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*Article*

# Climate change perceived-impact severity, its determinants and role in the planning of national adaptation policy: The case of rice farming in Indonesia

**Mohammad Rondhi[1,*], Ahmad Fatikhul Khasan[1], Yasuhiro Mori[2], and Takumi Kondo[2],**

[1] Department of Agribusiness, University of Jember, ahmad.fatih@unej.ac.id (A.F.K)
[2] Faculty of Agriculture, Hokkaido University; ymouri@agecon.agr.hokudai.ac.jp (Y.M.); kondot@agecon.agr.hokudai.ac.jp (T.K.)
* Correspondence: rondhi.faperta@unej.ac.id;

**Abstract:** This paper identifies the characteristics of the farmer that affect the degree of farmer's perceived-impact of climate change (CC). We use data from the Indonesian Rice Farm Household survey consisting of 87,330 farmers. An ordered probit regression model was used to estimate the effect of each variable on the degree of perceived-impact of CC. The results of this study confirm the previous empirical studies. Several variables that have been identified as having a positive effect on farmer adaptation practices such as farmer education, land tenure, irrigation infrastructure, cropping system, chemical fertilizer application, access to extension services and participation in farmer group affect the degree of CC perceived-impact negatively. However, a different result was found in the estimation of the gender variable. We found that female farmer has a higher resilience toward CC than the male farmer does. Furthermore, the female farmer has a more positive perception about future farming conditions than the male does. Finally, we suggest that the implementation of national adaptation policy should prioritize more to the farmer with insecure land tenure and utilize and expand the channel of agricultural extension services to deliver the planned adaptation policy.

**Keywords:** perceived-impact of climate change; climate change adaptation; ordered probit regression; determinants of climate change impact

## 1. Introduction

Climate change (CC) is a global phenomenon which harms climate-dependent activity such as agricultural production. The negative impacts of CC on agriculture, both for crops and animals production, has been well documented in the literature[1–4]. An appropriate adaptation strategy is required to moderate the adverse effect of CC on agriculture[5]. There are two types of adaptation to CC, autonomous and planned adaptation[6]. In the former, farmers autonomously adapt their farming practices to the observed climatic change. While in the later, the government plans and implements the adaptation policy. Several studies have reported that farmer in developing countries has adjusted their farming practices in response to CC, and find that the adaptation has a positive effect on crop yield[7,8]. However, the autonomous nature of CC adaptation limits the number of adapted farmers, and it leaves a large number of farmers vulnerable to CC. Currently, most developing countries have planned national agricultural plans and programs to adapt to CC[9]. While a large number of studies have suggested the form of adaptation strategy to be included in the content of policy, few studies have addressed the question of which farmer should be prioritized and through what channel the contents of the policy should be delivered.

Although CC is a global issue which impacts both developed and developing countries, it causes worse damages to the farmer in developing countries [10,11], since the majority of farmers are poor and less adaptable [12]. Also, these farmers located in the less favored agricultural area which makes them more vulnerable [13]. On the other hand, the availability of adaptation instruments, whether of physical nature such as stress-tolerance crops or of institutional nature such as crop insurance, are limited compared to those in developed countries [14]. Furthermore, there is a psychological-distance, the individual perception of how far a particular event is from that individual, among farmers regarding the impacts of CC which hinder the adoption of suggested adaptation strategy [15]. Moreover, the government-led nature of the implementation of national adaptation plans will likely to treat all farmers alike, whether they perceive CC impacts as significant or otherwise. Consequently, the number of actual farmers that adapt to CC will be fewer. Thus, it is crucial to not only focus on the form of adaptation policy but also the identification of farmer who experienced the most impacts of CC and more-likely to adopt the adaptation strategy.

One of the indicators that reflect the effectiveness of agricultural CC adaptation policy is the increased number of the farmer who adopts the suggested adaptation strategy. Farmers, especially in developing countries, treat CC as a threat to their farming activity only when they perceive it significantly decreases their crop yield[16,17]. Perceived-impact (P-I), a measure of how farmer personally feels about the impact of a particular occurrence, is different from the actual effect of CC on crop yield, for P-I are affected by many factors whether technical, social, economic, or institutional[18–20]. For example, the farmer who experiences crop yield-loss due to CC may feel that the impact is not significant because the loss is relatively small compared to their wealth or because of other reasons, and it is less likely that they will adopt any adaptation strategy. Conversely, a farmer who perceives the impact of CC is high will more likely to adjust their farming practices to minimize the effect. Thus it is critical to know where to target the implementation of particular adaptation policy, for it can avoid the wasting of resources from implementing standardized intervention and the unexpected or adverse outcome [21]. Based on this reasoning, the farmer's perceived-impact of CC influences their likeliness to adopt the suggested adaptation strategy. The higher the P-I, the more likely the farmer will adapt, and vice versa. Therefore, it is essential to identify what factors influencing the farmer’s P-I of CC. This information will be useful to determine which farmer should be prioritized and targeted.

Previous studies on the effect of CC on agriculture in developing countries have been extensively conducted. Although CC affects almost all aspects of a developing country economy, agriculture receives the most substantial impacts [22,23]. However, few studies analyzed the effects of CC using the nationally-representative farm data [24–26]. The nationally representative study on the impact of CC to agriculture in developing country often use aggregate data [10,27–30], or where the individual farm data were employed, the study is limited to local and community level [7,31,32]. While the former is useful in providing the overall view of the CC effect and the latter are useful in informing the detailed picture of how the farmer affected and manage to adapt, it is necessary to conduct a nationally representative study on how the farmers affected by CC. Furthermore, most of these studies assess the actual impact of CC on agriculture which can be different from what the farmer perceived. Using a nationally representative farm data comprising of 87,330 rice farmers in Indonesia, this study will contribute to filling this gap. Also, we use the perceived impact measure of CC (whether farmer regards they were not, less, or highly affected by CC) as a measure of how CC impact developing country agriculture.

