Chapter

Improving the Efficacy of Climate Policy in the Indonesian Rice Sector: The Potential Use of Perceived-Impact Measures in Targeting Policy Beneficiaries

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Abstract

Climate change (CC) increases the frequency of flood and drought and is a significant threat to smallholder rice farming in Indonesia. Adapting to these changes is crucial to minimize the damages to the Indonesian food system. Accordingly, the Indonesian government has formulated National Adaptation Plans (NAPs) to mitigate the effect of climate change on priority sectors, including rice farming. To this end, the Indonesian government included climate change adaptation into the National Development Plan (2019–2024). Selecting the appropriate beneficiaries of this program is crucial to improve the efficacy of Indonesian climate policy. In the case of rice farming, farmers with a high probability to adapt are the appropriate beneficiaries of this program. Thus, this chapter aimed to identify the characteristics of Indonesian smallholder rice farmers with a high probability to adapt to climate change. To this end, this chapter used the findings of the study on 87,330 rice farmers in Indonesia. Education, gender, land tenure security, presence of irrigation infrastructure, application of chemical fertilizer, cropping system, access to extension services, and participation in farmer group are significant determinants of adaptation practices. The finding suggests that prioritizing farmers based on these characteristics are crucial to improve the efficacy of climate policy.

Keywords: climate policy, smallholder rice farming, climate change perceived-impact, national adaptation plans, the efficacy of public policy

1. Introduction

It is estimated that the Indonesian economy will suffer a loss of at least IDR 100 trillion (~USD 6.7 billion) annually in the period of 2019–2024 due to climate change (CC). The estimation comes only from four economic sectors that are heavily impacted by CC: agriculture, marine and fisheries, water resources, and health. Among others, agriculture (rice sector) is the hardest hit with a total loss amounted to IDR 30 trillion per year, and more than 10 million farmers suffer a production loss of 30–60%. Furthermore, the production loss in the rice sector will impact national food security since rice is the staple food in Indonesia. Adaptation to climate change both at the macro and micro level are required to minimize and even reverse the negative impact of climate change.

Adaptation strategy, both at the national and farm level, are needed to moderate the negative impact of climate change [1]. Adaptation to climate change is grouped into two categories: autonomous and planned adaptation [2]. Autonomous adaptation is adaptation practices taken by farmers using their resources. In contrast, the planned adaptation requires government roles to conceptualize, formulate, and implement the adaptation practices using government resources. The former implemented at the micro/farm-level while the latter conducted at the macro/national level. Several studies have reported that farmers in developing countries have adjusted their farming practices in response to CC and found that the adaptation has a positive effect on crop yield [3, 4]. However, several barriers limit adaptation practices, such as financial barriers (lack of financial resources and lack of supporting institutions, whether public or private, to finance adaptation), social and cultural barriers (individuals and group perspectives, values, and beliefs toward CC), and informational and cognitive barriers (individual perceptions, values, and opinions about the risk of CC) [5]. This study focuses on the third barrier and specifically individual climate risk perception.

A farmer's perception of climate risk is essential because it represents the degree of perceived impact (P-I)—a measure of how a farmer personally feels about the impact of a particular occurrence [6, 7]. Past exposure to climate-related disaster increases the degree of P-I, which in turn drives farmers to undertake adaptation actions [8, 9]. Although some studies stressed the benefits of autonomous adaptation, other studies reported that it ultimately results in unintended maladaptive outcomes, such as increasing the farmer's vulnerability to CC, shifting the vulnerability to other stakeholders or sectors, and decreasing the quality of common pooled resources [10, 11]. Thus, assessing a farmer's P-I toward CC is essential in two aspects: first, it provides valuable information about the efforts to encourage autonomous adaptation; second, it provides crucial insight into the effort to avoid maladaptation practices. As most developing countries have a national adaptation policy [12], this study contributes to addressing the question of which farmers should be prioritized and through what channel the content of a policy should be delivered. **Figure 1** shows how climate risk perception is related to autonomous adaptation and adaptation outcome.

The role of climate risk perception in CC adaptation has received considerable attention. A study in Bangladesh showed that farmer perceptions of CC are mostly aligned with observed meteorological data and are correlated positively with the rate of adopted adaptation practices [9]. Similarly, a study in French coastal populations showed that they perceive the local changes in climate, weather, coral, and beaches. Still, they only regard it as a problem instead of a danger [13]. In contrast to the result from France, a study on the peri-urban community in Mexico that experiences a risk of drought indicated that the community perceives CC and treats it as a threat because their livelihood as brick producers is severely impacted by climate change [14]. A study on Canadian bivalve aquaculture indicated the importance of stakeholder perceptions of CC in adapting to these changes and further expanding the industry [15]. A cross-country analysis in Europe indicated that the perception of CC is affected by individual-level factors such as gender, age, political orientation, and education. Still, the size of the effects of each variable varies across countries [16].

