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Promotion of Climate Resilience in Rice and Maize

Indonesia National Study

Imprint

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Alternatively: German Federal Foreign Office

Promotion of Climate Resilience in Rice and Maize

Indonesia National Study

ASSOCIATION OF SOUTHEAST ASIAN NATIONS (ASEAN) and the GERMAN-ASEAN PROGRAMME ON RESPONSE TO CLIMATE CHANGE (GAP-CC), DEUTSCHE GESELLSCHAFT FÜR INTERNATIONALE ZUSAMMENARBEIT (GIZ) GMBH. IN PARTNERSHIP WITH THE SOUTHEAST ASIAN REGIONAL CENTER FOR GRADUATE STUDY AND RESEARCH IN AGRICULTURE (SEARCA)

List of Acronyms

AMS	ASEAN Member States
ASEAN	Association of Southeast Asian Nations
ATWGARD	ASEAN Technical Working Group on Agricultural Research and Development
BULOG	Badan Urusan Logistik (Indonesia Logistics Bureau)
CCA	Climate Change Adaptation
DITLIN	Directorate of Crop Protection
ENSO	El Niño and Southern Oscillation
GAPCC	German-ASEAN Programme on Response to Climate Change: Agriculture, Forestry, and Related Sectors
KUD	Koperasi Unit Desa (A community- or village-owned business unit)
GAPOKTAN	Gabungan Kelompok Tani (A larger group of farmer group or the second level of farmer organizations)
ICCSR	Indonesia Climate Change Sectoral Maps
MoA	Ministry of Agriculture of Indonesia (Kementerian Pertanian)
POKTAN	Kelompok Tani (Farmer group)
RAN-API	National Action Plan for Climate Change Adaptation
RASKIN	Beras Miskin (Rice distribution program for low-income households in Indonesia)
SEARCA	Southeast Asian Regional Center for Graduate Study and Research in Agriculture

Table of Contents

List of Tables

List of Figures

Foreword

The Indonesian Agency for Agriculture Research and Development (IAARD) under the Ministry of Agriculture is very proud to be a part of this regional study through the ASEAN Technical Working Group on Agricultural Research and Development (ATWGARD) with the support of the GIZ through the German-ASEAN Programme on Response to Climate Change (GAPCC), which seeks to promote resiliency of rice and other crops. Indonesia has good examples of climate adaptive practices, and through this project, we are happy to be given the opportunity to share and learn from our neighbors at ASEAN.

Global climate change poses a challenge to crop production in Indonesia. A number of studies already revealed the impacts of climate change on crop production, which is reasonable as climate variability significantly contributes to crop productivity. These climate change hazards include increased frequency of flood and drought, erratic rainfall particularly on harvesting period, increased temperature, and increasing infestations of pests and diseases. Within the course of this study, five good adaptation practices have been identified. Among them, three are identified as practical intervention for rice value chain, namely: crop insurance, planting calendar, and innovations on cropping strategies; while the remaining two are recommended for maize value chain, namely: production of silase for animal feed, and relay planting of maize using hybrid cultivars.

We hope that the examples provided by the national study will lead towards greater implementation of adaptive practices within Indonesia, and our neighboring countries that will overall benefit the region. These adaptive practices ensure that our people achieve food security, despite the threats of climate change.

Dr. Agung Hendriadi, M. Eng
Executive Secretary
Indonesian Agency for Agricultural
Research and Development (IAARD)

Executive Summary

The impacts of climate change on agricultural production, particularly the potential direct impacts of climate variation on crop growth and development, have been studied intensively in the last two decades. Many studies, including Masutomi et al. (2009) and Mathauda et al. (2000), reported the potential impacts of future climate change on the increase/decrease in rice yield, ranging from +1.5 percent to −2.3 percent, in countries in the Association of Southeast Asian Nations (ASEAN).

To address the potential impacts of climate change, seven ASEAN Member States (AMS) conducted national studies under the project ASEAN Network on Promoting Climate Resilience of Rice and Other Crops. The project is supported by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH; funded by the German-ASEAN Programme on Response to Climate Change: Agriculture, Forestry, and Related Sectors (GAP-CC); and implemented by the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA). The primary aim of the project is to identify good practices in climate change adaptation (CCA) within the participating AMS.

As its contribution to the project, Indonesia explored the potential impacts of climate change on crop production and identified CCA options that have been applied or planned. The study, which focused on rice and maize production systems, employed value chain mapping, literature review, stakeholder discussions, and field visits. Documents on climate change impacts and adaptation measures published by the government of Indonesia were used as the main references. Agricultural data published by Kementerian Pertanian, the Ministry of Agriculture (MoA), were analyzed to support the study. CCA options that have been planned or implemented were explored through literature review and two national consultation meetings attended by experts on agriculture and other related fields. Sites in Indramayu, the main rice cultivation area in West Java, and Jember, the main rice and maize cultivation area in East Java, were visited to gather information on issues associated with post-harvest losses and actors involved in the rice and maize value chains.

