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FARMERS' PERCEPTION OF CLIMATE CHANGE: EVIDENCE FROM POTATO FARMERS IN INDONESIA

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ABSTRACT
This study aims to investigate the farmers' perception of climate change and estimate the association between socio-demographic characteristics and climate change perception. Using cross-sectional data from 302 farmers in East Java of Indonesia employs a few quantitative methods including frequency mean and chi-square test. The climate perception was indicated by recalling the farmers' experience with climate-related indicators during the last 10 years. The finding indicated that the majority of farmers perceive the rain intensity, temperature, vegetation, also pest and disease increased. However, the farmers perceive the drought events are the same. This study confirms that farmers in our research location have a correct perception compared with the climate change real-time data. Furthermore, this study also indicated that education, total harvested area, land status, social network, cooperative membership, farmers group, and climate information were significantly associated with their perception of climate change, such as rain intensity, temperature, drought, vegetation, also pest and disease. This study provides a significant contribution to agricultural development to improve farmers' perception of climate change.

KEY WORDS
Climate change, climate perception, farmers, socio-demographic, Indonesia.

Agriculture in Indonesia has a big role in economic development and provides income for most Indonesian households (Rahmah, 2017). However, agriculture is the most vulnerable sector and negatively impacted by climate change (Karimi et al., 2018; Aryal et al., 2020; Alamgir et al., 2021; Jug et al., 2018; Bakhsh et al., 2022). Farmers living in rural areas with agriculture as the primary source of food and income will be the most affected (Haddad and bulletin, 2005; Abid et al., 2016). Consequently, agricultural production suffered losses and even crop failure. The potato production decreased by more than 87 %, due it was grown at higher temperatures, owing to a higher incidence of novel pests in Peru(Tito et al., 2018). Another study projected yield losses due to pests and pathogens attacks range from 17 to 30% globally across five major crops; including potato (17.2% (8.1–21.0%)) (Savary et al., 2019). Also, (Rakotonindraina et al., 2012) estimated 5% to 96% yield losses of potato production in France, due to pest and disease attacks.

The events of climate change including droughts, floods, high winds, extreme precipitation, and temperature impacted the farmers more vulnerable (Hussain et al., 2020; Bakhsh et al., 2022; Bein et al., 2020). However, people in general cannot easily predict and distinguish changes in the seasonal weather patterns of climate change (Solomon et al. 2011). Although many farmers are aware of climate change events, the experience of the incident, losses, how much it costs, and how to deal with are different (Hou et al., 2017; Tang et al., 2018; Tesfahunegn et al., 2016). Conversely, some farmers perceive climate change phenomena from religious, cultural, or modern perspectives (Kemausuor et al., 2011). As a result, it will produce different adaptation strategies in dealing with climate change. It is vital to have local information and knowledge of farmers' perceptions correctly on climate change to formulate appropriate policies that assist the farmers in dealing with climate change. Subsequently, farmers' indigenous knowledge will provide various solutions to reduce environmental risk in both upstream and downstream regions (Blaikie and Muldavin, 2004). Some previous studies also revealed that the awareness of the farmers depends on education level and local climate-related information (Ado et al., 2019; Tesfahunegn et al., 2016). Further, the farmers' perception plays an important role in developing adaptation strategies for the next cultivation activities (Pröbstl-Haider et al., 2016).

Although international studies related to farmers' perception in qualitative research with various factors, lack of research focused on quantitative research to understand farmers' perception on climate change. Yet, a study on farmers' perception that specifically in Indonesia is quite rare. Therefore, to fill this gap the study aims to investigate farmers' perception of climate change, and to estimate the association between socio-demographic conditions on climate change perception.

METHODS OF RESEARCH

This study was conducted in East Java of Indonesia, considering that it has been affected by climate change phenomena; such as temperature change and climate-related disasters (Rahman et al., 2021). In this investigation, multistage random sampling was performed. To begin, we identified two East Java regencies, Malang and Probolinggo, as the leading horticulture producers and the most vulnerable to climate change impacts. Second, based on the information provided by local agricultural departments, one district in each regency was chosen, including Poncokusumo for Malang and Sumber for Probolinggo. Finally, two villages from each district were chosen. Finally, 75 to 80 farmers from each village were chosen, for a total sample size of 302. The data was based on the previously published work by (Purwanti et al., 2022); by looking at different aspects of the data. The data used in this study contains socio-demographic conditions such as education, age, dependency ratio, total area, land status, social capital, and climate information. Also, farmers' perception of climate change. Based on the questionnaire the farmers were asked their experience about climate-related indicators during the last 10 years including rain intensity, temperature, drought, vegetation, pest, and disease.