Thus, the general purpose of this study is to identify the determinants of farmers perceived-impact of CC. Specifically, this study aims to determine what factors, whether economic, social, technical, or institutional, affecting farmers to perceive or not to perceive CC as a threat to their farming.

## 2. Background: Climate Change in and its impact on Indonesian Agriculture

Indonesia is the largest archipelagic country in the world with over 17,000 islands, comprising a total land area of 190 million hectares. Indonesia had 37 millions ha of agricultural land in 2018, and rice field accounts for 8 million ha where 58,13 percent of rice field has irrigation infrastructure [33]. The rice field is spread out in the major island in Indonesia but most of it (3.1 million ha) located on the island of Java [33]. Rice is the vital food crops in Indonesia alongside with maize, soybean, green bean, cassava, and sweet potato. The annual production of rice in Indonesia is 81 million ton of dry unhusked rice. Beside food crops, Indonesian agriculture also has horticulture such as vegetables (shallot, chili, cayenne, garlic, and potato), fruits (mango, banana, citrus, durian, pomelo, mangosteen), and flowers (chrysanthemum, rose, orchid, and tuberose). Also, Indonesia is producing plantation crops, medical crops, and livestock.

As in many developing countries, agriculture plays a vital role in the Indonesian's economy. Its production accounts for 13 percent of Indonesian gross domestic product [34], and it provides a livelihood for 25 million farm household [33]. Among various crops cultivated in Indonesia, rice is the primary food crops. Moreover, 17 out f 25 million farm households are rice farmers with an average land possession of 0.6 hectares [35]. As a smallholder farmer, rice farmer is economically more vulnerable to external shocks such as climatic change. In Indonesia, rice farming has experienced the severe impact of climate change. The changing rainfall frequency and intensity, the increase in temperature, and the rise of sea level have significantly contributed to the declining rice productivity. The occurrence of extreme events such as flood and drought is increasing which cause crop loss. Also, the increasing temperature causes the proliferation of pest and diseases [36]. Thus, the effort of mitigation of and adaptation to the risk of CC is required for the resilience of rice farming in Indonesia.

The study of CC in Indonesia is extensive and covers a wide range of aspects such as agriculture [36–41], natural disaster and management of coastal area [42–44], the politic of climate change [45–47], and the public perspective on climate change [48,49]. These studies stated that climate change would affect many aspects of the Indonesian economy and agriculture is the hardest hit. In response to this, the government has created a National Action Plan (NAP) to mitigate and adapt to the risk of climate change. One of the primary targets of NAP is to achieve economic resilience by achieving food security. The primary objective in achieving food security is by reducing the production loss due to extreme climate occurrences and CC [50]. The primary strategy to reduce farm production loss is by applying CC-resilient farming system and CC-adaptive farm technology. The government should deliver and make sure that the farmer adopts both of this strategy. However, the limited government resources and a large number of the farmer will limit the adoption rate of this strategy. Thus, it is essential to identify farmers with high probability to adapt and target the implementation of the NAP to these farmers.

## 3. A literature review of the factors affecting the degree of climate change impact on farmers

There are many factors which affect the degree of impact the CC has to farm production, whether social, economic, technical, institutional, or climatic factors. A particular factor might reduce the

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severity of effects because the existence or a high value of it makes farm production has a stronger resistance toward the changing climate so that it can sustain the change without suffering a significant yield loss. Alternatively, a factor might reduce the severity of impact because it drives the farmer to take action to limit the CC-caused damages.[1] This section briefly reviews the finding of the previous empirical literature on the factors affecting the impact of CC.

### *3.1. The social factors*

We define social factors as the personal characteristics attached to the self of a farmer. These factors include the age, education, and gender of farm household head. Several studies included these factors in identifying how a farmer perceive and adapt to the impact of CC. Several studies stated that a farmer's age correlates positively with the resilience of farmers against CC. Older farmers have a greater awareness of the impact of CC [51], and their vast farming experience makes them able to practice less costly adaptation method while still sustaining a higher level of farm productivity [7]. Similarly, the educated farmer copes with CC better than the less educated one since they can access better information about CC and adaptation technology [7,51,52]. Finally, the issue of gender in CC has received considerable attention because the female farmer is more vulnerable to CC, but they have limited access to resources that they can use to adapt [53,54]. Furthermore, the female farmer is less likely to adopt soil conservation, cultivate more diverse crops, and planting trees to reduce the effect of CC [52].

### *3.2. The economic factors*

The economic factors are the asset-related characteristics of farmers. We include three variables in this group such as land tenure, landholding, and the source of farm capital. Previous studies have shown that farmer with higher wealth tends to be better adapt to CC. Land tenure security is a critical factor for CC adaptation since the security of tenure will promote farmer to exert more efforts and investments on adaptation practices [55,56]. However, land size increases the cost of adaptation and reduces the adaptation practices of a farmer with higher land size. Previous studies, also stated that farmer with access to credit institution has a higher probability of adapting to CC [7,51,52]. However, having access to credit institution does not necessarily means that farmer obtains a large proportion of farm budget from borrowed money. Thus, we use farm capital source instead of mere access to the credit institution.

