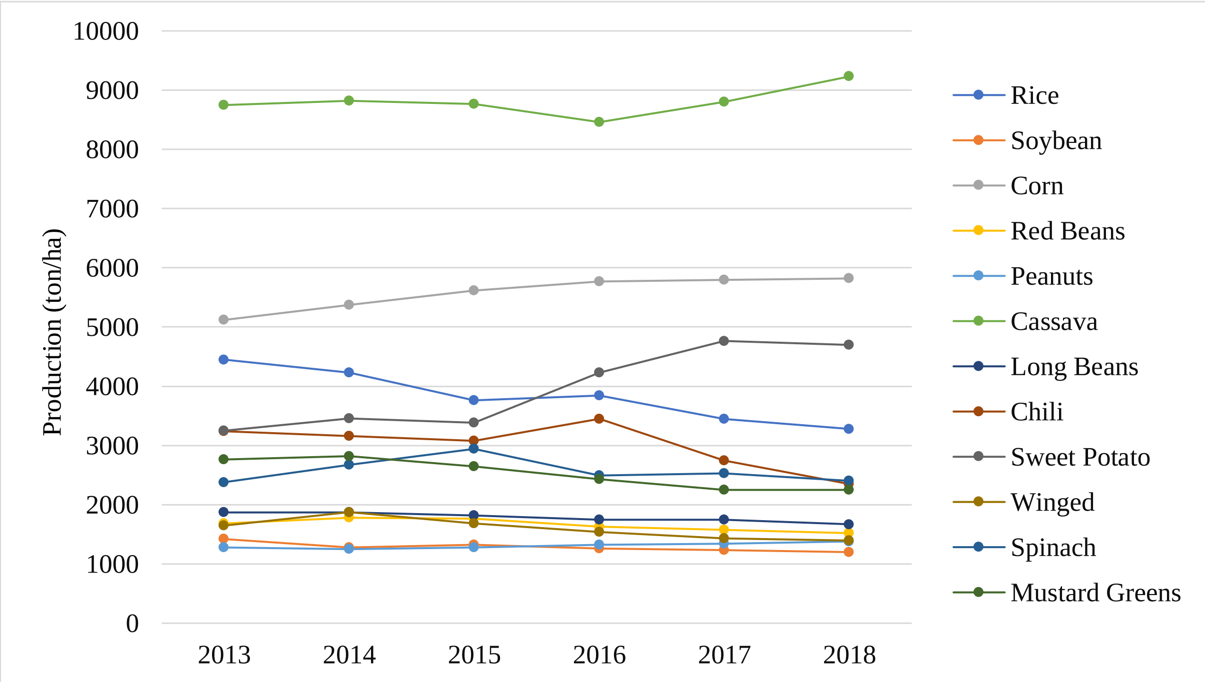

Figure 3. Average agricultural production (ton/ha) based on time
Sources: (Department of Agriculture of Pacitan Regency, 2018)

According to Figure 3, it is known that cassava has the highest production of around 9 tons/ha. In comparison, rice, as a favourite commodity and the primary food source, only produces between 3-4 tons/ha. When examined in detail, almost all agricultural commodities experienced a downward trend in production from 2013 to 2018. Among the 12 types of commodities, there are only 3 types that the production has experienced an upward trend from 2013 to 2018: cassava, corn, and sweet potato. This means that these three commodities have better resilience for climate fluctuations caused by inherent characteristics. These three types of plant have a character suitable for the micro-climate, soil type, and slope in this location to grow optimally. These three types of plants can be optimized for cultivation. The research results Abdelzaher et al. (2020) that the community or country must innovate to determine its position in overcoming climate change. This means that optimizing the cultivation of these three adaptive plant species represents the best position of dryland farmers in overcoming the impact of climate change.

The decrease in the production of 9 types of plants needs to be paid attention to find the solution. Interventions with superior seeds and more intense fertilizer application, according to the researchers, are not the best choice for overcoming the problem. These two interventions are reactive in response to climate fluctuations and climate anomalies but are only a short-term solution. This means that when there is a prolonged fluctuation in fertilizer, it must be given more and research to create superior seeds also needs to be done continuously (Brouder & Volenec, 2008). This will increase production costs and not guarantee the quality of the harvest. Another risk that arises is unsustainable agricultural commodity production due to dependence on seeds and fertilizer. If this is done, then adaptation will never be complete because it is only reactive. The Li i. (2019) research results that the reactive effort is not a solution and will burden the adaptation efforts in the future.