This study included a variety of statistical methods, including descriptive statistics such as means, standard deviations, and percentages to better understand farmers' views on climate change. The farmers' perception was measured using a Likert scale from 1 for significantly decrease to 7 for significantly increase. A chi-square test was also used to examine the relationship between socio-demographic factors and farmers' views on climate change. This study used STATA-15 software to conduct this analysis.

Based on the study purposes, we hypothesize that the farmers tend to perceive the climate-related variable during the last 10 years. Also, the farmers' perception will be significantly associated with their socio-demographic condition (i.e., education, age, dependency ratio, total area, and land status), social capital (social network, cooperative, and farmers group), and climate information access. For instance, when the farmers have access to climate information, they were likely to have a correct perception of the change of climate indicators such as temperature and rain intensity.

RESULTS AND DISCUSSION

This section presents and discusses the selected variable of this study. The descriptive statistics results summarized in table 1 show that the majority of respondents' education was 6 years, suggesting that the farmers achieve 6 years of formal education or elementary school. The average age of farmers is about 48 years old with lands cultivated are 1.8 Ha on average, and the majority of them have their own land (73% of the respondent). Likewise, only 3% of farmers have relations with farmers outside their village, 10% participated in the agricultural cooperative, and 67% of the respondent participated in the farmer's group. This finding implies that the farmers' social capital in term of community members is relatively low. Lastly, the climate information variable shows 35% of total respondents have access to climate information. Basically, climate information can be accessed through extension agents, climate institutions, mobile phones, and television. However, only 35% of the farmers have access to it. Hence, it's necessary to improve farmers' access to climate information services.

Table 1 – Descriptive statistics of socio-demographic

Variable	Measurement	Mean	Standard Deviation
Education	Farmers' education level in years	6.23	2.41
Age	Farmers' age in years	48.47	12.21
Dependency ratio	Number of family members with age below 16 and above 60	0.74	0.74
Total area	The total cultivated area in Ha	1.83	1.95
Land status	dummy 1 if own land; 0 otherwise	0.73	0.45
Social network	Dummy 1 if farmers have a relation with other farmers; 0 otherwise	0.03	0.17
Cooperative	Dummy 1 if the farmer is a cooperative member; 0 otherwise	0.10	0.29
Farmers group	Dummy 1 if farmers participated in farmers group; 0 otherwise	0.67	0.47
Climate information	Dummy 1 if farmers have climate information access; 0 otherwise	0.35	0.48

The farmers' perceptions of climate change were measured by four indicators including rain intensity, temperature, drought, and vegetation. We also include one agriculture-related variable that is associated with climate change namely farmers' perception of pest and disease attacks in agriculture production. Based on the interviews, the results of farmers' perceptions differ on perceptions on rain intensity, temperature, drought, vegetation, also pest and disease.