### *3.3. The technical factors*

We define this category as technical characteristics of rice farming and include four variable in the group such as irrigation infrastructure, cropping system, fertilizer application, and annual cultivation frequency. Irrigation infrastructure in particular and agricultural water management, in general, plays a vital role in mitigating the risk of CC [57–59]. The changing climate alters the frequency of rainfall and affects water availability and crop requirement. Adequate irrigation infrastructure is crucial for the effective distribution of water resources. Also, the application of mixed-species rather than monoculture farming can mitigate the adverse effect of CC [60]. Mixed-species cropping between crops with complementary traits with proper management will have biodiversity and economic advantages in the form of increased productivity. Also, other significant factors in the technical aspect of farming to CC is fertilizer application [61]. Fertilizer is one of the primary farm inputs. However, the excessive use of chemical fertilizer will increase the number of greenhouse gas emission which will exacerbate CC [62]. The primary challenge of limiting the excessive use of chemical fertilizer is the farmer's perception. Farmer perceives that fertilizer application correlates positively to farm yield. Thus it is essential to identify how fertilizer application affects how the farmer sees about the impact of CC. Similar to the previous variable, the number of annual rice cultivation will increase the number of fertilizer usage. Also, as the amount of cultivation

[1] This illustration is for factors which negatively correlated with the degree of impact. The reverse condition applies.

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increase, a farmer will have more extensive exposure to the risk of being impacted by CC. It is essential then to identify whether a farmer who cultivates rice more frequently perceive a more severe impact.

*3.4. The institutional factors*

Several studies have shown the importance of institutional factors in reducing the impact of CC and encouraging farmer to perform adaptation practices. We include three variable in this category, participation in farmer group, access to extension services, and participation in the farmer field school. Conceptually, farmer group is an important tool for the government to distribute and deliver the content of agricultural policy to farmers. Participation in the farmer group increases the productivity of farmer [63], and facilitate the member to obtain farm input [64]. Thus, the participation in farmer group has the potential to increase farmer's resiliency against climate change. Also, to deliver new information and technology, the government specifically established extension services and access to these services increases farm performance [65]. In the context of climate change, the extension services are the leading channel to deliver information about climate change and adaptation strategy and technology to farmers. Several studies indicated that access to extension services increases farmer awareness about CC and their adaptation practices [7,51,52]. Similar to the previous institutions, farmer field school (FFS) is a government-established service which facilitates the dissemination of new knowledge and skills to farmers. A longitudinal study in East Africa stated that participation in FFS increases farm productivity by 61% and plays a critical role in reducing poverty [66].

*3.5. The climatic factors*

Climate change alters the frequency and intensity of rainfall. In some areas, the intensity of rainfall increase and causing a flood, while in a mountainous area the increasing rainfall intensity causes landslides. In other areas, the intensity of rainfall decreases which causes drought. All of this CC-caused disaster have a substantial impact on agriculture. Flood and landslide cause severe economic damage including in the loss of crops, while drought reduces the amount of harvested farmland and reduces its yield [7,67]. Thus in this category, we include four types of CC-caused disaster, flood, drought, heavy rain, and another hazard (e.g., landslides) to find out which disaster that farmer perceives as having the most severe impact to their farming.

## 4. Data and empirical estimation method

*4.1. Data*

We use nationwide rice farming survey in Indonesia conducted by the Indonesian Beaureu of Statistics (BPS). The survey was conducted on May 2014 through June 2016 and covered a sample of 87,330 rice farm household (RFH). The sample selection employs two-stage stratified random sampling. In the first stage, the national BPS office randomly selected the census block from a total of 844,946 blocks and obtained 8,933 sample blocks. Only census block with 10 or more RFH which is eligible for sampling selection. In the second stage; the district BPS office determined the RFH which has been stratified by land size. Only RFH with land size not less than 550 $m^2$ for lowland rice and 100 $m^2$ for upland rice is eligible for sampling selection. Figure 2 shows the distribution of sample RFH and the percentage of the farmer who experienced the effect of CC for each province in Indonesia.

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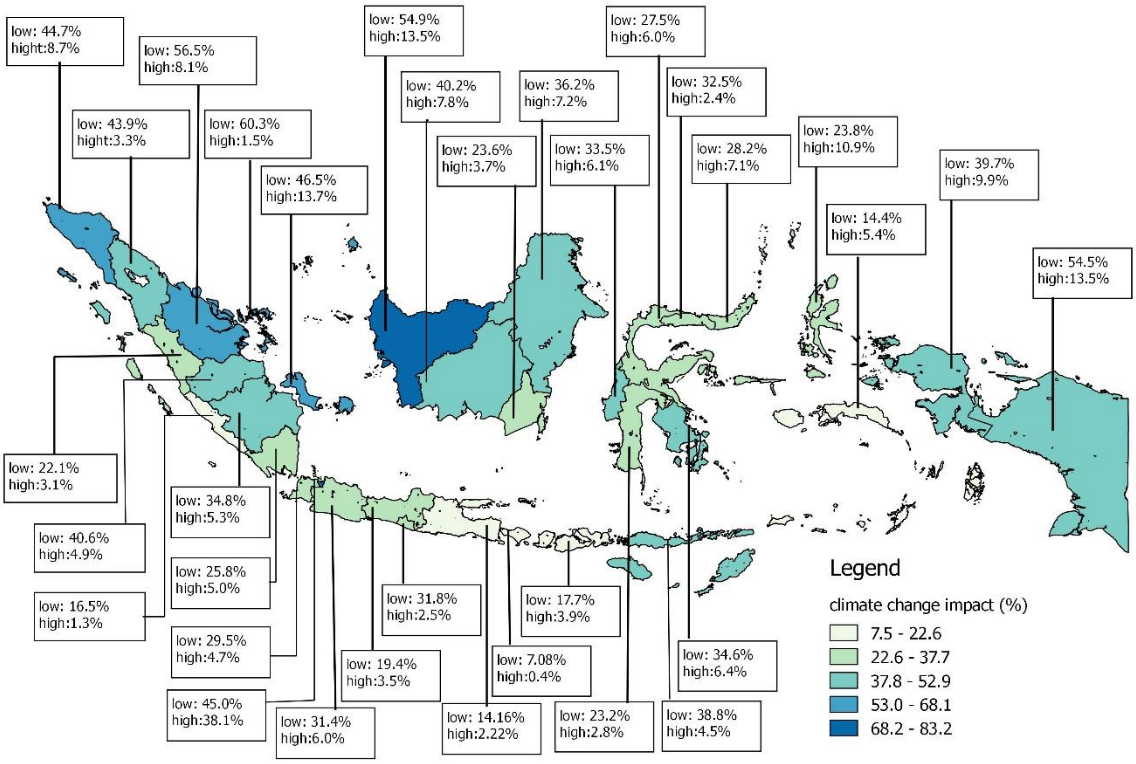