Dependence on a component in a cultivation system raises the risk to the harvest. The risk arises when the primary factor outside the standard conditions, as if a plant that requires much water shifts the rainy season, so crop failure becomes a threat. Therefore, researchers consider that selecting plants that are adaptive to climate fluctuations is the best solution. In the future, with the increasing risk of fluctuations and climate anomalies, each region needs to map its ecological characteristics as a basis for determining the appropriate type to be cultivated. For example, in the research location based on 12 types of plants cultivated only 3 types that the production has increased, then these 3 types should be cultivated optimally. Implementation of this will refer to the concept of the agricultural ecoregion, which encourages the realization of agricultural sovereignty. An ecoregion is a micro-climatic character, soil type, slope, and geomorphology of an area. Thus, all regions cannot be forced to plant similar types of crops such as rice. Each region must develop types of plants that are suitable and adaptive to climate fluctuations. It is consistent with the research results of Bindi & Olesen (2011), which stated that agricultural systems should be adapted to the region's characteristics to improve adaptability because crop similarity is not the best solution to adapt to climate change impacts. Therefore, agricultural ecoregions are considered capable of increasing agricultural production and the value of people incomes. The type that is adaptive to climate fluctuations does not require expensive planting costs. However, if it imposes unsuitable species, the planting costs will be expensive, and the value of farmer income will decrease. This concept is consistent with the Kvalvik et al. (2011) research that appropriate adaptation will reduce or even eliminate inhibition in managing agricultural land. Hence, the obstacles faced will become opportunities that can generate profits.

Farmer profit value becomes vital in an agricultural system because, generally, the harvest will be consumed by the farmer household, and the rest will be sold (Pambudi & Waryono, 2018). It means that farmers will be able to meet other living needs from the sale of their harvest. This condition is consistent with the Khanal & Wilson (2019) research results which stated that most small farmers make harvests as an economic foundation. If agricultural productivity is low, the farmer will lose some of the income. It is also found in research locations where farmers can obtain high income if the chosen type of plant is correct, so that the cost of planting and maintenance is affordable, then the harvest becomes optimal. In detail, the average expense and income of farmers are shown in Figure 4 below.