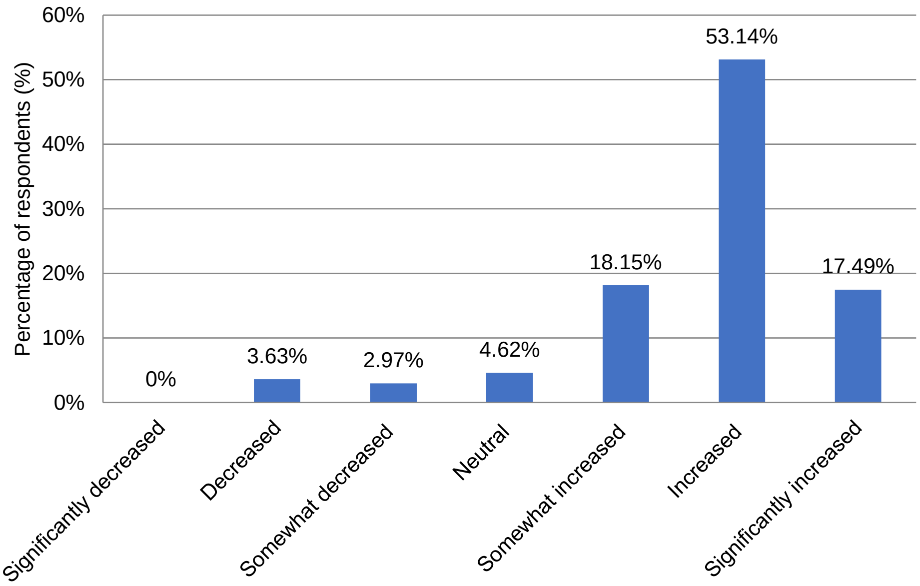

Figure 1 – Farmers' perception of changes in rain intensity for the past 10 years

Figure 1 shows that 53.14% of farmers perceived an increase in rain intensity. Meanwhile, farmers who perceived that there was a significant increase in rain intensity were only 17.49% and 18.15% perceived somewhat increase in rain intensity. A total of 3.63% and 2.97% of the respondents perceived a decrease and somewhat decrease in rain intensity respectively, while only 4.62% of farmers interviewed feel the same in rain intensity (neutral). The finding indicated that the majority of farmers in East Java of Indonesia perceived that there is an increase in rain intensity during the last 10 years. This finding indicated that the majority of farmers perceived that the temperature in the East Java of Indonesia had increased. Based on the real-time data from BPS (2021) the rain intensity of East Java tends to fluctuate, there is an increase from 2013 to 2016. However, it is slightly declined from

2017 to 2019. Based on our investigation the farmers' perception is in line with the last years of the real-time data i.e., 2019 to 2020. The average rain intensity in East Java slightly increases from 2019 to 2020 from 143.9 to 181.9 mm. This finding implies that farmers are only able to perceive their experiences with the rain intensity changes in the short term. Understanding the real-time change in the rain intensity will provide a suitable adaptation practice in dealing with this change, for instance, farmers can adopt a crop variety that is more tolerant of the highest rain intensity.

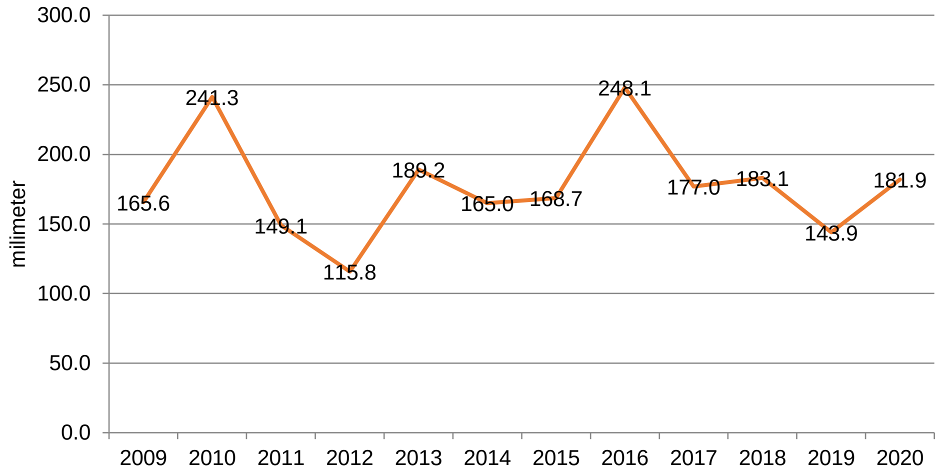

Figure 2 – The real-time data of rain intensity in East Java

Figure 3 presents the farmers' perception of temperature changes. The result showed that 57% of farmers interviewed perceived an increased temperature in the long-term, followed by 18.18% of farmers perceiving a significant increase and 15.18% perceiving a somewhat increase. The other results show that only a few farmers perceived a somewhat decrease in temperature by 2.31%, the rest 6.60% of farmers perceived the temperature did not change. The real-time data from BPS (2021) revealed that the average temperature of East Java tends to fluctuate, it was slightly increased from 2011 to 2016. However, it was sharply decreased from 2016 to 2019. Yet, it was increased from 2019 to 2020 from 27.3 to 38.2 degrees Celsius. This finding implies that farmers are only able to perceive their experiences with the temperature change in the short term, only a year in this particular finding.

