Characteristics and farmer’s response to climate variability to support sustainable agriculture: case study in Tasikmalaya, West Java

W Estiningtyas\(^1\)*, Suciantini\(^1\) and S K Dermoredjo\(^2\)

\(^1\) Indonesian Agroclimate and Hidrology Research Institute, Jl. Tentara Pelajar 1A Bogor, Indonesia
\(^2\) Indonesian Center for Agricultural Socio Economic and Policy Studies, Jl. Tentara Pelajar 3B Bogor, Indonesia

Corresponding author: woro_esti@yahoo.com

Abstract. Rice farming is strongly influenced by climate conditions. The availability of water from rainfall is a major consideration for farmers when determining the start of planting, while the beginning rainfall will change due to extreme climate events. The impact of climate variability as floods, droughts and attacks from pests and diseases brings losses for farmers in their food farming. The purpose of this paper is to identify the characteristics and responses of farmers to climate variability for the sustainability of food farming. Farming system in Singaparna sub-district is mostly carried out by farmers who are over 60 years old with primary school education and land ownership < 0.5 ha. Climate variability has an impact in a shift in the beginning of the rainy season and the beginning of the dry season. The area of land affected by seasonal shifts is a significant factor affecting production. Farmers' characteristics and responses can be used as a basis for increasing the adaptive capacity of farmers to minimize risks to the impacts of variability and climate change.

1. Introduction
In early March 2020, Indonesia confirmed the first case of the corona virus infection that caused Covid-19. This means that it has been more than 6 months since the Corona Virus (COVID-19) pandemic has occurred in Indonesia. Almost all sectors were affected. Since then, the government has made various countermeasures to reduce the impact of the Covid-19 pandemic in various sectors and program adjustments in the new normal era. Agriculture is very promising, because all people need food, they need adequate food and nutrition. In the midst of the Covid-19 pandemic, the agricultural sector was still able to grow 16.24%, while many other sectors experienced a downturn. This performance must be maintained and even improved for the sake of food security and sustainability in Indonesia despite various challenges.

One of the challenges in the agricultural sector are climate variability and change. Climate change can jeopardize sustainable agricultural development [1-3] and a serious threat to the yields and incomes of many farmers [4-7]. The impact will be felt on the economic, environmental and social fronts, especially in rural areas in vulnerable developing countries, where agriculture is the backbone of the economy [1,8]. Climate change is also having a negative impact on the agricultural sector by...
reducing crop yields, water and groundwater balance [9,10]; climate change greatly affects the livelihoods and food security of small farmers [11]. The variability of temperature and rainfall has a negative impact on farmers’ livelihoods [12]. It is projected that losses in the agricultural and coastal sectors due to climate change in 2100 are estimated to be around 2.2% [13].

The Food and Agriculture Organization (FAO) [14] states that one of the most serious threats to the future of sustainable food security is the implications of climate change. Since the onset of climate change, the likelihood of extreme climate events occurring has increased. On the other hand, humans cannot control climate behavior. Therefore, what is technically and socio-economically feasible is strengthening the ability to adapt to climate change. In the medium-long term, adaptation is not sufficient. The strategy that is considered appropriate is to adapt and mitigate synergistically [15,16].

The impact of climate change on food production occurs through decreasing productivity and harvest area. The decline in productivity is related to macro and micro-climatic conditions that are less conducive to vegetative and generative growth of plants (water stress and temperature) and increased plant-disturbing organisms and reduced planting area due to flooding, drought and pest attacks. There are 3 important points that need to be considered in working on agricultural land: 1) water sources, 2) technology and 3) farmer’s resources. Farmers as a resource and the main actors in the field have an important role in the sustainability of food farming. The characteristics and behavior of farmer is very important to increase adaptation capacity in order to minimize the impact of climate variability and change. This was also stated by Pakmehr et al.,] that to design effective public adaptation strategies, it is important to understand farmer behavior in responding to climate change.