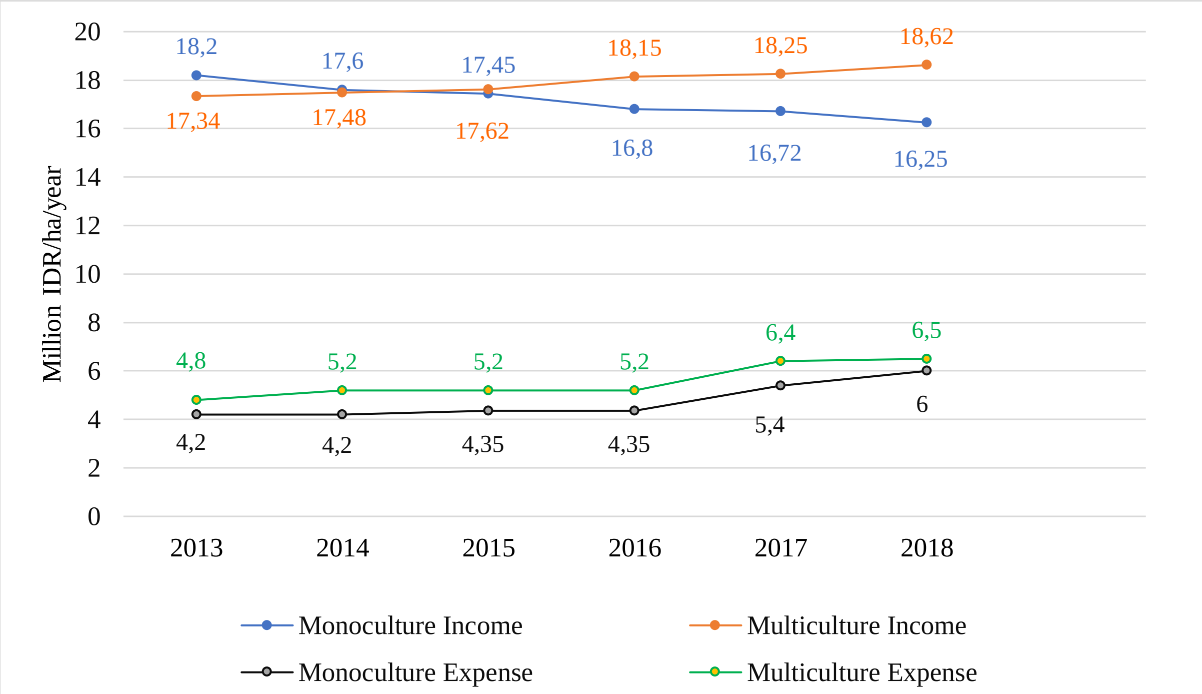

Figure 4. Average income and expense of dryland farming communities (IDR/ha/year)
Source: primary data, 2019

Figure 4 shows that the expense of farmers both for those who plant monocultures and multicultural is equally increasing. It means that the cost of managing agricultural land continues to increase along with climate fluctuations. The expense on monocultural patterns is much more significant when seen in detail, increasing by 4.2 million rupiah/ha/year in 2013 to 6 million rupiah/ha/year. Thus, the increase in expenses by farmers is 0.3 million rupiah/ha/year. Meanwhile, the farmer expenditure on multicultural farming has increased by 283 thousand rupiah/ha/year. When viewed from the expense aspect, the two farming patterns applied are the same as imposing costs that continue to increase each year. It cannot be denied because climate fluctuation is very influential on the adaptability of cultivated plants. The findings of this research support previous research conducted by Chatzopoulos et al. (2020) that climate change impacts the economy, including the agricultural sector, because some types of agricultural commodities cannot grow well under the pressure of climate change. Climate fluctuations cause some plants to grow slower and even die, so farmers need to replant (replanting) and provide more fertilizer.

Increased application of fertilizer is not a long-term solution and only a reactive response. Excessive application of fertilizers will increase the potential for plant dependence on external subsidies for nutrition, even though nutrients are always available in the biogeochemical cycle in an ecosystem. It supports Wu et al. (2017), which stated that Excessive nutrition to plants in climate fluctuations would only increase the dependence of these plants. Therefore, when seen in Figure 4, especially in terms of income, monoculture patterns continue to decrease annually. Noted farmers who apply monocultural patterns have a decreasing income by 325 thousand/ha/year. It is not how considerable the decrease is, but the downward trend is quite alarming if it occurs for a long time.

Moreover, the monocultural pattern has increased production costs, and farmers have a decreasing income. It is indeed worrying for the sustainability of farming systems and farmer households. On the other hand, farmers who apply multicultural patterns continue to experience an increase in 213 thousand/ha/year income. According to Figure 4, the application of multicultural farming patterns has better prospects in the middle of climate fluctuations threat (Pramudianto et al., 2019). In detail, to find out the feasibility of farming conducted both monocultural and multicultural can be seen in the following Figure 5.