**Figure 1** The distribution of the sample and the percentage of the farmer who experienced the effect of CC for each province in Indonesia.

Table 1 provides the summary statistics, the expected signs of predictors, and the definition of each variable.

**Table 1.** Summary statistics, the expected signs of predictors, and the definition of variables.

| Variable name | Definition | Mean and frequency | Expected sign |
|---|---|---|---|
| **Response variable** | | | |
| Perceived impact of CC | Ordered dummy variable (0=farmer perceives no impact of CC; 1=farmer perceives the low impact of CC, production decreases by ≤50%; 2=farmer perceives the high impact of CC, production decreases by >50%) | 0: 57,771(66,2%)<br>1: 25,306(29%)<br>2: 4253(4,9%) | |
| **The social variables** | | | |
| Age | The age of head of farm household (year) | 49.39 yr | - |
| Education | The years of formal training of head of farm household (year) | 5.81 yr | - |
| Gender | Dummy variable (1=male, 0=female) | 1: 77,094(88.3%)<br>0: 10,236(11.7%) | - |
| **The economic variables** | | | |
| Land tenure | Dummy variable (1=owned land, 0=other) | 1: 61,784(70.7%)<br>0: 25,139(28.8%) | - |
| Landholding | The area of cultivated land (ha) | 0.47 ha | + |
| Capital source | A dummy variable, the source of used farm budget (1=Bank, 0=other) | 1: 79,264(90.8)<br>0: 8,066(9.2) | - |
| **The technical variables** | | | |
| Irrigation | | 1: 39,530(45.3%) | - |

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| | | | |
|---|---|---|---|
| | A dummy variable, the type of irrigation infrastructure (1=technical irrigation infrastructure, 0=other) | 0: 47,800(54.7%) | |
| Cropping system | A dummy variable, the type of cropping system applied (1=monoculture farming, 0=mixed-species farming) | 1: 83,942(96.1%)<br>0: 3,388(3.9%) | + |
| Fertilizer | A dummy variable, the application of chemical fertilizer by the farmer (1=use chemical fertilizer, 0=does not use chemical fertilizer) | 1: 79,744(91.3%)<br>0: 7,586(8.7%) | + |
| Cultivation frequency | The number of rice cultivation in a year | 1.64 | + |
| **The institutional variables** | | | |
| Farmer group | Dummy variable, participation in farmer group (1=participate, 0=do not participate) | 1: 45,730(52.4%)<br>0: 41,600(47.6%) | - |
| Extension services | A dummy variable, access to extension services (1=having access to extension services, 0=do not having access to extension services) | 1: 21,902(25.1%)<br>0: 65,428(74.9%) | - |
| Farmer field school | A dummy variable, access to farmer field school (1=having access to FFS, 0=do not having access to FFS) | | |
| **The climatic factors** | | | |
| Flood | A dummy variable, experience impacted by flood (1=experienced, 0=do not experienced) | 1: 6,635(7.6%)<br>0: 80,695(92.4%) | + |
| Drought | A dummy variable, experience impacted by drought (1=experienced, 0=do not experienced) | 1: 16,538(18.9%)<br>0: 70,792(81.1%) | + |
| Heavy rain | A dummy variable, experience impacted by heavy rain (1=experienced, 0=do not experienced) | 1: 5,069(5.8%)<br>0: 82,261(94.2%) | + |
| Another hazard | A dummy variable, experience impacted by another hazard (1=experienced, 0=do not experienced) | 1: 1,317(1.5%)<br>0: 86,013(98.5) | + |

The outcome variable is the perceived impact severity of CC which measured by the question: "Did you impacted by the climate change? If yes, how much yield loss caused by climate change?" The responses consisted of 4 choices, <25% yield loss, 26-50% yield loss, 51-75% yield loss, and >75% yield loss. The response then converted into three categories, "no impact" for those answered 'no' to the first question, low impact for those who reported ≤50% yield loss, and high impact for those who reported >50% yield loss. The data shows that 66.2 percent (57,771 farmers) reported no impact of CC, 29 percent (25,306 farmers) reported the low impact of CC, and 4.9 percent (4253 farmers) reported the high impact of CC.