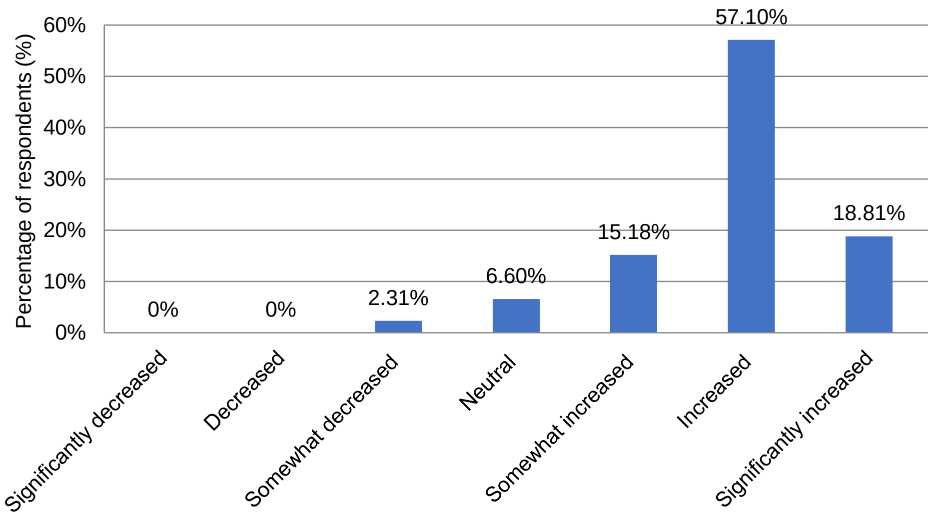

Figure 3 – Farmers' perception of changes in temperature for the past 10 years

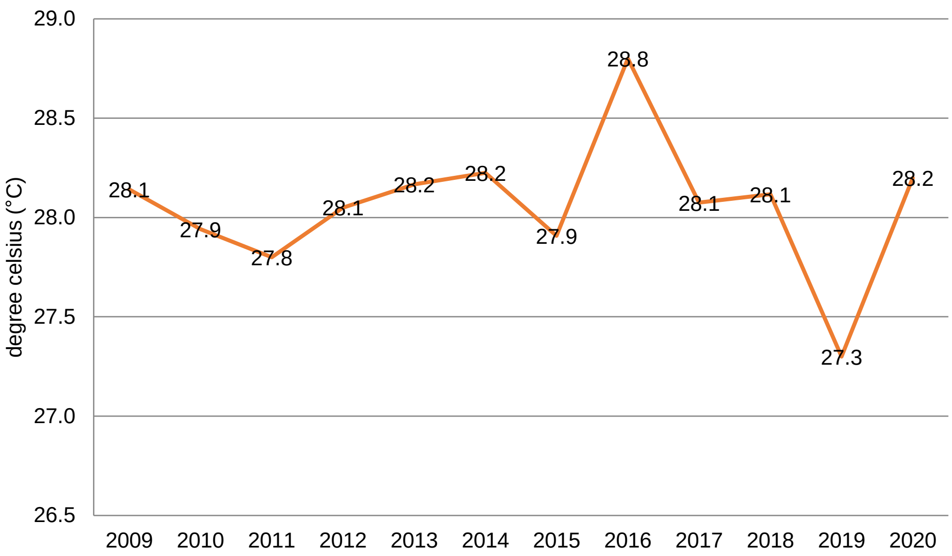

Figure 4 – The real-time data of temperature in East Java.

The response of farmers about the perception of temperature change was different from the drought perception. Figure 5 summarized that the majority of interviewees (87.2%) indicated in normal condition, its mean in the long-term farmers perceived there is no change in the length of the drought. About 21.45% and 22.11 % of the respondents give their perceived decrease and somewhat decrease of drought, respectively. On the other hand, less than 10% of farmers perceived an increasing temperature. This implies that the majority of farmers feel the availability of agricultural-related water supply has not changed. These phenomena can be seen by the rain intensity incensement in the previous discussion.