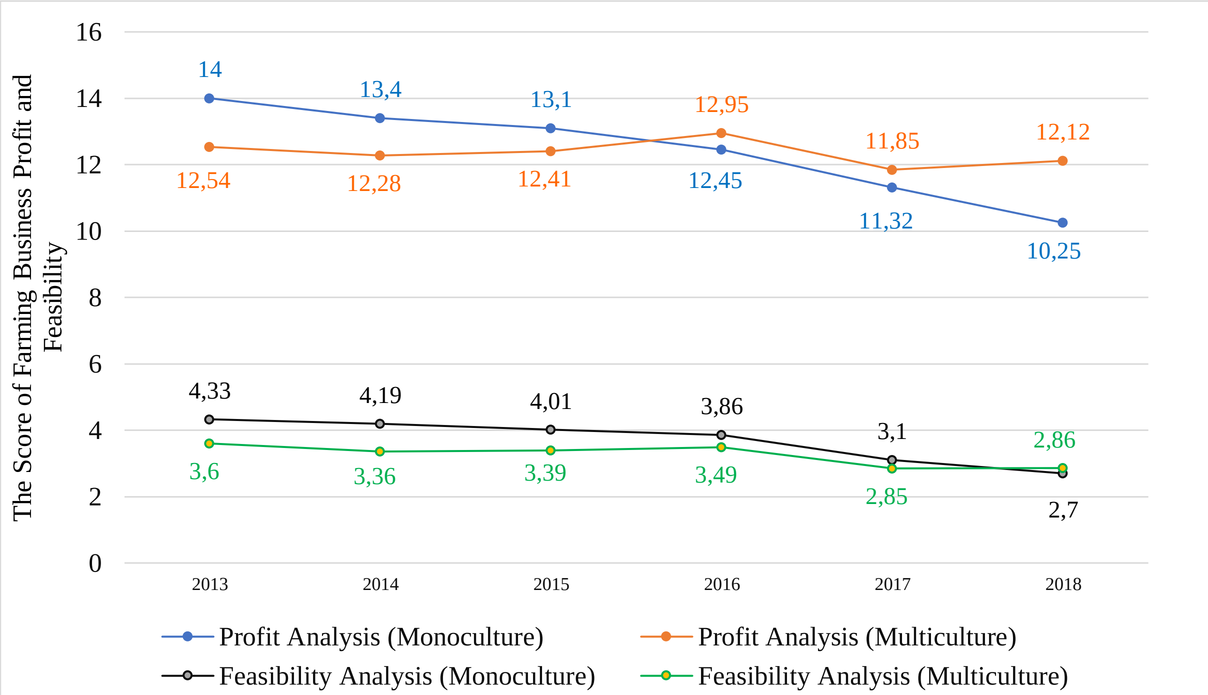

Figure 5. Analysis of income and feasibility of dry land farming
Source: primary data, 2019

According to Figure 5, it is known that the profits of farming by applying monocultural patterns continue to decrease from 14% to 10.25%. Rising expenses and decreasing income cause this decrease. Thus, in the middle of increasingly extreme climate fluctuations, the monocultural pattern is less recommended because profits continue to decrease when viewed from the aspect of profits. This finding is consistent with Guest (2010) which stated that the agricultural economy continues to experience the threat of unsustainability amid climate fluctuations. If there is no intervention, it is feared that in the future, it will collapse if the monocultural pattern is still maintained. However, based on a review of the feasibility analysis, the monocultural pattern is still feasible with a value of 2.7. It should be noted that if the feasibility value is more than 1, the business can continue. However, it should be noted that the greater the value, the better the business. Susanti & Waryanto (2017) mentioned that planting with monocultural patterns has advantages and disadvantages. The advantage of this farming pattern is that the cultivation technique is relatively easy because only one type of plant is planted. While the weakness of this system is that plants are relatively susceptible to disease and pests.

Multicultural farming systems, if viewed from Figure 5, have a better future in the middle of increasingly worrying climate fluctuations. Even though it has decreased, the multicultural pattern has a more significant profit value of 12.12%. Multicultural patterns need to be put forward because they are considered more adaptive to the climate change impact. Besides, the application of multicultural patterns (2.86) also provides higher worthiness compared to monocultural. Thus, the application of multicultural patterns in the dry land agriculture sector is better in terms of the profitability and feasibility of farming (Pambudi & Utomo, 2019). The multicultural patterns need to be optimized and mainstreamed to encourage the realization of an agricultural system that can provide a decent living for farming families. This mechanism supports Howard-Grenville et al. (2014) research that managing agricultural land for productivity and an income optimization is a form of adaptation.

Multicultural patterns, in addition to providing higher worthiness and other advantages compared to monocultural patterns, there are some weaknesses in this farming pattern, which are nutrient competition among plants and increasing plant pests. The more types of commodities planted, the higher the competition of nutrients absorbed because, in the same land, the nutritional needs of each plant are different, which can interfere with plant growth. Susanti & Waryanto (2017) confirmed this, stating that multicultural patterns have weaknesses, including competition for nutrient absorption and the number of OPT (Plant Pests Organism), making it more difficult to control.