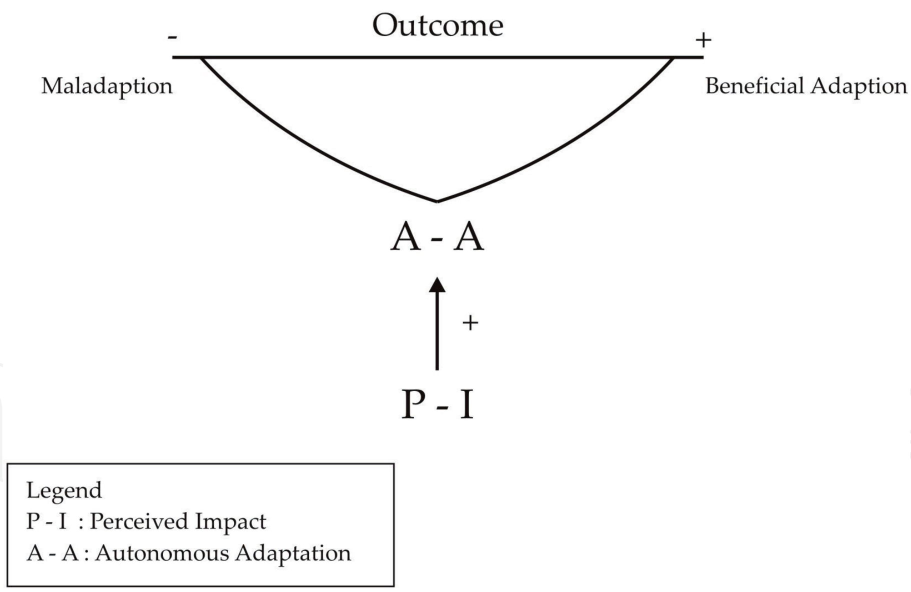

Figure 1.
Perceived-impact of climate change increase autonomous adaptation and affect adaptation outcome (source: Authors work).

This chapter focuses on identifying Indonesian rice farmer's characteristics that affect the perceived-impact of climate change. Understanding these characteristics is crucial to improve the effectiveness of climate policy since the probability of a farmer to adopt adaptation practices increase with the degree of their perceived-impact of climate change. Furthermore, understanding these characteristics assists the policy implementation-body to locate policy beneficiaries. This chapter is structured as follows; the next section provides an overview of Indonesian small-holder rice farming. The third section discusses Indonesia national framework of climate change adaptation, the RAN-API. The fourth section reviews the findings of our study on factors affecting the degree of perceived-impact of climate change on Indonesian smallholder rice farming. The fifth section explains the policy instruments to improve the effectiveness of Indonesian climate action. And the last section concludes the chapter.

2. Overview of Indonesian rice farming

Rice is the most important food crop in Indonesia. The harvested area for Indonesian rice in 2019 reached 10.68 million hectares, with the highest harvest occurring in March of 1.72 million hectares. Indonesia's rice production in 2019 reached 54.60 million tons, with the highest amount of rice production occurring in March at 9.17 million tons. Rice is cultivated throughout Indonesia, but the majority of farmers are on the island of Java. The percentage of rice farmers in Java Island is 55%, followed by Sumatra Island at 9%, Kalimantan Island at 7%, and Sulawesi Island at 6%, while the remaining 20% is spread across other islands. 46% of paddy land is on the island of Java, 14% on the island of Sulawesi, 12% on the island of Sumatra, 8% on the island of Kalimantan, and the remaining 20% is spread over other islands. In 2019, rice production in Indonesia decreased by 4.60 million tons compared to the previous year. Climate change is the leading cause of this decline in production [17].

Climate change is the main factor causing a decrease in rice production in Indonesia. Changes in the intensity and frequency of rainfall, as well as an increase in air temperature, have a significant effect on decreasing rice production in Indonesia. For example, during El Nino, rainfed lowland rice production in Maluku decreased by 2.9% [18]. Then, an increase in temperature of 10°C increases the rainfall by 5% and decreases rice production in North Sulawesi from 6.86 tons/ha to 6.33 tons/ha [19]. An increase in air temperature of 0.4–0.6°C and a decrease in rainfall of 0–197 mm reduce rice productivity in South Sumatra by 0.59% annually. Similarly, Rice productivity in Malang Raya also decreased by 1.59% per year due to an increase in air temperature of 0.7–0.8°C and a decrease in rainfall of 0–550 mm [20].

At the farm level, climate change increases the risk of farming and decreases farmers' income. For example, climate change increases the risk of pest and disease attacks in Subak Penebel District, Tabanan Regency [21]. Then, the flood that occurred in Rawang Panca Arga District, Asahan Regency reduced rice production by 0.60% and caused a total farm loss of IDR 1,256,036 [22]. Furthermore, the floods that occurred during 2006–2010 reduced rice production in West and Central Java by 2.5 tons/hectare and 3.0 tons/hectare; as a result, farmers suffered losses of Rp. 6.5–7.0 million/hectare [23]. These studies show that climate change harms the agricultural sector, especially rice farming, in Indonesia. Government policies to mitigate the impacts of climate change on the agricultural sector are required.

Government policies to mitigate the impacts of climate change are crucial to minimizing losses due to climate change [24]. To overcome the risk of crop failure and decreased productivity due to climate change and pest outbreaks, the government issued a rice farming insurance program (AUTP). The AUTP has a premium price of IDR 36,000/hectare/season and provides benefits for farmers of IDR 6,000,000/ha/season if damage to farming reaches ≥75% [25]. Farmers well receive this program because it helps them provide farming capital for the next planting season when they experience failure in farming [26]. However, farmer participation in this program is low, even though the government subsidized the premium by 80% [27]. It shows that a more comprehensive policy framework and a careful implementation of that policy are required to mitigate the impact of climate change on rice farming in Indonesia.

3. Indonesian National Action Plan for climate change adaptation

Indonesia is one of the agricultural countries most vulnerable to the impacts of climate change. Data from the study conducted by the Indonesian Ministry of Environment shows a trend of increasing temperatures of 1°C during the 20th century [28]. Climate change has a significant negative impact on various development sectors in Indonesia, such as food security, health, infrastructure and settlements, and ecosystems. Efforts and strategies to mitigate the impacts of climate change in the short and long term are essential to reduce higher economic losses in the future. For this purpose, the Government of Indonesia has formulated a strategy to deal with the negative impacts of climate change in the form of a national policy framework to address the impacts of climate change, namely the National Adaptation Plan and the National Action Plan for Adaptation to Climate Change Indonesia [29].