The predictors consist of 17 variables which have been described in Section 3. The average age Indonesian rice farmer is 49.5 years, having only elementary schooling (5.81 years, six years of elementary school), and most are a male farmer. The majority of the farmer (70.7%) cultivate their land with an average landholding for each farmer is 0.467 hectares. Ninety percent of rice farmer financed their farming leaving only nine percent farmer who financed their farming through a loan. The irrigation infrastructure covers 45.3% of the rice farmer in Indonesia, while the rest depended on non-technical (46.4%) and rain-fed irrigation (7.9%). Ninety-six percent of farmer only cultivate rice while only 3.9% of farmer perform mixed-species cultivation. Chemical fertilizer is the primary input in rice farming, and 91 percent farmer apply chemical fertilizer while 8.7% farmer does not apply chemical fertilizer at all. The average cultivation frequency is twice annually. As with the institutional factors, 52% of farmers participate in the farmer group, and only 25% is having access to extension services, and only 11.2% have participated in the farmer field school. Finally, the climatic variables show that 7.6% of farmers experienced a flood, 18.9% of farmers experienced a drought, 5.8%, and 1.5% reported experienced heavy rain and another climate-induced hazard respectively.

*4.2. Empirical model*

To estimate the effect of each predictor on the ordinal response variable, we use an ordered probit regression. Ordered probit estimate can estimate how each predictor determine the probability of farmer to perceive (whether high or low) or not perceive the impact of CC on their rice farming. The use of ordered-probit regression to analyze the effect of independent variables on the ordinal response is favored to avoid *false alarms* (detecting a non-existent effect) and *loss of power* (failure to detect an effect) problems [68]. Equation 1 shows the specification of the model.

$$y_i^* = \sum_{i=1}^{17} \beta x_i + \varepsilon_i, \qquad i = 1, 2, \ldots, N \tag{1}$$

Where $y_i^*$ is the response variable that represents the perceived impact of CC, $\beta$ is the parameter to be estimated, $x_i$ is the vector of predictors and $\varepsilon_i$ is the error term. N is the number of observation.

## 5. Result and discussion

The purpose of this paper is to identify the characteristics of farmers based on the degree of CC impact they perceive. The information will provide useful information for the government to identify which farmer experienced the most effect of CC and putting a prioritization in the adaptation and mitigation policy. We identify those characteristics using an ordered probit regression, and Table 2 provides the estimation results. Based on the estimation results, the model is robust for identifying the determinants of perceived impact of CC. There 14 out of 17 predictors which has a statistically significant effect on the perceived impact of CC.

**Table 2.** The estimation results

| Variable name | Estimate | Sig. |
|---|---|---|
| **Response variable** | | |
| Perceived impact of CC | | |
| Threshold *low impact* (1) | -24.133 | 0.000*** |
| Threshold *high impact* (2) | -19.532 | 0.000*** |
| **The social variables** | | |
| Age | -0.001 | 0.513 ns |
| Education | -0.016 | 0.000*** |
| Gender (Male) | 0.071 | 0.011** |
| **The economic variables** | | |
| Land tenure (Own land) | -0.039 | 0.050** |
| Landholding | -0.002 | 0.907 ns |
| Capital source (loan) | 0.030 | 0.340 ns |
| **The technical variables** | | |
| Irrigation (technical irrigation) | -0.075 | 0.000*** |
| Cropping system (monoculture) | -0.324 | 0.000*** |
| Fertilizer (applying fertilizer) | -0.098 | 0.000*** |
| Cultivation frequency | 0.030 | 0.042** |
| **The institutional variables** | | |
| Farmer group | -0.034 | 0.091* |
| Extension services | -0.060 | 0.019** |
| Farmer field school | -0.001 | 0.980 ns |
| **The climatic factors** | | |
| Flood | 7.271 | 0.000*** |
| Drought | 7.086 | 0.000*** |
| Heavy rain | 6.746 | 0.000*** |
| Another hazard | 6.682 | 0.000*** |
| **Regression robustness** | | |
| Likelihood test ratio | 135205.866 | 0.000*** |
| Pearson goodness of fit | 28051.967 | 1.000 ns |

| | | |
|---|---|---|
| Deviance goodness of fit | 22696.188 | 1.000 ns |
| Cox and Snell $R^2$ | 0.789 | |
| Nagelkerke $R^2$ | 0.998 | |
| N | 87,330 | |

*** significant at 1%

** significant at 5%

* significant at 10%

*5.1. The social factors*

In the social factors, there 2 out of 3 variables which has a statistically significant effect on the perceived-impact of CC. Education and gender have a significantly negative and positive effect respectively, while farmer's age does not have a statistically significant effect. The estimation result of the farmer's education seems to confirm the previous empirical results that farmer with longer years of formal education is more resilience to climate change. For example, Deressa et al., [52] who stated that a year longer in formal education would increase the probability of a farmer to practice soil conservation by 1% and the probability of adjusting planting date by 0.6%. The estimation result in this study shows that an increase in formal education by one unit would reduce the ordered log-odds of a farmer being experienced a higher degree of CC impact. While the farmer's age, which has been associated with farming experience, does not have any significant effect. It shows that farming experience not only influenced by farmer's age but also but other factors, such as education.