The potential impacts of global climate change on Indonesia's climate are manifested in increasing air temperature and changing rainfall patterns. The available literature notes that air temperature has been increasing and will continue to rise. As for precipitation, it is difficult to draw a conclusion for rainfall trends as rainfall patterns vary over geographic locations. Rainfall variability is also changing, but the magnitude may increase or decrease depending on the area. Surveys conducted in Indramayu and Jember show that the respondents have also been experiencing warmer conditions and erratic rainfall. The rising sea level is projected to be even higher in the future, which may cause saltwater intrusion and loss of coastline in low-lying areas.

The potential effects of climate change on crop production in Indonesia are frequently identified based on the consequences of climate-related disasters such as floods and droughts. These two events frequently occur and can decrease crop production or cause crop failure. The Directorate of Crop Protection (DITLIN), MoA reported that the floods that occurred throughout Indonesia from 2009 to 2011 damaged the following crop areas: 222,481 hectares (ha) in 2009; 307,809.6 ha in 2010; and 169,464.3 ha in 2011. It also reported that the droughts that occurred from 2009 to 2011 damaged the following crop areas throughout Indonesia: 231,912 ha in 2009; 96,721.3 ha in 2010; and 250,836 ha in 2011. Based on the report, the areas totally damaged by floods (failure or puso) were 67,821 ha in 2009; 93,929.4 ha in 2010; and 29,383.1 ha in 2011; while the areas totally damaged by droughts (failure or puso) were 18,975 ha in 2009; 20,856 ha in 2010; and 53,127 ha in 2011.

Future climate change is generally expected to adversely affect rice and maize production due to the projected increase in the frequency of floods and droughts. The application of modeling tools showed that future climate change that alters the magnitude and pattern of climate variables (e.g., rainfall and temperature) may decrease rice and maize productivity. In addition to the impacts of climate change, potential losses during post-harvest activities from harvesting to milling dry grains or gabah kering giling remain a challenge for Indonesia. Losses are mainly due to unavailability of farming technology or improper use of farming technology that are accessible to farmers.

Understanding the above challenges, the government of Indonesia has been serious in identifying CCA and mitigation measures. Research activities on cultivars have been conducted to develop crop varieties that are tolerant to floods, droughts, salinity, and pests and diseases. The main challenge is farmers' low adoption of new crop varieties. Promoting interaction among actors within the value chain of each crop will likewise increase the acceptance of interventions. For instance, farmers highly consider the consumers' demand for a certain type of rice.

Crop insurance, web-based planting calendar, silase for animal feed, and climate-smart farming practices are the CCA options that can be scaled up nationally and regionally. The availability of human resources, specifically extension workers, is a critical element in promoting the adoption of these CCA options (e.g., introducing new technologies or practices to farmers). Farmers usually decide what farming practices they will employ, but collaboration between extension workers and farmer groups could influence the farming activities in a particular region or location. Therefore, it is advisable to consider the distribution of extension workers in Indonesia during the introduction or implementation of CCA options.

The capacity of both farmers and extension workers is another challenge in implementing CCA options. The government of Indonesia should consider the farmers' educational background and socio-economic conditions. For instance, the farmers' low education and poor economic conditions may hinder the successful implementation of crop insurance and the web-based planting calendar developed and maintained by MoA. The use of the web-based planting calendar requires familiarity with the system and knowledge of its functions. Extension workers should also have sufficient knowledge of the program so that they can guide farmers in using it. The local government should promote the cropping calendar and build stakeholder capacity through communicative and interactive methods such as counseling, training sessions, and workshops, among others.

The successful implementation of CCA strategies highly depends on strong collaboration between national and local governments and all actors in the rice and maize value chains. It is imperative to implement these strategies because global climate change also threatens national food security.

I. INTRODUCTION

Crop production is highly vulnerable to the impacts of climate change because climate variability influences crop growth and development (Hoogenboom 2000; Motha and Baier 2005; Tubiello, Soussana, and Howden 2007). Globally, future climate change is expected to decrease global crop production with or without the inclusion of carbon dioxide fertilization effects (Cline 2007). It should be noted that the impacts are disproportionately felt by each country around the globe. Countries located near the equator are estimated to experience the most adverse impacts of climate change, while those in the middle latitude may benefit from the positive effects (Cline 2007).

AMS, which are mostly located near the equator, have been addressing the potential consequences of climate change. A regional study conducted for AMS found that extreme climate hazards are increasing as a result of global warming and climate change in the last few decades (ADB 2009). This reflects the urgency of CCA and mitigation efforts in crop production.