CONCLUSION AND RECOMMENDATION

Conclusion

Most dryland farmers in the research location only have a land area of 0.05 ha (56,25%). Small/narrow land owned triggers the vulnerability of farmer economy in overcoming climate change impact. Farmers must consider agroecology to choose suitable commodities. It is worsened by elderly farmers (51-70 years old) that dominate the farmer age structure in the research location as many as 46,87%. Meanwhile, young farmers (future farmers) less than 30 years old are only 6,25%. This condition is quite worrying because it can see that there will be a vacancy of farmers for the next few years and is worsened by climate fluctuations. If no intervention is made, the agriculture sector will collapse, and food sovereignty is at stake. Most farmers are high school graduates/equal, and no farmer has a higher education level. It is related to opportunities and employment so that the agricultural sector is more open and becomes the ideal sector, especially research conducted in rural areas.

The most widely planted agricultural commodities are chilli, cassava, and peanuts, respectively 13%. Climatic conditions that fluctuate due to global climate change to drive the local impact like El-Nino pose a risk to the social and economic stability of farmer households. Because of the 12 types of commodities commonly planted, there are only three types that the production has increased from 2013 to 2018. These commodities are cassava, corn, and sweet potatoes, while nine other commodities continue to decrease in production because they are affected by climate fluctuations. Farmers quite feel this impact because the income of farmers who apply the monocultural pattern (cassava or corn or sweet potatoes) continues to decrease, and the cost continues to increase, so the profit is only 10.25% remaining with a farming feasibility value of 2.7.

On the other hand, farmers who apply multicultural patterns with trees like Aqularia spp., Sesbania gandlifora, and Gnetum gnemon as a primary and Zea mays, Manihot sp., and Vigna angularis as a secondary, and Oryza sativa, Capsicum annum, Amaranthus sp., and Arachis hypogea as a tertiary, the expense is also increasing, but offset by increased incomes, so it is more promising to continue applying multicultural patterns. It contributes to the profit value of 12.12%, with a farming feasibility value of 2.86. Applying multicultural farming patterns is one of the best forms of adaptation in the agricultural sector in overcoming the worrying climate change.

Recommendation

We proposed recommendations including:

1. Farmers need to apply a multicultural pattern with local plant types in accordance with ecological characteristics, including (cassava, sweet potato, peanuts, kidney beans, and chilies).
2. The Department of Agriculture and Plantation of Pacitan Regency needs to provide training support, coaching and assistance for farmers to be more adaptive to climate fluctuations.

ACKNOWLEDGMENT

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REFERENCES

Books:

Irianto, G. (2016). *Lahan dan Ketahanan Pangan [Land and Food Sovereignty]*. Gramedia Utama.

Soekartawi. (2006). *Analisis Usaha Tani [Analysis of Bussiness Farming*]. Universitas Indonesia Press.

Reports:

Central Bureau of Statistic Agency

Pacitan Regency. (2017). *Pacitan Regency in Figures 2018*. BPS-Statistic of Pacitan Regency.

Department of Agriculture of Pacitan Regency. (2018). *Statistic of Food Agriculture of Pacitan Regency* 2018.

Li, D., Zhou, T., & Zhang, W. (2019). *Extreme precipitation over East Asia under 1.5 °C and 2 °C global warming targets: a comparison of stabilized and overshoot projections.* Environmental Research Communications, 1(8), 085002. https://doi.org/10.1088/2515-7620/ab3971

Ministry of Agriculture, R. I. (2016). *Agricultural Statistic 2016*. Center for Agricultural Data and Information System Ministry of the Agriculture Republic Republic of Indonesia.

Susanti, A. A., & Waryanto, B. (2017). *Agricultural Statistics 2017*. Center for Agricultural Data and Information System Ministry of the Agriculture Republic of Indonesia.

Articles:

Abdelzaher, D. M., Martynov, A., & Abdel Zaher, A. M. (2020). *Vulnerability to climate change: Are innovative countries in a better position?* Research in International Business and Finance, 51(November 2018), 101098. https://doi.org/10.1016/j.ribaf.2019.101098

Adu, D. T., Kuwornu, J. K. M., Anim-Somuah, H., & Sasaki, N. (2018). *Application of livelihood vulnerability index in assessing smallholder maize farming households' vulnerability to climate change in Brong-Ahafo region of Ghana. Kasetsart* Journal of Social Sciences, 39(1), 22–32. https://doi.org/10.1016/j.kjss.2017.06.009

Albers, J. H. (2017). *Human rights and climate change protecting the right to life of individuals of present and future generations.* Security and Human Rights, 28(1–4), 113–144. https://doi.org/10.1163/18750230-02801009

Ashok, K. . R., & Sasikala, C. (2012). *Farmers' Vulnerability to Rainfall Variability and Technology Adoption in Rain-fed Tank Irrigated Agriculture.* Agricultural Economics Research Review, 25(2), 267–278.