A somewhat different finding is on the gender variable. The estimation result shows that female farmer has a lower probability of experiencing high CC effect. The ordered log-odds of a female farmer being profoundly affected by CC is 0.071 less than a male farmer. There is established literature which shows that women have a relatively disadvantaged position compared to man [69] in agricultural production. Moreover, in the case of climate change, many empirical studies show that female farmer adapting less to the changing climate than the male farmer does [7,51,52]. However, there are some cases in which gender issue do not significantly affect farm decision regarding CC adaptation practices [5], and even female farmer in the US tend to buy more crop insurance to mitigate the financial effect of CC [14]. In our cases, the female farmer has a higher participation rate on crop insurance than the male farmer does. The participation rate of the female farmer on crop insurance is 0.255% while the male farmer is 0.192%. Also, the female farmer has a more positive perception regarding farming profitability in the future. Figure 2 shows the distribution of farmer perception on the future farming condition.

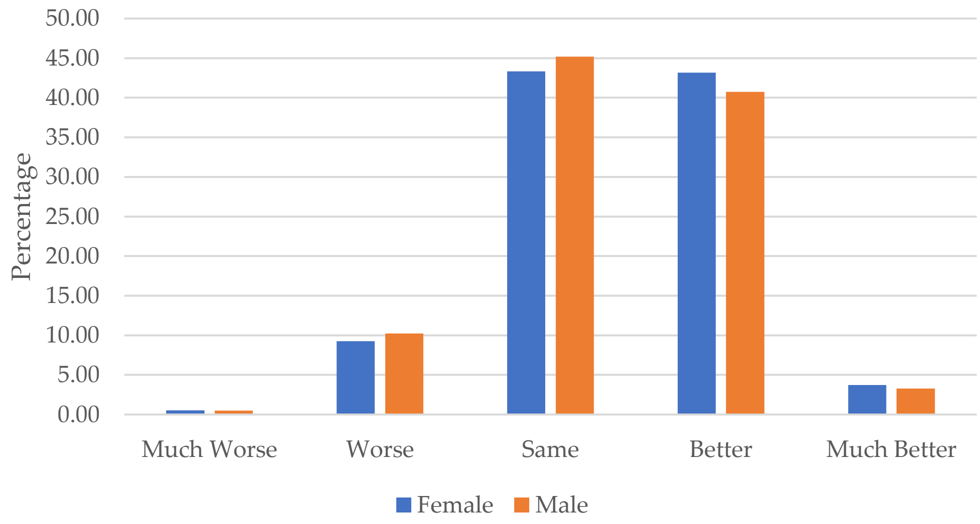


**Figure 2** The perception of a female and male farmer in the future farming conditions.

*5.2. The economics factors*

The estimation results of the economic factors show that land tenure is the only variable which has a statistically significant effect on the perceived impact of CC. The farmer who cultivated their land has an ordered log-odds 0.039 less than the farmer who cultivated lease or sharecropping land. The security of tenure has become a primary issue in the adaptation and mitigation policy of CC in agriculture. Secure land tenure will encourage the farmer to adopt land management practices that yield financial investment in the long term; hence without tenure security, such investment would be financially not feasible for the farmer [70]. Furthermore, insecure land tenure is one of the primary constraints to CC adaptation in the most vulnerable area to CC such as Pakistan [71]. Also, a case study in the rural area of East Java Indonesia shown that farmer who cultivated rice on leased land tend to be less cautious on their farming practices, such as practice no soil conservation [72], and overexploit the land using excessive chemical pesticide [73].

### *5.3. The technical factors*

The estimation of technical variables shows that each variable has a statistically significant effect on the perceived impact of CC. Irrigation infrastructure decreases the degree the perceived impact of CC, a farmer whose land irrigated with technical irrigation has an ordered log-odds less than those whose land is irrigated by non-technical and rain-fed irrigation. In Indonesia, both non-technical and rainfed agriculture rely mainly on rainfall to supply irrigation. Hence, both of this area is vulnerable to drought occurrence and should pay a higher cost of irrigation due to water scarcity. Also, the rice and agricultural productivity in this area are lower compared to the area with technical irrigation. It makes farmer in this area economically more vulnerable to CC. While the development of technical irrigation in Indonesia has been conducted since the 1970s with the support of the Green Revolution programme. The establishment of technical irrigation infrastructure has increased yields, cropping season, and cropping intensity of rice farming in Indonesia [58].

Both the cropping system and fertilizer variables decrease the perceived impact of CC. The farmer who practices monoculture farming has an ordered log-odds of 0.324 less than those who practice mixed-species farming. It means that the former is more likely to experience the less severe impact of CC. The monoculture in rice farming is less a threat to biodiversity since its temporal dimension is short [74], and the majority of farmer applies crop rotation. The fertilizer application has a similar effect to the cropping system. The application of chemical fertilizer decreases the probability of a farmer being affected by CC, the farmer who use chemical fertilizer has an ordered log-odds of 0.098 less than those who apply chemical fertilizer. The final variable, cultivation frequency increases the probability of farmer being affected by CC since the more frequent the farmer cultivate rice the higher the exposure he has on CC.