Indonesia's National Action Plan for Adaptation to Climate Change (RAN-API) is a national policy framework for dealing with and adapting to climate change. The RAN-API program is an integrated policy concept and involves all relevant parties from the government, society, community organizations, and industry. The purpose of RAN-API is to ensure the achievement of the national development plan and to increase the physical, economic, social, and environmental resiliency of the community against the impacts of climate change. The inclusion of climate change adaptation in national development plans was aimed to reduce the risk of climate change to national development. The targets and policy directions of the RAN-API are in the form of adaptation strategies, policy adjustments, management, technology, and attitudes to minimize the negative impacts of climate change. The strategic targets of RAN-API cover several areas, namely economic resiliency, livelihood resiliency, ecosystem resiliency, and special region resiliency. **Figure 2** shows the schematic representation of the strategic goals and targets of RAN-API.

One of the strategic targets of the national action plan for climate change adaptation (RAN-API) is economic resilience. Climate change harms economic stability and economic development efforts. The emphasis of the RAN-API strategy in the field of economic resilience is divided into two aspects, namely food and energy security. The RAN-API has three priorities to achieve food security. First, reducing the climate-change-related loss rate of food and fisheries production. Second, establish new sources for food production and inland fisheries in areas with low climate risk and minimum environmental impact. Third, develop a food security system for farmers, fishers, and the community with a healthy, nutritionally balanced diet and food diversification.

The primary targets of RAN-API in the field of food security are realized by several means. These are adapting and developing farming systems that are resistant to climate change, developing and applying technologies that are adaptive to climate change, as well as developing and optimizing land, water, and environmental ecosystem resources. The existence of seven main programs supports these strategies—these programs are (1) Adapting the food production system to climate change; (2) Expanding the area of food production; (3) Improvement and development of climate-proof agricultural infrastructure; (4) Food diversification; (5) Development of innovative and adaptive technologies; (6) Development of information and communication system (for climate and technology); and (7) Establishing supporting programs.

To achieve these targets, the Indonesian government established a coordinating body specialized in managing the impact of climate change. This coordinating body

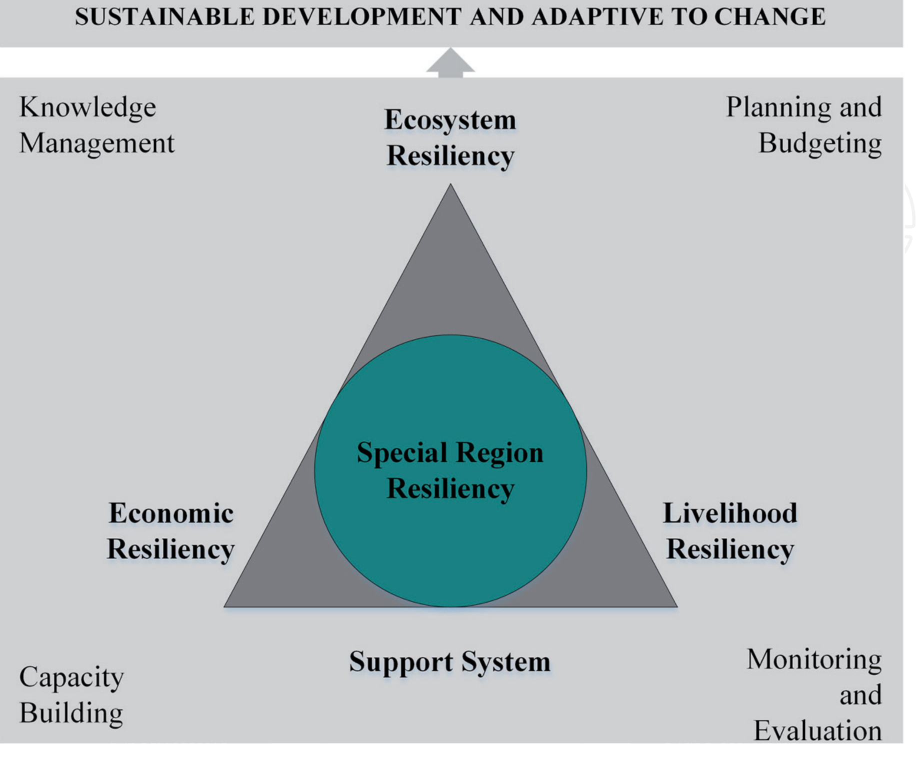

Figure 2.
The strategic goals and targets of RAN-API (source: BAPPENAS [29]).

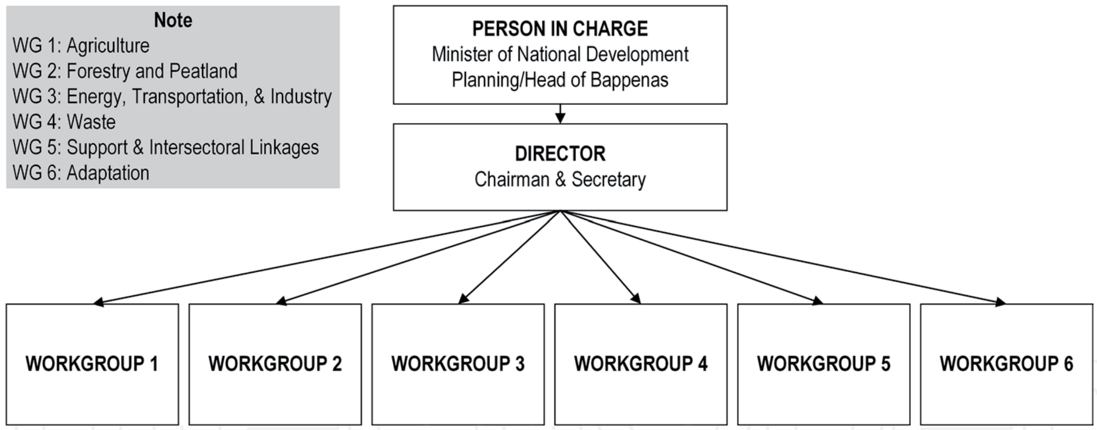

Figure 3.
The organizational structure of the CCCT (source: Authors works).