Balana, B. B., Bizimana, J. C., Richardson, J. W., Lefore, N., Adimassu, Z., & Herbst, B. K. (2020). *Economic and food security effects of small-scale irrigation technologies in northern Ghana*. Water Resources and Economics, 29(March 2019), 100141. https://doi.org/10.1016/j.wre.2019.03.001

Bindi, M., & Olesen, J. E. (2011). *The responses of agriculture in Europe to climate change.* Regional Environmental Change, 11(SUPPL. 1), 151–158. https://doi.org/10.1007/s10113-010-0173-x

Brouder, S. M., & Volenec, J. J. (2008). *Impact of climate change on crop nutrient and water use efficiencies*. Physiologia Plantarum, 133(4), 705–724. https://doi.org/10.1111/j.1399-3054.2008.01136.x

Bruno Soares, M., Gagnon, A. S., & Doherty, R. M. (2012). *Conceptual elements of climate change* *vulnerability assessments: A review*. International Journal of Climate Change Strategies and Management, 4(1), 6–35. https://doi.org/10.1108/17568691211200191

Challinor, A. J., Watson, J., Lobell, D. B., Howden, S. M., Smith, D. R., & Chhetri, N. (2014). *A meta-analysis of crop yield under climate change and adaptation.* Nature Climate Change, 4(4), 287–291. https://doi.org/10.1038/nclimate2153

Chatzopoulos, T., Pérez Domínguez, I., Zampieri, M., & Toreti, A. (2020). *Climate extremes and agricultural commodity markets: A global economic analysis of regionally simulated events.* Weather and Climate Extremes, 27(October 2018), 100193. https://doi.org/10.1016/j.wace.2019.100193

Chen, Y., Liu, A., & Cheng, X. (2020). Q*uantifying economic impacts of climate change under nine future emission scenarios within CMIP6*. Science of the Total Environment, 703, 134950. https://doi.org/10.1016/j.scitotenv.2019.134950

Cockburn, J., Cundill, G., Shackleton, S., & Rouget, M. (2018). T*owards place-based research to support social-ecological stewardship.* Sustainability (Switzerland), 10(5). https://doi.org/10.3390/su10051434

Diyawadana, D. M. N., Pathmarajah, S., & Gunawardena, E. R. N. (2017). *Vulnerability of smallholder farmers to climate change: a case study from Hakwatuna-Oya irrigation scheme in Sri Lanka*. Tropical Agricultural Research, 28(3), 223. https://doi.org/10.4038/tar.v28i3.8227

Etwire, P. M., Al-Hassan, R. M., Kuwornu, J. K. M., & Osei-Owusu, Y. (2013). *Smallholder farmers' adoption of technologies for adaptation to climate change in Northern Ghana.* Journal of Agricultural Extension and Rural Development, 5(6), 121–129. https://doi.org/10.5897/JAERD13.0481

Fahad, S., & Wang, J. (2018). F*armers' risk perception, vulnerability, and adaptation to climate change in rural Pakistan.* Land Use Policy, 79(August), 301–309. https://doi.org/10.1016/j.landusepol.2018.08.018

Fenner, M. (1998). *The phenology of growth and reproduction in plants. Perspectives in Plant Ecology*, Evolution and Systematics, 1(1), 78–91. https://doi.org/10.1109/CRMICO.2002.1137327

Galbreath, J., Charles, D., & Oczkowski, E. (2016). T*he Drivers of Climate Change Innovations: Evidence from the Australian Wine Industry*. Journal of Business Ethics, 135(2), 217–231. https://doi.org/10.1007/s10551-014-2461-8

Guan, Y., Zhou, W., Bai, Z., Cao, Y., Huang, Y., & Huang, H. (2020). *Soil nutrient variations among different land use types after reclamation in the Pingshuo opencast coal mine on the Loess Plateau, China.* Catena, 188, 1–11. https://doi.org/10.1016/j.catena.2019.104427

Guest, R. (2010). *The economics of sustainability in the context of climate change: An overview*.