To address the potential impacts of climate change, seven AMS conducted national studies under the project ASEAN Network on Promoting Climate Resilience of Rice and Other Crops. The project is supported by GIZ, funded by GAP-CC, and implemented by SEARCA. The primary aim of the project is to identify good practices in CCA within the participating AMS. Each AMS conducted a national study to explore the potential impacts of climate change on crop production and identify CCA options that have been applied or planned. The next steps are to scale up the selected CCA practices nationally and regionally. The CCA options, which were identified using value chain mapping, literature review, stakeholder discussions, and field visits, focused on the main crops (i.e., rice and maize or cassava) of each AMS.

The Indonesia team, which is composed of MoA as the country's focal point to the ASEAN Technical Working Group on Agricultural Research and Development (ATWGARD), and the Climate Center for Risk and Opportunity Management in Southeast Asia and Pacific of Bogor Agricultural University, conducted the national study. The Indonesia team studied the potential impacts of climate change on rice and maize based on existing literature and stakeholder consultations. CCA measures that have been planned or implemented were also explored through literature review and two national consultation meetings attended by experts on crop production and other related fields.

As recommended during the first national meeting in Bogor on 3 April 2014, rice and maize production centers were also visited. Sites in Indramayu, the main rice cultivation area in West Java, and Jember, the main rice and maize cultivation area in East Java, were visited. West Java and East Java considerably have the largest planted area for crop production in Indonesia (Figure 1). The total areas reported in 2011 were 1,151,322 ha for West Java and 1,143,780 ha for East Java, which accounted for about 8.35 percent and 8.29 percent of the national total area, respectively.

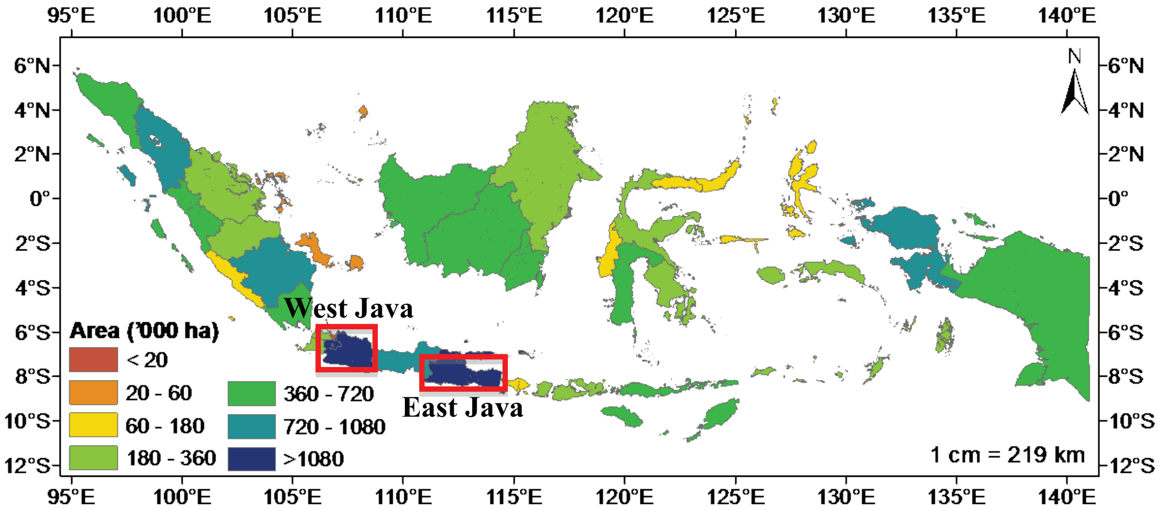

Figure 1. Total area of agricultural production by region in Indonesia
Note: West Java and East Java are indicated by the red rectangles. The area is the total area for inundated field (sawah) and dry land (ladang) reported in 2011.
Source: MoA 2014

The government of Indonesia has already documented studies on climate change, as well as its impacts and vulnerabilities, into national reports. These reports include the Indonesia Climate Change Sectoral Maps (ICCSR) (2010); the Indonesia Second National Communication under the United Nations Framework Convention on Climate Change (MoE 2010); and more recently, the National Action Plan for Climate Change Adaptation (RAN-API), which promotes the need for national adaptation to climate change (BAPPENAS 2013). The Ministry of Environment published Pedoman Umum Adaptasi Perubahan Iklim Sektor Pertanian (General Guidance of Climate Change Adaptation for Agriculture Sector) (BPPP 2011), which reviews the potential impacts of climate change on agriculture and the directions for adaptation actions to enhance and support national food security. The above documents served as the chief references for this report.

II. VALUE CHAIN MAPPING

2.1 Value Chain Selection

This study explored the potential impacts of climate change on rice and maize production because of the national production volume and value of the two crops (Table 1). The study focused on lowland rice and maize production, but it also investigated upland maize production in Jember to complete the analysis.