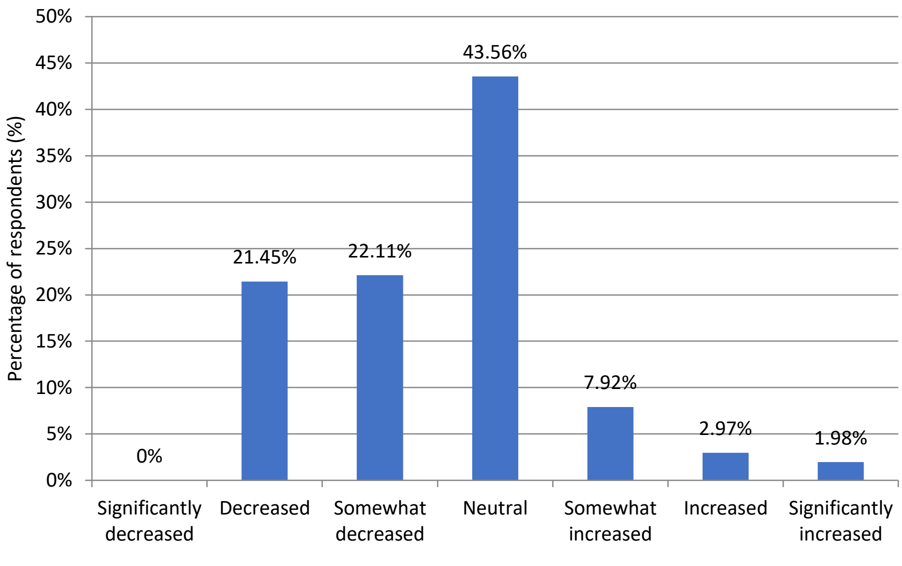

Figure 5 – Farmers' perception of changes in drought for the past 10 years

In contrast to the previous discussion, Figure 6 shows the perception of respondents regarding the amount of vegetation around the farmers' lives. The result showed that 28% of farmers indicated perceived an increase in total vegetation, while 7% of farmers felt a significant increase. Moreover, 14% of respondents interviewed perceived that there was a decrease in vegetation and 2% of farmers perceived a significant decrease. There are 18% of farmers who felt that there was no change in total vegetation. This finding suggests that farmers feel the vegetation in East Java of Indonesia increased.