Journal of World Business, 45(4), 326–335. https://doi.org/10.1016/j.jwb.2009.08.008

Gupta, A. K., Negi, M., Nandy, S., Alatalo, J. M., Singh, V., & Pandey, R. (2019). *Assessing the vulnerability of socio-environmental systems to climate change along an altitude gradient in the Indian Himalayas*. Ecological Indicators, 106(June), 105512. https://doi.org/10.1016/j.ecolind.2019.105512

Howard-Grenville, J., Buckle, S. J., Hoskins, B. J., & George, G. (2014). *Climate change and management*. Academy of Management Journal, 57(3), 615–623. https://doi.org/10.5465/amj.2014.4003

Hursh, A., Ballantyne, A., Cooper, L., Maneta, M., Kimball, J., & Watts, J. (2017). *The sensitivity of soil respiration to soil temperature, moisture, and carbon supply at the global scale*. Global Change Biology, 23(5), 2090–2103. https://doi.org/10.1111/gcb.13489

Khanal, U., & Wilson, C. (2019). *Derivation of a climate change adaptation index and assessing determinants and barriers to adaptation among farming households in Nepal*. Environmental Science and Policy, 101(August), 156–165. https://doi.org/10.1016/j.envsci.2019.08.006

Kvalvik, I., Dalmannsdottir, S., Dannevig, H., Hovelsrud, G., Rønning, L., & Uleberg, E. (2011). *Climate change vulnerability and adaptive capacity in the agricultural sector in Northern Norway*. Acta Agriculturae Scandinavica Section B: Soil and Plant Science, 61(SUPPL.1), 27–37. https://doi.org/10.1080/09064710.2011.627376

Leisner, C. P. (2020). *Review: Climate change impacts on food security-focus on perennial cropping systems and nutritional value*. Plant Science, 293(December 2019), 110412. https://doi.org/10.1016/j.plantsci.2020.110412

Lesnikowski, A. C., Ford, J. D., Berrang-Ford, L., Barrera, M., & Heymann, J. (2013). *How are we adapting to climate change? A global assessment*. Mitigation and Adaptation Strategies for Global Change, 20(2), 277–293. https://doi.org/10.1007/s11027-013-9491-x

Lowder, S. K., & Carisma, B. (2011). *Financial resource flows to agriculture investment* (Issue 11).

Martin, G., & Saikawa, E. (2017). *Effectiveness of state climate and energy policies in reducing power-sector CO2 emissions*. Nature Climate Change, 7(12), 912–919. https://doi.org/10.1038/s41558-017-0001-0

Montle, B. P., & Teweldemedhin, M. Y. (2014). *Assessment of farmers perceptions and the economic impact of climate change in Namibia: Case study on small-scale irrigation farmers (SSIFs) of Ndonga Linena irrigation project*. Journal of Development and Agricultural Economics, 6(11), 443–454. https://doi.org/10.5897/jdae2014.0596

Neset, T., Asplund, T., & Käyhkö, J. (2019). *Making sense of maladaptation: Nordic agriculture* *stakeholders perspectives Content courtesy of Springer Nature, terms of use apply*. Rights reserved. Content courtesy of Springer Nature, terms of use apply. Rights reserved. Climatic Change, 153, 107–121.

Olayide, O. E., & Alabi, T. (2018). *Between rainfall and food poverty: Assessing vulnerability to climate change in an agricultural economy*. Journal of Cleaner Production, 198, 1–10. https://doi.org/10.1016/j.jclepro.2018.06.221

Omerkhil, N., Chand, T., Valente, D., Alatalo, J. M., & Pandey, R. (2020). *Climate change vulnerability and adaptation strategies for smallholder farmers in Yangi Qala District, Takhar, Afghanistan.* Ecological Indicators, 110(June 2019), 105863. https://doi.org/10.1016/j.ecolind.2019.105863

Pambudi, P. A., & Utomo, S. W. (2019). *Pendekatan eko-habitat sebagai strategi untuk meningkatkan pendapatan masyarakat pertanian.* Jurnal Ekonomi & Kebijakan Publik, 10(2), 157–170.