Table 1. Rice and maize production systems in Indonesia, 2012

Production system type	National production volume (t)	National production value (IDR 10,000 = USD 1)	Assessment of impact on national/regional consumption (1–3)	Indication/estimate of relative vulnerability to climate change (1–3)
Rice	69.056.126[a]	USD 3.298.811.139[b]	3	3
Maize	19.387.022[a]	USD 615.925.689[b]	2	3

Sources: [a]Central Bureau of Statistics of Indonesia website; [b]Trade Performance of Agriculture Commodities, Data Center website, and Agriculture Information System of MoA

Note: In the assessment of impact on national/regional consumption, the production system is estimated to represent the following values of domestic rice consumption for national food security: 1 – Low (less than 30%), 2 – Medium (30%–55%), and 3 – High (greater than 55%). In the relative vulnerability to climate change, the following descriptions apply: 1 – Low (any impact upon the production system is likely to be manageable), 2 – Medium (without intervention, the production system is likely to suffer problems in the future), and 3 – High (the production system is already experiencing significant problems with extreme weather events and these are very likely to become more severe in the future).

Rice is a staple food for the majority of the Indonesian people, and its availability is crucial to the country's development.

According to Simatupang and Rusastra (2004), rice is important to the Indonesian economy in the following ways: (1) the rice agribusiness system strengthens national food security; (2) rice farming activities are labor-intensive and major contributors to the national farming system; and (3) many rice farmers are still considered poor and thus sensitive to any production loss. Compared to other countries in Asia where rice is also the staple food, rice consumption in Indonesia is the highest. With an average consumption rate of about 102 kilograms per capita per year (kg/capita/year), Indonesia surpasses Malaysia (80 kg/capita/year), Thailand (70 kg/capita/year), Japan (50 kg/capita/year), and Korea (40 kg/capita/year) (Neraca 2013).

Given the high demand for rice commodities, paddy rice is grown in several areas in Indonesia. The majority of paddy-growing areas are in Western Indonesia, mostly in Java Island (Figure 2). The climate and soil types in this part of the country are more suitable for paddy growth and development than in the eastern part. Java Island, where West Java and East Java are located, contributes 36,526,000 tons (t) or about 52.9 percent of the national production.

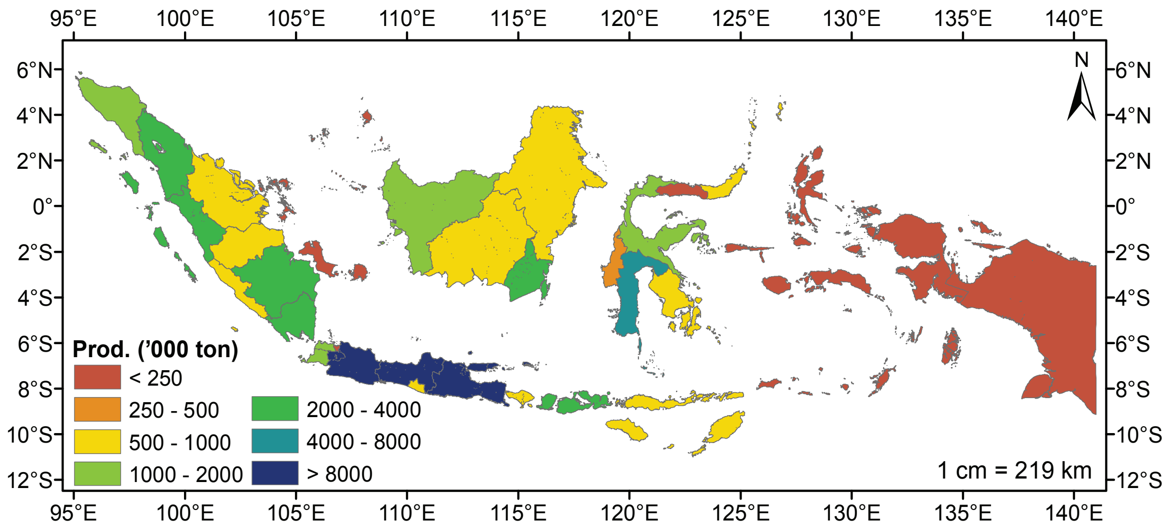

Figure 2. Distribution of paddy production in Indonesia, 2012
Note: The image was created based on data of total agricultural production by province.
Source: Central Bureau of Statistics of Indonesia 2014

Harvested paddy yield produced in the major growing areas are then distributed to consumers through a value chain system (Figure 3). The long and complex value chain may contribute to price disparity received by farmers and paid by consumers. The diagram displays the supply chains of paddy from farmers to consumers. Harvested paddy will pass through post-harvest activities such as drying and milling to produce rice. Rice is then stored and directly distributed to consumers through supermarkets. Rice can also pass through bazaar traders that will sell rice to retailers or small traditional markets where consumers can buy rice. Small millers that process paddy into rice send rice to Koperasi Unit Desa (KUD), a cooperative or community-owned business unit that sends rice to Badan Urusan Logistik (BULOG), the Indonesia Logistics Bureau. BULOG is a state-owned company that may sell rice at a lower price for low-income households.