is under the Ministry of National Development Planning/National Development Planning Agency and was named *Tim Koordinasi Perubahan Iklim* (Climate Change Coordination Team/CCCT). The primary task of CCCT is to coordinate the national government bodies (ministries and institutions) and regional government (province and regency) in the preparation and implementation of climate policy both at the national and regional levels. Structurally, the CCCT is directed by a chairman and secretary who are under the responsibility of the Minister of National Development Planning/Head of Bappenas. The CCCT has six workgroups which specialized in agriculture; forestry and peatland; Energy, Transportation, and Industry; Waste; Support and Intersectoral Linkages; and Adaptation. **Figure 3** shows the organizational structure of the CCCT.

Currently, the CCCT's primary task is to coordinate the adaptation efforts conducted by both national and regional governments. However, the government has no specific budget for the adaptation program. The current budget for the climate change adaptation program comes from the national and regional government budgets as a part of a general development budget. Besides, the fund for financing climate change adaptation programs comes from government debt, private investment, and corporate social responsibility.

4. Improving the efficacy of climate policy using perceived-impact of climate change

The key to improving the efficacy of climate policy in the Indonesian rice sector is to target farmers who are highly likely to adopt the suggested adaptation practices. Increasing the number of farmers who implement adaptation practices would reduce production loss due to climate change at the national level. The problem remains on selecting which farmers to target. The probability of farmers implementing the suggested adaptation practices depends mostly on how much farmers perceive the severity of climate change impact on their farming. The higher farmer perceived the severity of CC impact, the more likely they are to implement adaptation practices. And vice versa. Thus, an understanding of factors that affect the degree of farmer's perceived-impact of CC is of paramount importance. This section will review factors that affect the degree of farmer's perceived-impact of CC based on the finding of the study of 87,330 smallholder rice farmers in Indonesia [30].

This section grouped these factors into the driving and inhibiting factors to adaptation practices. In doing so, the perceived-impact measure was used to determine the category of each factor. A factor that increases the degree of perceived-impact of climate change was categorized into the driving factors of adaptation practice, and those that decrease the degree of perceived-impact were categorized into the inhibiting factors of adaptation. **Figure 4** shows the distribution of driving and inhibiting factors of climate adaptation. The driving factors are those with a positive probability to adapt. In contrast, the inhibiting factors are those with a negative probability of adopting the suggested adaptation practices.

This study suggests that targeting farmers with a high probability of adopting the suggested adaptation practices will improve the efficacy of Indonesian climate policy. Below we describe each variable and its spatial distribution across Indonesian territory.

4.1 Education

The first variable is the farmer's education. Education decreases the degree of perceived-impact of climate change. Thus, farmers with a high formal education reported a low degree of climate change impact while those with a low formal education perceived a high degree of climate change impact. Consequently, the latter group has a higher probability of adopting the suggested adaptation practices. Farmer education has received considerable attention in the previous studies. A study on farmers in Pakistan shows that the higher the education of the farmers, the better the adaptation will be. The form of adaptation taken is planting drought-tolerant crops, crop diversification, and these adaptations have a positive impact on food security [31]. Other similar studies on farmers in Ethiopia show that education has a positive impact on climate change adaptation through land conservation and changes in planting time [32]. In general, education plays a crucial role in farm decisions making in Indonesia. Farmer's education significantly affects participation in contract farming for tobacco [33], sugarcane [34], and broiler farmers [35, 36]. Furthermore, education also significantly affects the adoption of certified seed plants for Indonesian sugarcane farmers [37].

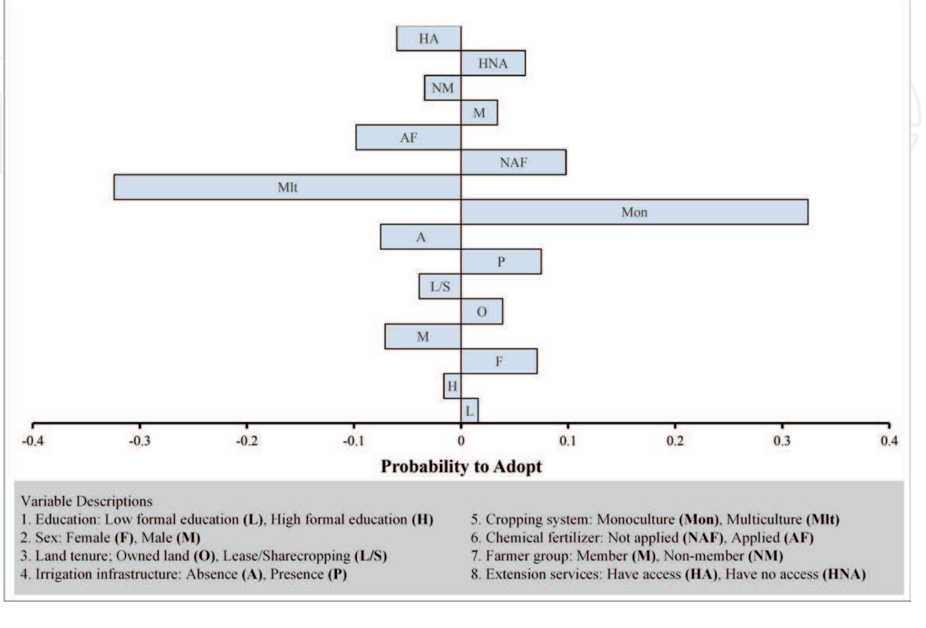

Figure 4.
The driving and inhibiting factors of farmer adoption of the suggested adaptation practices (source: Authors works).