### *5.4. The institutional factors*

Extension services are statistically significant in reducing the probability of a farmer being affected by CC. Extension services have been long regarded as an efficient channel to deliver knowledge and information about the risk of CC and the way to adapt to it. Several empirical studies indicate that access to knowledge, information, and adaptation technology increases the resilience of farmer towards CC [7,52,71]. In Indonesia, the farmer receives extension services from several sources such as state agricultural extension officer (PPL), state pest-control officer (POPT), an officer from the office of agriculture at the district level (Diperta), and private extension services. Figure 3 shows the number of farmers who receive extension services based on the type of extension services officer. There are only 25% of a rice farmer in Indonesia who have received an extension. The primary extension officer is those coming from the government. The nongovernment extension officer comes from a variety of institution, such as a private corporation (pesticide and fertilizer factory), NGO, and peer-farmer. Increasing the number and coverage of extension officer is essential to CC adaptation policy since the majority of the farmer (41%) receiving extension services are concentrated in Java.[2]

[2] 21.4% in Sumatera, 8.3% in Bali and Nusa Tenggara, 10.6% in Kalimantan, 14.4% in Sulawesi, 1.2% and 1.9% in Maluku and Papua

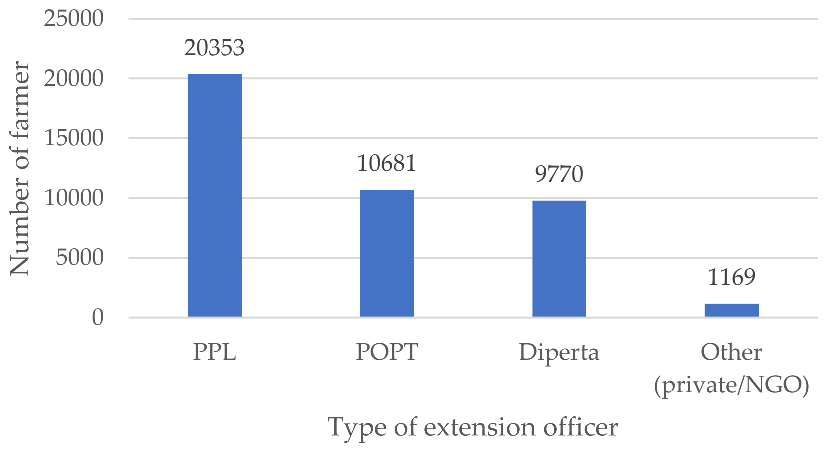


**Figure 3** The number of a farmer who receives extension services based on the type of extension officer.

Also, the government should encourage the establishment of farmer-to-farmer extension since there is a potential human resource in Indonesian rice farming. Currently, 82% of the rice farmer population is at their 20-60 years of age, and 2% of rice farmer has an education of bachelor degree or higher. Moreover, 87% of this educated group (bachelor degree or higher) are aged between 20 and 60 years.[3] Facilitating the establishment of farmer-to-farmer extension would provide a strong foundation for sustainable agricultural extension. Furthermore, the farmer-to-farmer extension provides a cost-effective training method for farmer since the trained farmer will disseminate their useful technology to the non-trained farmer, and also the non-trained farmer is eager to adopt the technology as they caught up with the increased yield and profit of the trained farmer [75]. Another variable in the institutional factor is participation in farmer group which decreases the likeliness of the farmer being affected by CC. Participation in the farmer group is the primary requisite to obtain farm inputs, extension, and other program provided by the government [64]. While farmer field school does not has a statistically significant effect on the degree of perceived CC impact.

### *5.5. The climatic factors*

This category focuses on identifying which type of impact farmer perceives as having severe damage to their farming. The category contains four variables, flood, drought, heavy rain, and another hazard (such as landslides). The estimation result shows that farmer perceives flood as causing the most severe impact, followed by drought, heavy rain, and another hazard. Flood and drought are the primary consequences of the changing rainfall frequency and intensity. The occurrence of drought and flood is the causes of agricultural loss in developing countries and generally its effect a spatially large area [76,77]. Figure 4 shows the distribution of farmer who experienced flood and drought occurrence in Indonesia. The distribution shows that there more farmer who is experiencing drought than the flood. Even in the province with high rainfall intensity, the occurrence of drought is larger than the flood. Moreover, the spatial distribution of the affected farmer shows that farmer outside Java is more vulnerable to CC. This information is vital in the implementation of adaptation policy; the government should put more attention on increasing the climate resiliency of farmer outside the Java island. The effort to increase the resiliency of farmers towards CC can be achieved through expanding the coverage of agricultural extension services to this farmer.

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[3] 25% in 20-40 years, and 61% in 41-60 years group.

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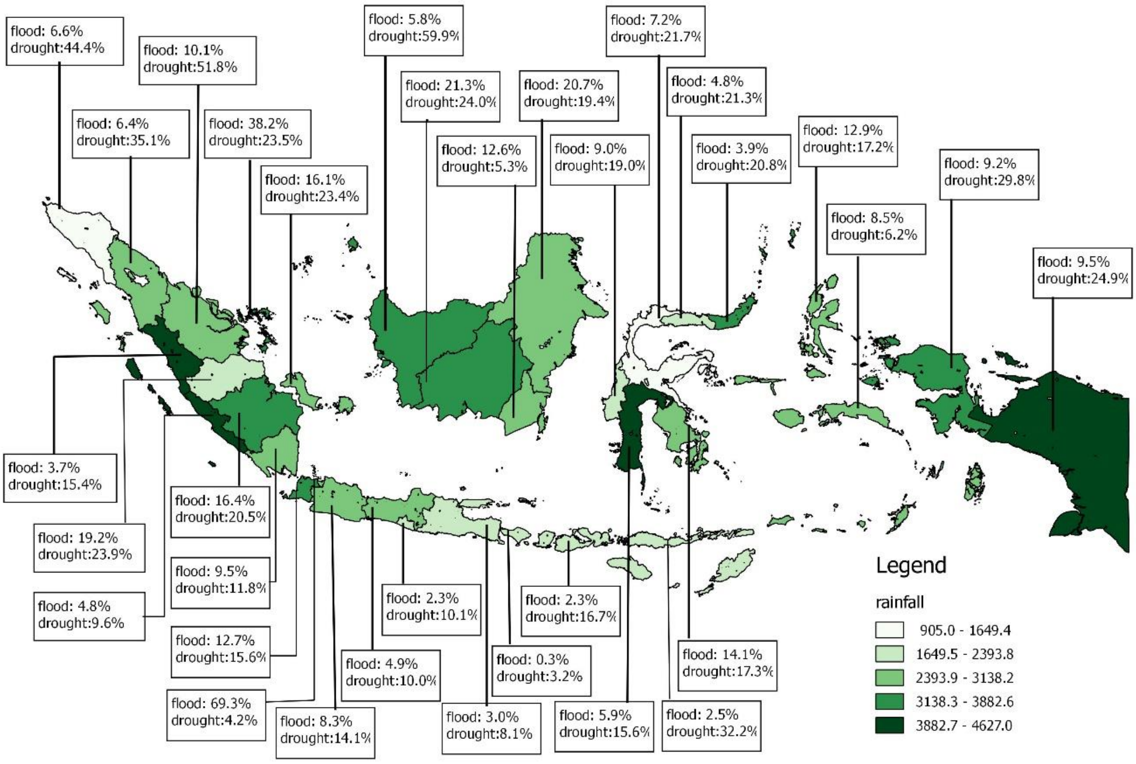