Tasikmalaya is one of the central rice production districts in West Java Province. About 4.9% of West Java rice production comes from Tasikmalaya Regency [17]. Meanwhile, West Java Province contributes 16.6% of rice production at the national level [18]. The objective of this research is to identify the characteristics and responses of farmers to climate variability for the sustainability of food farming.

2. Materials and methods

2.1. Location and data

The research was carried out in Singaparna Sub-District in July 2019. Singaparna Sub-District was part of Tasikmalaya District, West Java province, Indonesia (Figure 1).

This study used primary and secondary data. Primary data was obtained from farmer interviews, while secondary data (monthly rainfall data) from Meteorological, Climatological, and Geophysical Agency (BMKG)/Public Works Service/Indonesian Agroclimate and Hydrology Research Institute (IAHRI) with a data period of 10-27 years.

![Figure 1. Location of research in Singaparna Sub-District, Tasikmalaya District, West Java, Indonesia](image-url)
2.2. Methods
Interviews were conducted at Agricultural Extension Center (BPP) Singaparna by questionnaire. The questions in the questionnaire were grouped into 3 topics: 1) farmer characteristics, 2) climate variability and its impacts and 3) farmers’ challenges and hopes for food farming. Before the interview, the respondent received an explanation of the purpose and objectives and the mechanism of the interview. Determination of location and respondents used purposive sampling. Interviews were conducted in-depth interviews through questionnaires one by one. The number of respondents was 28 people who came from various villages in Singaparna Sub-District.

The data analysis was done descriptively based on the results of the interview and regression analysis. Based on the results of interviews through questionnaires, identification and description were carried out to describe the characteristics of farmers including age, education and length of farming. To determine farming system, identification of cropping patterns, land ownership and production was carried out. The influence of climate variability was seen through the identification of the beginning of the rainy season and dry season, shifting of seasons, and climate-related disasters (floods, drought and pest/disease attacks). Land area affected by climate variability was identified based on the area of land that experienced a shift in the beginning of the rainy and dry seasons. Farmers’ responses to farming were also explained through the identification of the challenges and hopes of farmers in doing farming.

To determine the factors that influence production, regression analysis was carried out with equations:

\[ Y = f(X1, X2, X3, X4, X5) \]

where
- \( Y \) = Production (Kg/Ha)
- \( X1 \) = Farmer’s old (Years)
- \( X2 \) = Level of Farmer’s education (Years)
- \( X3 \) = Length of farming (Years) – (A)
- \( X4 \) = Land area that is affected by early season shifts (Ha)
- \( X5 \) = Duration of the disaster (Month) - (B)
- \( X6 \) = Season (0 = Wet Season and 1 = Dry Season)
- \( X7 \) = Interaction (A) and (B)

3. Results and discussion

3.1. Farmer characteristic
Farmer characteristics show the age of farmers is dominated by > 60 years old (50%). Another age group are <40 years (22%), 41-50 years (14%), and 51-60 years (14%) (Figure 2a). Most education of farmer is elementary school (36%). Other educational groups are high school (29%), junior high school (25%), bachelor/university (7%), and baccalaureate (3%) (Figure 2b).

Farming experience is reflected based on the length of time doing farming activities (length of farming). Dominant length of farming is less than ten years (44%). However, there are also farmers who have been farming for more than 40 years (21%) (Figure 2c). Based on the age group, most of the farmers were more than 60 years old, while from farming experience most of the farmers answered that they were less than 10 years old. This illustrates that most farmers start farming activities at an old age or farmers have a clear rice field status as property or inheritance at the age of farmers who are no longer young. Very limited farming experience affects their ability and capacity to manage their farm. Socio-economic factors (number of livestock, household size, plot area, farming experience, off-farm income) had a significant impact on mixed cropping and crop rotation, and the use of chemical fertilizers [19]. In rice plants, land along with the quality of seeds, N fertilizer, P fertilizer, and labor significantly affect the efficiency of farming, in addition to factors such as age, education, season, farmer group, and land ownership status [20].
Figure 2. Farmer’s characteristics: old (a), Farmer’s education (b), and length of farming (c)

Most of the farming in the Singaparna sub-district is irrigated land. The main cropping pattern is paddy-paddy-paddy (68%). Most of the farmers (52%) have a land area less than 0.5 ha. The land holdings are relatively narrow resulting in not achieving technical and economic efficiency. The average rice productivity is 4-5 tons/ha. However, some farmers can produce rice production of more than 6 tons/ha. Rice production in the dry season is on average higher than the rainy season. This is due to adequate irrigation and optimal sun intensity during the dry season. However, in the rainy season the production can reach more than 5 tons/ha (Figure 3).