The following are the general rice supply chains:

- Farmer --> Collective --> Bazaar Trader--> Retail Seller --> Consumer
- Farmer --> Collective --> Bazaar Trader --> Small Traditional Market --> Consumer
- Farmer --> Collective --> Supermarket --> Consumer
- Farmer --> Collective --> Coop --> BULOG --> Low-income Households

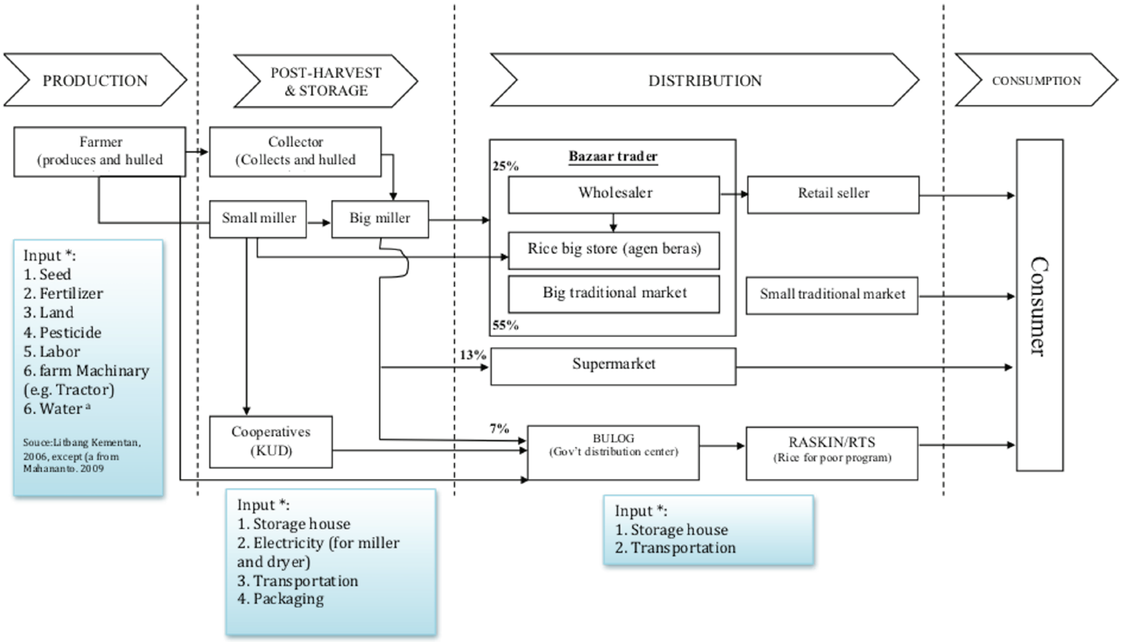

Figure 3. Rice value chain in Indonesia

As discussed during the second national meeting in Bogor on 22 May 2014, BULOG also buys paddy directly from farmer groups (BULOG 2014a). The BULOG representative who attended the second national meeting also mentioned that the company works with farmer groups in post-harvest processing of paddy to rice, allowing it to buy rice directly from farmer groups. BULOG also supplies rice to low-income households at a lower price through a rice distribution program called Beras Miskin (RASKIN) (BULOG, 2014b). These efforts show the government's commitment to help farmers and households access the staple food and maintain food security.

Farmers can buy production inputs such as seeds and fertilizers from agricultural shops.

The national government also supplies seeds and fertilizers to farmers. The seed supply from the government is usually in the form of seed subsidy or for testing a new variety (Figure 4). The government, through the Research and Development Agency of MoA, has produced several new rice varieties that aim to boost rice productivity. Unfortunately, as discussed during the second national meeting, the acceptance of new varieties is still low as farmers regularly choose rice varieties based on market or consumer demand. For example, since consumers already accept the Ciherang variety, it is recommended to name a new variety based on the consumers' preference or knowledge. It was also discussed that the specifications of the milling machinery suit the physical characteristics of the Ciherang variety.