The majority of Indonesian rice farmers have low-level formal education. 70% of Indonesian rice farmers fall in the category of low education farmers having attended only elementary or never attended formal education. Then, 27.6% of Indonesian rice farmers have a middle-level formal education, both junior (SMP) and senior high school (SMA). Meanwhile, only 2.4% of farmers completed higher education. The majority of low education farmers are located in Java and Sumatera (65.78%), followed by Sulawesi, Bali and Nusa Tenggara, Maluku, and Papua. Even though the majority of farmers have low-level education, each region has a farmer who attended higher education. This figure is crucial to plan a farmer-to-farmer extension program, where high education farmers acted as the key farmer. Establishing a farmer-to-farmer extension is promising in improving the adaptation program and is crucial in the general agricultural development program. **Table 1** shows the distribution of Indonesian rice farmers based on their level of formal education.

4.2 Gender

The second variable is the farmer's gender. The study shows that female farmers perceived a lower impact of climate change on their farming. The finding implies that female rice farmers in Indonesia are better at adapting to climate change than male farmers. The literature found a varied effect of farmer's gender on climate adaptation. Studies conducted in Ethiopia [32] and Kenya [38] show that male farmers are more able to adapt to climate change than female farmers. However, research on farmers in Pakistan shows that female farmers are better able to implement climate change adaptation strategies and can maintain food security [31]. Also, research on farmers in Europe suggests that female farmers are more sensitive to climate change [16]. This finding suggests that involving female farmers and policymakers in climate action and climate-related decision making are crucial to improve the effectiveness of the adaptation program. Furthermore, female farmers are present in each region in Indonesia (**Table 2**).

Region	Low	Middle	High
Sumatera	14,442 (23.65)	8486 (35.14)	537 (25.50)
Java	25,729 (42.13)	6749 (27.95)	708 (33.62)
Kalimantan	5962 (9.76)	2466 (10.21)	348 (16.52)
Sulawesi	6997 (11.46)	2490 (10.31)	175 (8.31)
Bali & Nusa Tenggara	6846 (11.41)	3442 (14.25)	308 (14.62)
Maluku	579 (0.95)	282 (1.17)	16 (0.76)
Papua	520 (0.85)	234 (0.97)	14 (0.66)
Indonesia	**61,075 (70)**	**24,149 (27.6)**	**2106 (2.4)**

Notes:
1. *The region of **Sumatera** consists of ten provinces (Aceh, North Sumatera, Riau, Jambi, Riau Islands, Bengkulu, Bangka Belitung Islands, West Sumatera, South Sumatera, and Lampung); **Java** consists of six province (Jakarta, Banten, West Java, Central Java, Yogyakarta, and East Java); **Kalimantan** has five provinces (West, Central, South, East, and North Kalimantan); **Sulawesi** has six provinces (North, Central, West, South, and Southeast Sulawesi, and Gorontalo) **Bali & Nusa Tenggara** has three provinces (Bali, East Nusa Tenggara, and West Nusa Tenggara); **Maluku** has two provinces (Maluku and North Maluku); **Papua** has two provinces (Papua and Papua Barat).*
2. *The value in brackets indicates the percentage within each education level.*
3. *The value in brackets on the lowest row indicates the percentage within the total number of the farmer.*

Table 1.
The distribution of Indonesian rice farmers based on their level of education.

Region	Male	Female	Density
Sumatera	19,762 (25.53%)	3793 (37.06%)	6
Java	29,701 (38.53%)	3485 (34.05%)	9
Kalimantan	7909 (10.26%)	867 (8.47%)	10
Sulawesi	8255 (10.71%)	1407 (13.75%)	6
Bali & Nusa Tenggara	10,004 (12.98%)	592 (5.78%)	17
Maluku	844 (1.09%)	33 (0.32%)	26
Papua	709 (0.92%)	59 (0.58%)	13
Indonesia	**77,094 (88.28%)**	**10,236 (11.72%)**	**8**

Notes:
*1. The region classification is similar to those presented in **Table 1.***
2. The value in brackets indicates the within-group percentage (male/female).
3. The density is the male to female ratio. For example, in Maluku, for every 26 male farmers, there is only one female farmer.
4. The value in brackets on the lowest row indicates the percentage of male/female farmers to total farmers.

Table 2.
The distribution of male and female Indonesian rice farmers.

Table 2 shows that the majority of Indonesian rice farmers are male (88.28%), and only 11.72% are female. Similar to the previous variables, both male and female farmers were concentrated in Sumatera and Java. However, the data indicate that female farmer density varies across the region. Sumatera and Sulawesi have the highest female farmer's density of 6, which means that there is one female farmer for every six male farmers in the region. Java and Kalimantan have a somewhat similar density of nine and ten. The region of Papua, Bali & Nusa Tenggara and Maluku has the lowest density of 13, 17, and 26 respectively. These figures suggest that involving female farmers in climate action and climate-related decision making in Sumatera, Java, and Sulawesi is a good option. 75.9% of Indonesian rice farmers were located in Sumatera, Java, and Sulawesi. Also, 84.85% of female farmers were located in these regions. Thus, focusing on the gender-related program in these regions is crucial to improve the efficacy of climate policy.

4.3 Land tenure

The third variable is land tenure. Land tenure represents the security of farmland ownership. A higher land tenure security encourages the farmer to provide farm investment in the form of adaptation practices. This study categorized land tenure into three groups: owned land, leased land, and sharecropping land. As expected, a farmer who cultivates their land perceives a lower impact of climate change. In contrast, those who cultivated on leased or sharecropped land perceive a higher impact of climate change. This finding suggests that targeting farmers with insecure land tenure is crucial to mitigate the negative impact of climate change.