Several variables are used to determine factors contributed to the production by regression methods including: age, education, length of farming, land area affected by shifting seasons, duration of disasters, seasons and interactions between A and B with regression model. Based on the results of this study, the area of land affected by seasonal shifts is a significant factor affecting production. Production is also influenced (with little effect) by the length of farming and the interaction between the length of farming and the duration of the disaster. This means that climate variability which has an impact in the form of a shift in the beginning of the season greatly affects the area of land cultivated by farmers so that it will affect production. According to Sumaryanto et al., [23] the productivity growth of agricultural products is influenced by, among other things, increased harvested area and increased productivity.

Figure 3. Rice productivity in wet and dry season (ton/ha)

3.2. Farmer’s response and impact to climate variability and change
Tasikmalaya Regency rainfall data used from fifteen (15) rain stations with a period of ten until twenty-four (10-24) years. In Figure 2, we can see fluctuations in rainfall in Tasikmalaya Regency with ranges from one hundred three until three hundred thirty-six (103 – 336) mm/month and average two hundred fifty (250) mm/month, while annual rainfall is 2999 mm/year. The lowest rainfall is August, while the highest rainfall in September (Figure 4). Based on the climate classification, wet months occur for 9 months and no dry months [21]. Agroclimatic Zone according to Oldeman is B-1. Zone B can be planted with rice 2 times a year.
Figure 4. Rainfall characteristic in Tasikmalaya District

The impact of climate variability can be seen from the shift in the beginning of the rainy season and the beginning of the dry season. Based on farmers’ perceptions 52%, during the last 5-10 years the start of the rainy season has been delayed from normal and vice versa on dry season about 59% of farmers stated that the start of the dry season was also ahead of normal.

Based on farmers’ perceptions (27%), the beginning of the Wet Season (WS) mostly occurs in September. For the beginning of the Dry Season (DS), according to most farmers (35%) occurred in March (Figure 5a). According to farmers, the most frequent climate-related disasters are pest and disease attacks (56%), followed by drought (37%) and floods (7%). The main causes of the disaster were limited water availability (31%) and the climate (19%). The impact of floods, drought and OPT causes a decrease in production of 25-50% (Figure 5b). Based on the results of the interviews, it appears that farmers’ understanding of climate variability and changes are still limited. Hereditary habits that last for a long time are more dominant in influencing farmers to make decisions in food farming. One example is in determining planting time, farmers only rely on experience when the rainfall has fallen and it is enough to start planting. The results of the study showed that indigenous knowledge often involves undocumented practices that farmers often use to tackle declining agricultural production or climate change without external influence or information [22]. Thus, farmers must be involved in the design and implementation stages of agricultural land use policies. It also involves participatory learning and training which creates a forum for farmers to provide their own knowledge of agriculture, learn about developments in climate smart agriculture.

Figure 5. Farmer’s perception about early wet and dry season (a) and cause of disaster (b)

3.3. Challenges and expectation

In Figure 6a we can be seen what factors are the challenges in food farming in the study location and what are their expectations. Based on farmer’s perception, pests and diseases are the main problems for farming system (42%). Water sources is also a limiting factor (14%) and fertilizers (11%), labor (8.3%). Another factor are flood, seeds, capital, climate, yield and price with average 5% (Figure 6a).

The expectation of most farmers (28%) is that production can increase, infrastructure and facilities are available (22%) and pests can be eradicated (17%). Another hope from farmers are socialization
about climate and season, capital and seed availability, fertilizer subsidies, good price, success and better farmer’s welfare (Figure 6b).