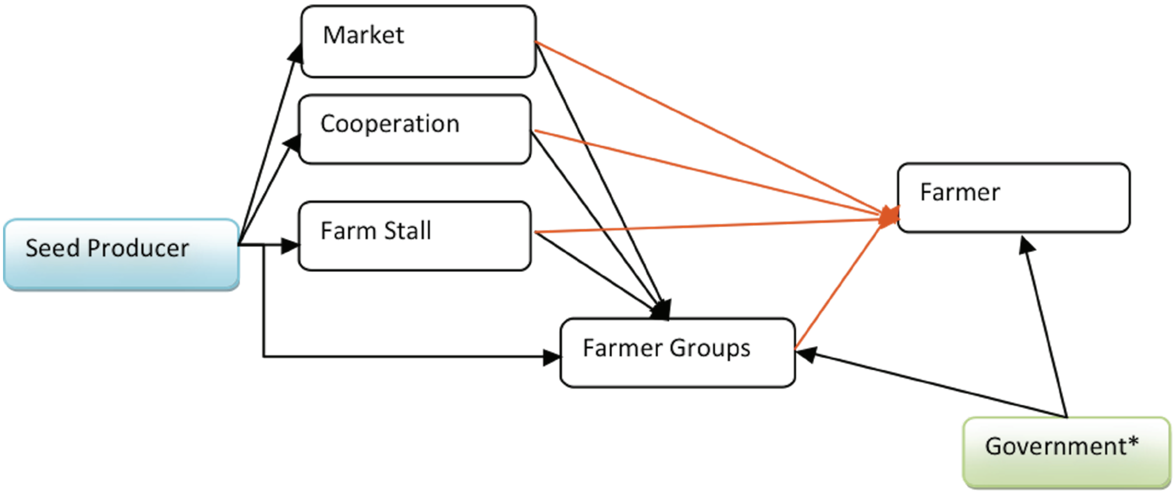

Figure 4. Distribution of rice seeds from producer to consumers

Maize is the second most important commodity in Indonesia. In some areas, people consider this crop as their staple food, such as Ampok Rice and Maize Rice in East Java, Pencok in Bali, Kemunak Rice in Jambi, and Binte Biluhuta in North Sulawesi (Krisnamuthi 2010). Approximately 55 percent of maize domestic production goes to the feed industry, where maize is used as raw material to produce livestock feed. As with paddy rice production, the major maize-growing areas are mostly in Java Island (Figure 5). East Java, which has the highest total maize production among the main maize-growing areas in Java Island, is considered the main maize producer. The total production for East Java reported in 2012 was about 6,295,000 t, which accounted for 32.5 percent of the national production. Some people in East Java also consume maize as their staple food, which can be one of the reasons why maize is mostly cultivated in the province.

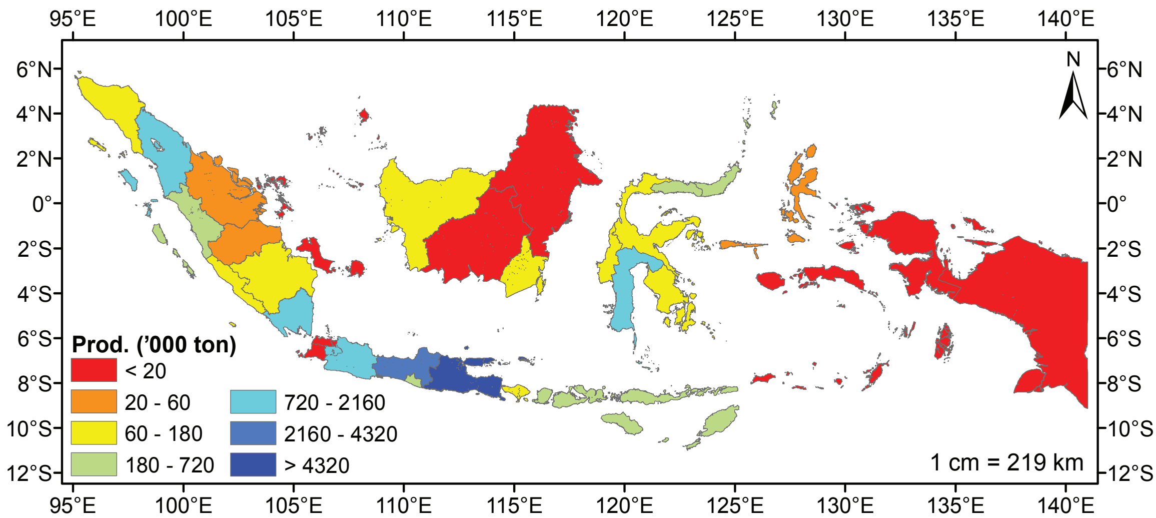

Figure 5. Distribution of maize production in Indonesia, 2012

Note: The image was created based on data of total agricultural production area by province.

Source: MoA 2014

Maize is not only produced for human consumption but also for producing livestock feed. These different demands result in two big schemes of maize supply chain from producers to consumers. In the first chain, harvested yield is delivered to dryers, collectors, wholesalers, retail sellers, and consumers. The second is similar to the first chain, but the collectors send maize yield to the corn-based industry for further post-processing then distribute the post-processed products to wholesalers, retail sellers, and consumers. The schemes are presented in Figure 6.