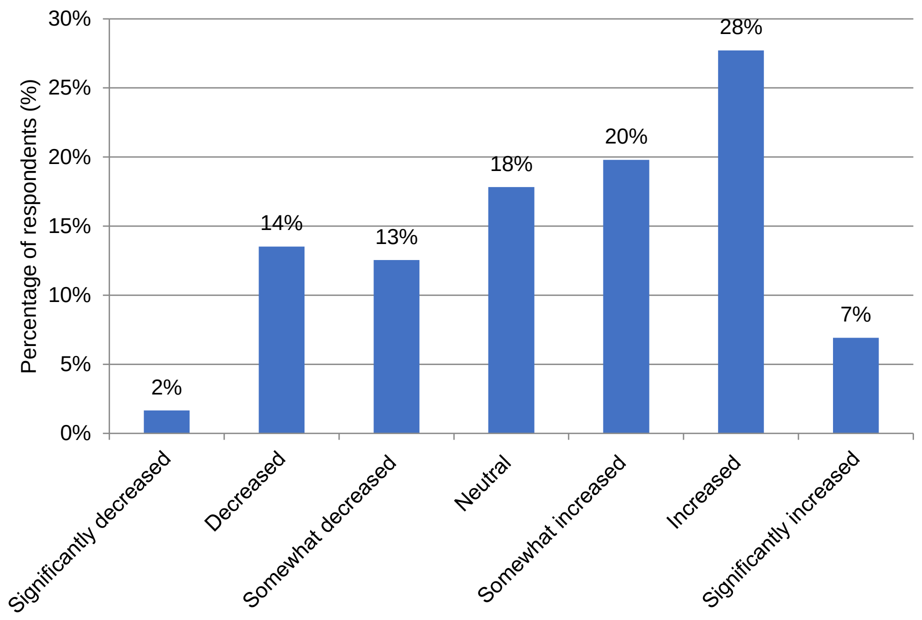

Figure 6 – Farmers' perception of changes in vegetation for the past 10 years

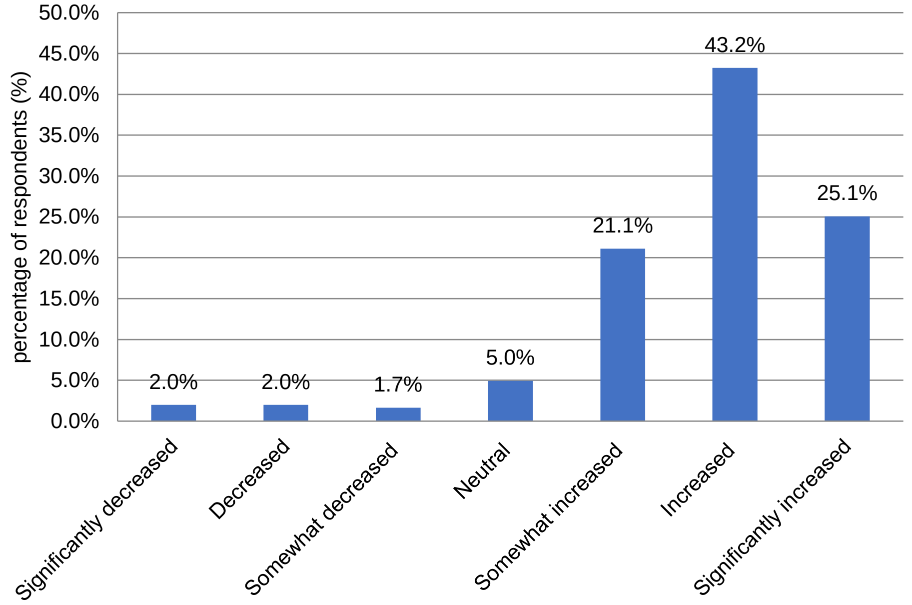

Figure 7 – Farmers' perception of changes in pests and disease for the past 10 years

The problem of pests and disease attacks is one of the problems that farmers often complain about, especially in the research location. This statement, supported in figure 7, shows that the great majority of interviewees perceived an increase in pest and disease by 43.2%, very increase (25.1% of farmers), somewhat increase (21.1% of farmers). The rest, only a small number of farmers perceived that decrease, very decrease and somewhat decrease in pest and disease attacks. This finding indicated that the majority of potato farmers perceived the pest and disease increased in East Java of Indonesia. The farmers' perception is in line with an investigation by Hilman (2019), who claimed that the horticulture farmers in east java facing a pest and disease incensement due to the change of rain intensity and it has been reducing farmers productivity since 2018. Pest and disease attacks are one of the immediate impacts of climate change. To deal with it, farmers can reformulate the use of fertilizer. However, the pesticides used have a negative consequence on environmental sustainability and farmers' health. Therefore, farmers can apply sustainable agricultural practices such as organic pesticides and fertilizer used to combat pest and disease attacks.

In estimating the association between the socio-demographic characteristic of farmers and climate perception, this study used a chi-square test, the result was presented in table 2. In general, we found there is an association between education, total area, land status, social network, cooperative membership, farmers group, and climate information with farmers' perception of climate change.

Table 2 – The association between socio-demographics and farmers perception of the climate change

Variables	Rain intensity	Temperature	Drought	Vegetation	Pest and disease
	X^2	X^2	X^2	X^2	X^2
Education	76.110***	28.752	29.804	47.830	88.071***
Age	272.728	197.006	293.158	300.002	345.703
Dependency ratio	8.661	7.163	17.090	12.205	14.560
Total area	213.232**	166.002*	163.108	184.870	325.548***
Land status	14.816	12.982	18.392**	29.377***	10.951
Social network	29.723***	3.136	20.667***	6.488	1.997
Cooperative	63.397***	18.979***	1.643	13.316**	6.413
Farmers group	8.384	5.742	6.419	10.688*	14.386**
Climate information	24.399***	12.034**	7.906	32.987***	30.057***