**Figure 4** The distribution of farmer experiencing flood and drought in each Province of Indonesia (the rainfall intensity unit is mm/year).

### *5.6. Policy implications*

The primary purpose of agricultural adaptation policy to CC is to reverse the adverse effect it has to farm yield. Thus, adaptation to CC limit agricultural yield loss and improve food security. In some cases, CC is beneficial to agricultural production if a proper adaptation practice is implemented [78,79]. While the majority of countries have formulated a specific adaptation strategy to be implemented at the farm level, the remaining challenge is how to deliver the strategy so that a considerable number of farmer adopt it. The theory on risk perception suggests that the individual who perceives a higher degree of risk would be willing to take any action required to remove the risk [18–20]. In the case of CC impact on agriculture, the farmer would be more willing to adopt adaptation strategy if they individually perceive and feels the damages caused by CC. Thus identifying the factors that affect how a farmer feels about the degree of CC impact is crucial in the implementation of adaptation policy.

The result of this study shows that the perceived-impact of CC is affected by various factors. Female farmer and those with higher formal education perceive a lower impact of CC. Similarly, the farmer who cultivated a technically irrigated land, performs monoculture farming, and applying chemical fertilizer also those with secure land tenure has a higher resiliency towards CC. The result also shows that extension services and farmer group are the efficient institutions to increase farmer's CC-resilience. Geographically, a farmer residing outside the Java island perceives a higher impact of CC. Based on these results, we propose three implications to improve the effectiveness of adaptation policy.

1. There should be an effort to implement the adaptation policy based on farmer's land tenure and prioritize farmer who cultivates land under lease or sharecropping contract. The security of tenure affects the farmer's incentive to conduct adaptation practices. The farmer who grows land under lease or sharecropping contract will not put much effort and investment in adaptation practices. Currently, 20% of Indonesian rice farmer are in this category, if they do not practice adaptation

strategy, the decrease in rice production would be substantial, and in the context of food security, this will decrease the national rice supply.

2. Extension services is currently an effective way to deliver the substance of the policy to the farmer. It is crucial to use the current channel of agricultural extension in providing the adaptation strategy to the farmer and expand the coverage area of the extension services.
3. The government should also facilitate the establishment of the farmer-to-farmer extension. It can be implemented by first identifying key farmer (farmer with a high degree of formal education), give intensive training to the key farmer, and facilitate the dissemination of the information and technology of this key farmers. This strategy is feasible because Indonesian rice farmer with a high degree of formal education are aged between 20 and 40 years, and has a high potential to be a key farmer.

## 6. Conclusions

This paper attempted to identify factors affecting the degree of perceived-impact of CC among rice farmer in Indonesia. The perceived impact can be different from the actual effect of CC to farm yield. The perceived impact is more subjective than the actual one. This subjective nature of perceived-impact is essential because it indicates how farmer willingness to adapt to CC. The more severe the perceived-impact of CC the more likely they are willing to adopt adaptation practices. In general, the result seems to support the finding of the previous empirical study, and it also appears that there is not much difference between the actual and the perceived impact of CC. Higher education, secure land tenure, the existence of irrigation infrastructure, and access to extension services decrease the degree of perceived impact of CC. Previous empirical studies show that these variables improve the likeliness of farmer to adopt adaptation practices to CC. Thus, since farmer with a high value in these variables is likely to take adaptation practices, we conclude that the adaptation limits the adverse effect of CC. Hence the farmer perceives a lower impact of CC.

However, the estimation result for gender variables contrasting with the result of previous empirical studies. Indonesian female rice farmer has a lower probability of experiencing a severe impact on CC. Thus, this result provides a basis for the future research direction as follows,

1. An investigation into how female farmer adapts their farming to CC will yield a crucial insight into the discussion of the gender issue in the CC literature and policy discourse.
2. As extension services play a vital role in bridging the information to the farmer, an investigation into the mechanism by which extension services improve the resilience of farmer toward CC will provide essential information to improve the efficiency of extension services in delivering timely information to the farmer.
3. The identification of which type of extension officer and what kind of information that contribute most to increase farmer resilience toward CC will yield vital information about which type of extension service officer should be encouraged and what type of information should be delivered to the farmer.

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