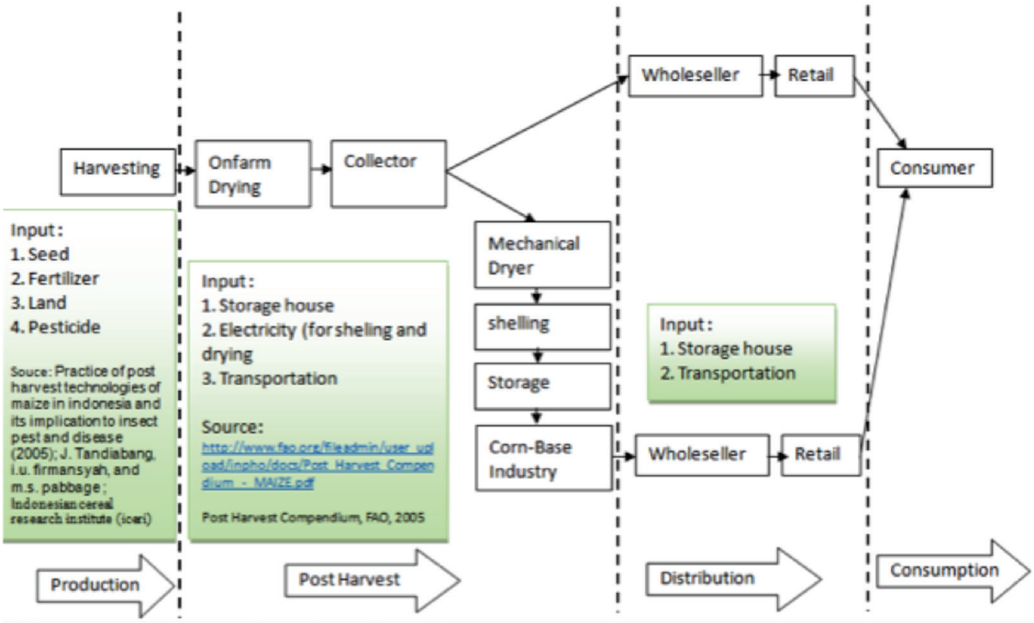

Figure 6. Maize value chain in Indonesia

The government's involvement in maize production is minimal compared to its involvement in rice production. Farmers usually purchase production inputs from agricultural shops, but many private companies also supply seeds. As discussed by a representative during the first and second national meetings, Dupont-Pioneer, a seed company that focuses on maize, already works closely with farmers and farmer groups through the company's extension workers to educate them on the new seeds that they sell. It also supplies post-processed maize to the feed industry. The feed industry has a high demand for silase, a corn-based product that is used to feed cattle. Silase, which is produced from the maize stalks, can reduce feeding costs because cows eat less silase (25 kg/day) than green grass (70 kg/day). Milk producers have also tapped Dupont-Pioneer as a silase supplier.

2.2 Role of Value Chain Players

The roles of players or actors in each stage of the rice and maize value chains are similar. The inputs required for production and post-harvest processes are also similar, but with some exceptions. For example, there is generally no government subsidy for maize seeds. Thus, the information of inputs required for each value chain and actor are also similar. For instance, seeds, fertilizers, and pesticides are produced by associated companies for the farming inputs and purchased by farmers. The inputs and actors in the rice supply chain are presented in Table 2.