**Figure 6.** Farmer’s perception about challenge in their food farming system (a) and their hope in food farming system (b)

The characteristics and responses of farmers become important information and input in order to increase their adaptation capacity to climate variability and change. Related with the climate change adaptation Singh S [12] has identified the key determinants, which influence and motivate farmers to adopt rational, cost-effective and climate-smart adaptation strategies. As a process involving perceptions of climate change, farmers take advantage of their past experiences in dealing with climate uncertainty, risks and hazards. Their dependence on fellow farmers (agents) through social relations and institutional mechanisms in the form of extension (credit and insurance) helps to take adaptation actions. The household adaptation to climate change is positively and significantly influenced by education, livestock raising, cooperative membership, extension services, farmer income and household perceptions of climate change [11]. Public policies on climate change adaptation need to take into account the resource base of local communities and their lifelong views so as to reduce the potential costs of climate change to farmer livelihoods. Regarding the narrow land ownership, the solution to increase the welfare of farmers can be done by leading to group empowerment policies [24]. One of them is through the Corporate Farming model, which is land consolidation with the unification of farm management which is managed in a business manner so that economies of scale are met.

The importance of adaptation was also highlighted by Dumenu W K and Obeng E A [25] that it is important and needed for special regional actions to reduce vulnerability and improve adaptation among rural smallholder farming communities. Based on a study, a series of important adaptation strategies that farmers often adopt for seasonal adaptation include irrigation, changing crop varieties, switching to non-agricultural incomes, and changing their cropping patterns [12]. Low livelihood status, fewer non-agricultural employment opportunities and low planted area under irrigation are major obstacles to climate change adaptation.

Sustainable agricultural productivity is not guaranteed simply by recommending land management technologies that improve soil quality at the farm level, but by a more holistic approach, and thus further investigation into some of the constraints identified in this study, such as due to access to agricultural inputs (fertilizers, pest and disease control methods, better crop varieties), it is also important to be further explored. Farmers’ specific socio-economic conditions, land agro-ecological conditions, and institutional factors, need to be considered in the development of measures and policies aimed at encouraging farmers to adopt additional land management practices to increase sustainable agricultural production [19].
3.4. Policy implication
Reflecting on the various impacts of climate variability and change on the agricultural sector, as well as the phenomenon of climate events that have occurred and are likely to continue, then the effort that needs to be done is to adapt. However, through adaptation measures, farmers can manage the impacts of climate variability and/or change and reduce their vulnerability. To design effective public adaptation strategies, it is important to understand farmer behavior in responding to climate variability and change. Variability and climate change must be seen as an opportunity and opportunity and a resource that must be optimized. This has been implemented by Danish farmers whom are more likely to take advantage of the opportunities provided by climate change than to protect against its dangers, revealing the potential for temporal bias and optimism [26].

The study recommends that relevant stakeholders need to provide capacity building training in climate change, raise awareness of smallholders about adaptation options to climate change and their sizes. Farmers' access to proper training will increase rural household perceptions of climate change and use best practices that are environmentally friendly to climate change; and improve access to updated climate change information.

In anticipating production disruptions, it is necessary to have collaboration between relevant stakeholders in improving land infrastructures in order to anticipate disaster control. Assistance is needed for farmers in obtaining information related to climate, food farming / horticulture and other related information so that farmers are better prepared when a disaster occurs.

4. Conclusion
Farming system in Singaparna sub-district is mostly carried out by farmers whom are over 60 years old with primary school education and land ownership < 0.5 ha. Farmers' understanding of climate variability, its impacts and handling is still limited. The main problems for farming system are pests and diseases, water sources are also limiting factors aside from fertilizers, and climate.

The impact of climate change in the study location can be seen through shifts in the beginning of the rainy and dry seasons. The area of land affected by seasonal shifts as a result of climate variability is a significant factor affecting production. Related with food farming system, farmers have several hopes among others their crop production can increase, infrastructure and facilities are available, and pests can be eradicated.

Farmers' characteristics and responses can be used as inputs in order to increase adaptive capacity. Intensive socialization and assistance are needed related to climate information and technology for the sustainability of food farming.

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