The importance of land tenure security on smallholder farming has been studied extensively. A study on farmers in Ghana shows that land tenure increases a farmer's willingness to adapt to climate change [39]. The results of this study also show that landowners have a high level of willingness to adapt to climate change compared to tenants and sharecropping farmers. Similarly, farmers in Rome, Italy, with the status of landowners, have a high level of initiative to adapt to climate change [40]. Land tenure security also plays a crucial role in Indonesian agriculture. Land tenure security increases the productivity and profitability of rice farming in Indonesia [41], the probability of participating in contract farming [34], and the adoption of certified seed plants [37]. A weak land tenure security lessens farm investment and makes the farmer more vulnerable to shocks, including climate change. Thus, focusing the climate action on farmers with a weak land tenure security is crucial in moderating the impact of climate change. **Table 3** shows the distribution of Indonesian rice farmers based on land tenure security.

Table 3 shows that about 30% of Indonesian rice farmers have weak land tenure security and perform farming either on leased or sharecropped land. The majority of these farmers were located in Java and Sumatera. Furthermore, the majority ratio of own farmer to lease/sharecropping farmer is lowest in Java and Sumatra. Both Java and Sumatera have 3 and 2 own to lease/sharecropping farmer ratio, indicating that there is one lease/sharecropping farmer for every three own farmers in Java, and two in Sumatera. Focusing climate action on lease/sharecropping in Java and Sumatera is crucial to improve the effectiveness of the adaptation program.

4.4 Irrigation

The fourth variable is the irrigation infrastructure. Historically, irrigation infrastructure has played a central role in Indonesian rice farming. The development of the irrigation system in Indonesia started in the colonial era and continued in each government regime. In the independence period, irrigation development was characterized by the construction of massive irrigation infrastructure [42]. The finding of this study shows that the presence of irrigation infrastructure reduces the perceived-impact of climate change. It indicates that irrigation infrastructure moderates the negative impact of climate change, especially during drought. It also implies that farmers with no access to irrigation are vulnerable to climate change and is appropriate as the beneficiary of climate adaptation program.

Several studies have found the benefit of irrigation infrastructure in mitigating the impact of climate change. The development and improvement of irrigation infrastructure are crucial in mitigating the negative impact of drought due to climate changes in the Vietnamese rice sector [43]. Irrigation development in Vietnam is also able to overcome the excess of water during the rainy season and provide water during the

Region	Own	Lease	Sharecropping	Ratio
Sumatera	14,452 (23.39%)	5826 (36.90%)	3101 (33.16%)	2
Java	24,708 (39.99%)	4976 (31.52%)	3319 (35.49%)	3
Kalimantan	6646 (10.76%)	1243 (7.87%)	829 (8.87%)	4
Sulawesi	7535 (12.20%)	1414 (8.96%)	676 (7.23%)	4
Bali & Nusa Tenggara	7064 (11.43%)	2222 (14.07%)	1270 (13.58%)	3
Maluku	747 (1.21%)	72 (0.46%)	57 (0.61%)	6
Papua	632 (1.02%)	35 (0.22%)	99 (1.06%)	5
Indonesia	**61,784 (70.75%)**	**15,788 (18.08%)**	**9351 (10.71%)**	**3**

Notes:
*1. The region classification is similar to those presented in **Table 1**.*
2. The value in brackets indicates the within-group percentage (own/lease/sharecropping).
*3. The data contains 407 observations with missing value, thus excluded from data presented in **Table 3**.*
4. The data reported three categories of land tenure owned, leased, and lease-free. However, we categorized 'lease-free' as sharecropping since there are a resource and result-sharing agreement between the farmer and the landowner.
5. The ratio is own to the farmer lease+sharecropping ratio. The value indicates the number of lease/sharecropping farmers for every own-farmer.

Table 3.
The distribution of Indonesian rice farmers based on land tenure.

dry season [44]. Research conducted on rice farmers in Indonesia shows that irrigation infrastructure development can increase yields of crops, planting season, and planting intensity [45]. Furthermore, the presence of irrigation infrastructure increases agricultural land value in the rural and peri-urban areas in Indonesia [46] and drives the way farmers govern water-user associations [47]. However, the current irrigation infrastructure only covers less than half of Indonesian rice farmers (**Table 4**).

Table 4 shows that irrigation infrastructure covers only 45.27% of Indonesian rice farmers. Furthermore, the majority of farmers who have access to irrigation infrastructure were located in Java (42.30%), followed by Sumatera, Bali & Nusa Tenggara, Kalimantan, Sulawesi, Maluku, and Papua. However, the percentage of farmers with having no access to irrigation infrastructure was also located in Java (34.45%). But, looking at the ratio, Sulawesi has the highest ratio of 96. It means that for every ten farmers in Sulawesi who have access to irrigation infrastructure, 96 farmers do not. Java, Kalimantan, Bali & Nusa Tenggara, and Maluku have a ratio of less than ten. It means that the number of farmers that have access to irrigation infrastructure is higher than those who do not. This figure indicates that irrigation development was concentrated on the island of Java.

4.5 Farming system

The fifth and six variables are cropping system and chemical fertilizer application and belong to the farming system category. Multicultural rice farming system increases farmer's perceived impact of climate change. Thus, farmers applying multi-culture rice farming perceived a high degree of climate change impact. Fortunately, the majority of Indonesian rice farmers applied monoculture rice farming (96.1%). 65.8% of farmers applied monoculture rice farming were located in Sumatera and Java. In contrast, the application of chemical fertilizer decreases the degree of perceived impact of climate change. Chemical fertilizer increases rice yield. Thus, the use of chemical fertilizer is associated with higher rice production. Consequently, it is associated with the low degree of perceived impact of climate change. The majority of Indonesian rice farmers applied chemical fertilizer (91.4%), and 67.8% of them were located in Java and Sumatera. **Table 5** shows the distribution of farmers based on the cropping system and chemical fertilizer application.