*Note = *** sig at 1%; ** sig at 5%; *sig at 10%.*

Table 2 revealed that education had positive significance associated with farmers' perception of rain intensity and pest and disease. Both positive signs indicated that the higher level of education was more likely to perceive rain intensity and pest and disease attacks to increase. Having a better education will increase farmers' understanding of agriculture-related problems such as pests and diseases (Roco et al., 2015). Also, the total area was positively and significantly associated with the farmers' perception of rain intensity, temperature, pest and disease; the result indicated that the higher the total area that farmers cultivated are more likely to perceive an increase in rain intensity, temperature, pest and disease with the significant level 5%, 10%, and 1% respectively. Having larger land cultivation improves farmers' perception of climate change because they will feel the highest loss for their agricultural productivity due to climate change.

Land status shows a positive and significant association with farmers' perception of drought and total vegetation. That statement implies that if the farmers are landowners, they are likely to perceive an increase in the length of drought and vegetation increase. As landowners, they are perceived to be more responsible for the commodities that are cultivated and the land used. They consider the impact of climate change on the land assets they own and their land activities. The social network has a positive coefficient and statistically significantly associated with farmers' perception of rain intensity and drought. The result suggests the farmers who have connections with other farmers are more likely to perceive an increase in rain intensity and length of the drought. Normally, the farmers who have connections with other farmers tend to share information. For that reason, the farmers tend to be aware and concerned with increasing rain intensity and drought phenomena.

The next result shows that cooperative has a positive and significant coefficient on rain intensity, temperature, and vegetation. The farmers are more aware and perceived about the climate change phenomena such as increased rain intensity, temperature, and vegetation. This is because one of the cooperative functions also gives much information related to climate phenomena to all the members. Furthermore, farmers' groups show a positive and significant association with vegetation, also pest and disease. The farmers who participated (members) in the farmers group tended to have perceived an increase in total vegetation and the farmers felt that increase in pest and disease attacks. In this study, farmers group gatherings mostly discussed problems faced by farmers during farming activity, such as pest and disease attacks. Therefore, members of farmers group are more aware and perceive an increase or decrease in pest and disease attacks. Cooperative membership and farmers group is a social capital that can improve farmers' understanding about climate change phenomena including climate perception by deserving a sharing from agriculture-related institutions and farmers to farmers’ extension material (Smith et al., 2012). This finding is in line with a previous study by (Tologbonse et al., 2010) who highlighted a positive association between social capital and farmers’ perception of climate change. Although social capital such as social networks, cooperative membership, and farmers group have an essential role in farmers’ climate information. These findings suggest that these social capitals provide a correct perception since the farmers’ perception is in line with the real-time data from the Central Bureau of Statistics.

Climate information shows a positive and significant association with farmers’ perception of all climate change indicators, except for drought. This statement implies that the farmers who receive climate information are more likely to perceive an increase in rain intensity, temperature, vegetation, also pest and disease attacks. This happened because climate information provides a lot of information related to climate change and is easily accessible by farmers. They received much information through extension agents, climate institutions, mobile phones, and television. Climate information is an essential factor that determines farmers' understanding of climate change (Dong et al., 2018; Mase and Prokopy, 2014; Zongo et al., 2016). It provides real-time information about climate-related information such as rain intensity and temperature change.

CONCLUSION

This investigates farmers’ perception of climate change and its association with socio-demographic factors using cross-sectional data from 302 farmers in East Java of Indonesia. Furthermore, the data were analyzed by descriptive statistics such as mean, standard deviation, frequency, and chi-square test. The finding indicated that the majority of farmers perceive the rain intensity, temperature, vegetation, also pest and disease are increasing. However, the farmers perceive the drought events are the same. Furthermore, this study also indicated that education, total harvested area, land status, social network, cooperative membership, farmers group, and climate information were significantly associated with their perception of climate change. Also, we confirm that a correct farmers’ perception of climate change because it is in line with the real-time data from the Central Bureau of Statistics. Therefore, this study provides important implications for agriculture development which can be implemented by considering the factors associated with farmers’ perception in this study such as social network, cooperative, farmers group, and climate information. By doing this, farmers can apply a suitable adaptation strategy that can improve their agricultural productivity.

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