Pambudi, P. A., & Waryono, T. (2018). *Life cycle assessment of dryland paddy farming in Ngadirojo District, Pacitan*. E3S Web of Conferences, 74, 1–7. https://doi.org/10.1051/e3sconf/20187407001

Paul, S. K. (2014). *Vulnerability Concepts and its Application in Various Fields: A Review on Geographical Perspective.* Journal of Life and Earth Science, 8(May 2013), 63–81. https://doi.org/10.3329/jles.v8i0.20150

Pramudianto, A., Sudaryanto, Utomo, S. W., & Pambudi, P. A. (2019). *Suitability of agroforestry system against climate conditions in Tugu Utara Village, Cisarua Sub-District, Bogor.* IOP Conference Series: Earth and Environmental Science, 399(1). https://doi.org/10.1088/1755-1315/399/1/012095

Runyon, J. B., Butler, J. L., Friggens, M. M., Meyer, S. E., & Sing, S. E. (2012). *Invasive species and climate change.* USDA Forest Service - General Technical Report RMRS-GTR, 285 GTR, 97–115. https://doi.org/10.2307/j.ctv8jnzw1.34

Salazar-Espinoza, C., Jones, S., & Tarp, F. (2015). *Weather shocks and cropland decisions in rural Mozambique.* Food Policy, 53, 9–21. https://doi.org/10.1016/j.foodpol.2015.03.003

Sarkodie, S. A., & Strezov, V. (2019). *Effect of foreign direct investments, economic development and energy consumption on greenhouse gas emissions in developing countries.* Science of the Total Environment, 646, 862–871. https://doi.org/10.1016/j.scitotenv.2018.07.365

Sassenrath, G. F., Davis, K., Sassenrath-Cole, A., & Riding, N. (2018). *Exploring the Physical, Chemical and Biological Components of Soil: Improving Soil Health for Better Productive Capacity.* Kansas Agricultural Experiment Station Research Reports, 4(3). https://doi.org/10.4148/2378-5977.7577

Sitepu, M. H., McKay, A., & Holt, R. J. (2019). *An approach for the* *formulation of sustainable replanting policies in the Indonesian natural rubber industry.* Journal of Cleaner Production, 241, 118357. https://doi.org/10.1016/j.jclepro.2019.118357

Susanti, D., Listiana, N. H., & Widayat, T. (2016). T*he Influence of the Farmer Ages, Levels of Education and Land Area to Blumea Yields.* Jurnal Tumbuhan Obat Indonesia, 9(2), 75–82. http://ejournal.litbang.kemkes.go.id/index.php/toi/article/view/7848

Susilowati, S. H. (2016). *Farmers Aging Phenomenon and Reduction in Young Labor: Its Implication for Agricultural Development.* Forum Peneliti. Agroecon., 34(1), 35–55.

Tang, K., & Hailu, A. (2020). *Smallholder farms' adaptation to the impacts of climate change: Evidence from China's Loess Plateau.* Land Use Policy, 91(October), 104353. https://doi.org/10.1016/j.landusepol.2019.104353

Waha, K., van Wijk, M. T., Fritz, S., See, L., Thornton, P. K., Wichern, J., & Herrero, M. (2018). *Agricultural diversification as an important strategy for achieving food security in Africa.* Global Change Biology, 24(8), 3390–3400. https://doi.org/10.1111/gcb.14158

Widyawati, R. F., & Pujiyono, A. (2013). *Effect of Age, Amount of Family Responsibility, Amount Land, Education, Distance of Workers Life to Place of Work, and Advantages of Output Working Time of Female Agriculture Sector in Tajuk Village, Getasan regency, Semarang.* Diponegoro Journal of Economics, 2(3), 1–14. http://ejournal-s1.undip.ac.id/index.php/jme

Wu, Q. S., Srivastava, A. K., Zou, Y. N., & Malhotra, S. K. (2017). *Mycorrhizas in citrus : Beyond soil fertility and plant nutrition.* Indian Journal of Agricultural Sciences, 87(4), 427–443.