Region	Non-irrigated land	Irrigated land	Ratio
Sumatera	13,674 (28.61%)	9.791 (24.77%)	13
Java	16,466 (34.45%)	16,720 (42.30%)	9
Kalimantan	3212 (6.72%)	8776 (14.08%)	5
Sulawesi	8757 (18.32%)	905 (2.29%)	96
Bali & Nusa Tenggara	4988 (10.44%)	5608 (14.19%)	8
Maluku	226 (0.47%)	651 (1.65%)	3
Papua	477 (1%)	291 (.74%)	16
Indonesia	**47,800 (54.73%)**	**39,530 (45.27%)**	**12**

Notes:
*1. The region classification is similar to those presented in **Table 1**.*
2. The value in brackets indicates the within-group percentage (irrigated/non-irrigated land).
3. The data contains 407 observations with a missing value.
4. The ratio represents the number of the farmer with no access to irrigation infrastructure for every ten farmers with access to irrigation infrastructure.

Table 4.
The distribution of Indonesian rice farmers based on access to irrigation infrastructure.

Region	Cropping system		Chemical Fertilizer	
	Multiculture	Monoculture	Not applied	Applied
Sumatera	881 (26.2)	22,584 (27.1)	2633 (35)	20,832 (26.3)
Java	880 (26.2)	32,306 (38.7)	225 (3)	32,961 (41.5)
Kalimantan	829 (24.7)	8833 (10.6)	2947 (39.2)	6715 (8.5)
Sulawesi	183 (5.4)	10,413 (12.5)	820 (10.9)	9776 (12.3)
Bali and Nusa Tenggara	551 (16.4)	8225 (9.9)	805 (10.7)	7971 (10)
Maluku and Papua	39 (1.2)	1120 (1.3)	84 (1.1)	1075 (1.4)
Indonesia	**3363 (3.9)**	**83,481 (96.1)**	**7514 (8.6)**	**79,330 (91.4)**

Notes:
1. The value in brackets indicates the within-group percentage (multi-culture/monoculture and not applied/applied chemical fertilizer).
2. The data contains 486 observations with a missing value.

Table 5.
The distribution of Indonesian rice farmers based on the cropping system and chemical fertilizer application.

Region	Extension services		Farmer group	
	Have no access	Have access	Non-member	Member
Sumatera	18,748 (28.8)	4717 (21.8)	11,299 (27.2)	12,166 (26.8)
Java	24,022 (36.9)	9164 (42.3)	17,794 (42.9)	15,392 (34)
Kalimantan	7331 (11.3)	2331 (10.8)	4465 (10.8)	5197 (11.5)
Sulawesi	7442 (11.4)	3154 (14.5)	4176 (10.1)	6420 (14.2)
Bali and Nusa Tenggara	6937 (10.6)	1839 (8.5)	3703 (8.9)	5073 (11.2)
Maluku and Papua	684 (1)	475 (2.2)	84 (0.2)	1075 (2.4)
Indonesia	**65,614 (75.2)**	**21,680 (24.8)**	**41,521 (47.8)**	**45,323 (52.2)**

Notes:
*1. The region classification is similar to those presented in **Table 5**.*
2. The value in brackets indicates the within-group percentage (have no access/have access and non-member/member).
3. The data contains 39 observations with a missing value for Extension services and 486 missing values for the farmer group.

Table 6.
The distribution of farmers based on access to extension services and farmer group membership.

4.6 Farm institutions

Farm institutions consist of two variables: agricultural extension services and farmer groups. The farmer group plays a crucial role in Indonesian rice farming. The government used farmer groups to deliver various programs related to rice farming, such as the distribution of subsidized fertilizer, seed, agricultural machinery, and program related to the improvement of farming practices. Thus, participation in farmer group improves farmer ability to adapt to climate change and decreases their perceived impact of climate change. Unfortunately, only 52.2% of Indonesian farmers registered in the farmer group. It suggests that there is still a large proportion of farmers with no access to farmer groups and their subsequent facility.

Agricultural extension service is the second farm institution. Agricultural extension plays a crucial in the dissemination of agricultural technology, farming practices, and current agricultural knowledge and information to farmers. Agricultural extension plays an even more crucial role in climate change adaptation efforts. Farmers require accurate information to adapt to climate change. Furthermore, the existence of agricultural extension officers is crucial in informing the appropriate adaptation practices to farmers and improves farmer's awareness of the threat of climate change on their farming. Unfortunately, the coverage of agricultural extension in Indonesia is relatively low. The current agricultural extension service covers only 24.8% of Indonesian rice farmers. Increasing the coverage of agricultural extension service should be the long-term priority of the Indonesian government in the rice sector policy. Currently, the government should optimize the channel of agricultural extension to identify and target the most vulnerable farmers to climate change (**Table 6**).

5. Policy implications

The results of this study indicate that several factors influence the impact of climate change on farmers. Female farmers are more able to adapt to climate change than male farmers. Socialization theory suggests that women are sensitive to respond to change. Thus, female farmers have relevant characters for implementing climate change adaptation and mitigation than male farmers. Therefore, increasing the participation of women farmers in climate change adaptation activities and making adaptation decisions is a crucial factor in increasing farmers' resilience to climate change. Besides, focusing on the region with a high number of vulnerable farmers is crucial to improve the effectiveness of the policy. **Figure 5** shows the distribution of farmers with characteristics of those who perceived a high climate change impact.

The level of education and access to extension reduce the negative impacts of climate change. The information provided by extension agencies can encourage farmers to adapt to face the risks of climate change. Studies on farmers in Mali and Senegal [48] and West Africa [49] show that information is a crucial factor for determining the type of adaptation and increasing farmers' resilience to the risks of climate change. Therefore, it is essential to increase the ability to provide information to minimize the impact of climate change. Strengthening information on climate change can be done in two ways, namely increasing the reach of extension agencies, as well as increasing the role of individual extension workers or extension carried out from farmer to farmer.

The government can strengthen the role of individual farmer extension agents by selecting key farmers or farmers with high levels of education and knowledge. Conduct intensive training for these farmers, and provide supporting programs through these farmers. This strategy is feasible to implement, considering that rice farmers with a high level of education are at the age of 20–40 years.

Land ownership has a positive effect on minimizing the risk of climate change impacts. This study shows that farmers with owned land types have a greater incentive to adapt than farmers with production sharing or rental models. The implementation of climate change policies based on land ownership types can be focused on farmers with weak ownership status. So that farmers with a land lease and sharecropping status will apply adaptation strategies. This strategy is crucial to be implemented, considering that 30% of rice farmers in Indonesia are classified as lease and sharecropping farmers. If these farmers do not adapt to climate change, rice production will decline substantially and threaten food security in Indonesia.

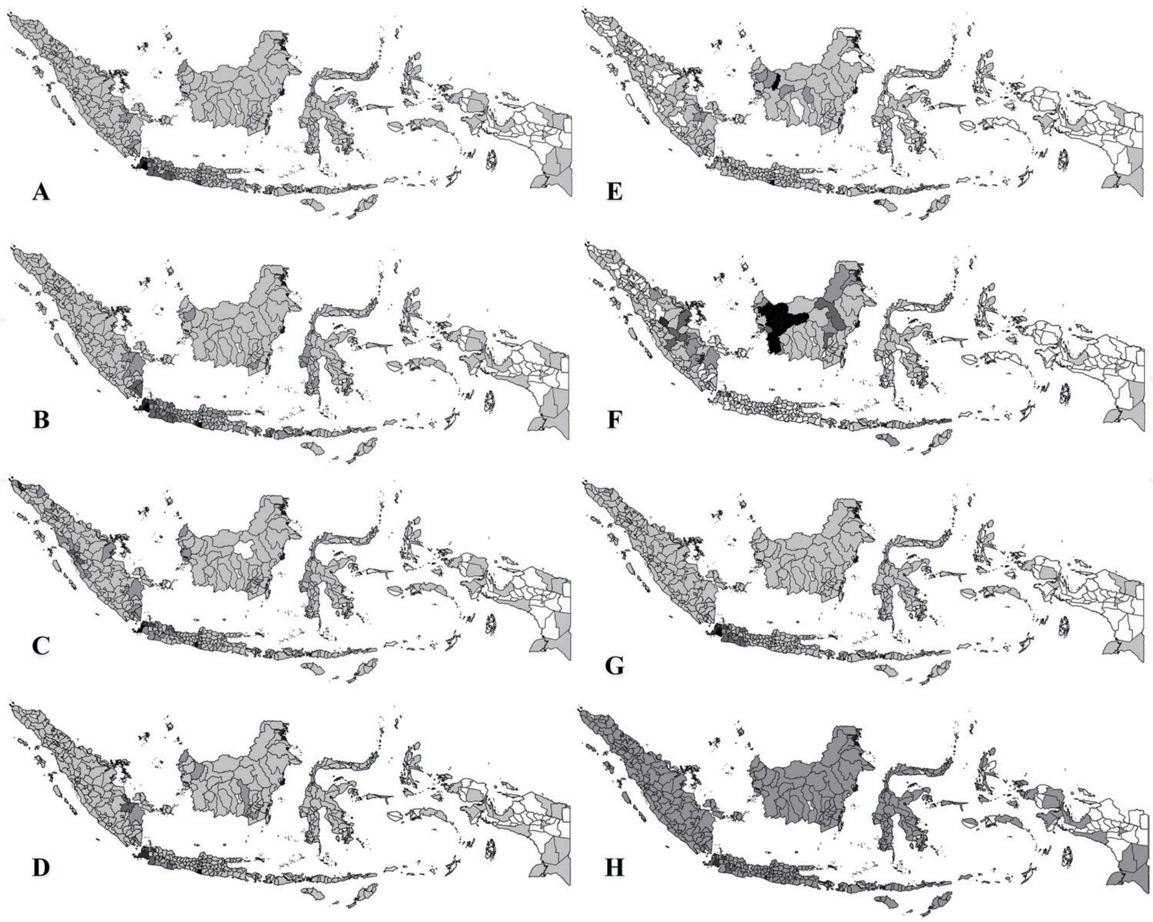

Figure 5.
The distribution of farmers with a high perceived-impact of climate change (A) low education farmers, (B) male farmers, (C) lease/sharecropping farmers, (D) farmers with no irrigation, (E) multiculture farmers, (F) farmers not applied fertilizer, (G) non-member in farmer group, and (H) No access to extension services (the color indicate the farmer density, the darker the color, the higher the density) (source: Authors work).

6. Conclusions

The purpose of this chapter is to review the Indonesian framework for climate change adaptation and identify factors affecting the perceived-impact of climate change on smallholder rice farmers in Indonesia. Eight factors significantly affect how a farmer perceived the impact of climate change. The study indicates that Indonesian rice farmers are concentrated in the Java and Sumatera island. However, a substantial number of farmers outside these areas are heavily impacted by climate change. Thus, targeting program beneficiaries based on the characteristics of vulnerable farmers are crucial in improving the efficacy of Indonesian climate policy.

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Conflict of interest

The authors declare no conflict of interest.

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