Table 2. Inputs and actors in the rice supply chain

Input and actor	Description
Production	
Seeds	Farmers can obtain seeds for their planting activities from numerous sources. They can get it from GAPOKTAN, a group of farmer cooperations (Koperasi Tani) (Darwis 2012), to which MoA distributes seeds subsidized by the government; and seed markets. They could also use the seeds that they stored from their previous harvest. Regarding seed provision, MoA usually provides superior seed varieties to increase harvested yield or productivity, but such projects usually fail because of farmers' lack of knowledge and support. Also, some varieties may not grow well because they are not suitable for some land types (Firdaus, Baga, and Pratiwi 2008). Generally, seeds can be obtained through farmers, individual suppliers, associations (e.g., farmer associations that also distribute seeds), and cooperatives (KUD).
Fertilizers	There are two types of fertilizers: organic and inorganic. As with seeds, farmers can obtain fertilizers from several sources, such as GAPOKTAN, cooperatives, or fertilizer traders. In the market, there are also two types of fertilizers: subsidized or non-subsidized. Based on discussions during the experts' meeting, the issue of accessing subsidized fertilizers is usually related to limited stocks or farmers' lack of knowledge on how to obtain subsidized fertilizers. Farmers can also make their own organic fertilizers using crop residues or manure. Generally, fertilizers can be obtained through individual suppliers, associations (e.g., farmer associations that also distribute fertilizers), and cooperatives (KUD).
Pesticides	The use of pesticides increased during the agricultural intensification program announced by the government in the 1970s. Most farmers depended on it and assumed that pesticide application was the only way to control pests. During the experts' meeting, a representative of MoA mentioned that to reduce farmers' reliance on toxic chemical pesticides, the government issued several programs to inform the public about using the correct amount of pesticides. It also introduced the use of biopesticides. Generally, pesticides can be obtained through individual suppliers, associations (e.g., farmer associations that also distribute fertilizers), and KUD.
Land	The two common land problems are (1) high rate of land conversion, wherein rice-growing areas are turned into land for residential and industry purposes (Departemen Pertanian 2010); and (2) suitability of land for rice production, which depends on land types, morphology, and climate, among others (Departemen Pertanian 2010).
Water	Water, one of the most important inputs for rice production, can be obtained from rainfall or rainfed systems and irrigation systems.
Machinery	Machinery can be obtained from individual suppliers and farmer associations.
Labor	Labor for farming activities can be categorized into (1) family members and (2) farm workers. They are hired (1) throughout the growing season or (2) only during a certain stage, such as planting or harvesting. Farm workers are paid either monthly or by the end of the season
Post-harvest	
Collectors	Collectors are individuals who often gather harvested paddy directly from the field or farmland.
Rice dryers and millers	Farmers commonly send the harvested paddy to a milling center. The drying and milling centers can be privately owned, belong to a farmer group, or managed by KUD.
Cooperatives (KUD)	A cooperative is an economic institution at the village level that is originally a combination of an agricultural cooperative and a village cooperative (Government Regulation No. 60/1959).
Storage house owners	Rice and other grains are kept in a storage house before they are sent to the distributor. In Indonesia, rice and other grains are stored in open bags or granaries, exposing them to insect, rodent, and bird attacks. High equilibrium moisture content is greater than 14. Grain is not always protected from rain.

cont... Table 2. Inputs and actors in the rice supply chain

Input and actor	Description
Transportation (workers)	Workers need to have proper transportation to move rice from the storage house to the distributor.
Electricity	Electricity is required for milling and drying.
Packaging facilities	These facilities are necessary for packaging rice before distribution.
Distribution	
Bazaar traders	Bazaar traders, such as wholesalers, big rice stores, and large traditional markets, are traders who sell rice in large quantities.
Supermarkets	Supermarkets are larger versions of the traditional grocery store. They are self-service shops that offer a wide variety of food and household products.
BULOG	BULOG is a state-owned company engaged in food logistics. It covers business logistics or warehousing, surveying, pest eradication, plastic bag provision, transport business, food commodities trading, and retail businesses. In terms of RASKIN distribution, BULOG moves the rice into its storage house, transports it to the distribution point, and delivers it to the RASKIN working group or a village shop. A village shop is a regular shop that sells agricultural products such as rice. From the working group or village shop, RASKIN delivers the rice to poor households. BULOG has a number of dropping points for RASKIN distribution.
Retail sellers and small traditional markets	Retail sellers and small traditional markets are traders who sell rice in small quantities.
Consumption	
Consumers	Consumers are the people who purchase and eat rice.

2.3 Post-Harvest Losses

The post-harvest processes for rice and maize are almost similar as shown in Figures 3 and 6. The team wanted to elaborate on post-harvest losses, but adequate information on such was found for rice only. Therefore, this section discusses post-harvest losses in rice production (Table 3).

Table 3. Post-harvest losses in rice production in Indonesia

Production stage	Losses (%)		
	1986–1987	1995–1996	2007
Harvest	9.19[a]	9.52[a]	1.57
Separation	5.48[a]	4.78[a]	0.98[a]
Transportation	0.59	0.19	0.38
Drying	1.94[a]	2.13[a]	3.59[b]
Milling	3.51[b]	2.19[b]	3.07[b]
Storage	0.32	1.61	1.68
Total	21.03	20.51	11.27

Source: Translated from the book published by MoA (BBPMP 2011).
Note: [a]Percentage of GKP (gabah at dry harvest), [b]Percentage of dry milled gabah

According to Pak Koesnomo Tamkani, a former agriculture extension worker for about 30 years and also a former director of Dinas Pertanian Indramayu, the Agricultural Agency of Indramayu, post-harvest losses when processing harvested paddy to rice can be due to (1) natural causes or (2) behavioral causes. Natural causes occur because the water content of rice should be reduced before the product is sold to consumers. Reducing the water content is also necessary to maintain rice quality during storage. After harvesting, the farmers will dry unhulled paddy (gabah) under the sun. Gabah is gathered by separating produced paddy seeds from the paddy crop. The paddy crop is pounded into a base and gabah is collected using a plastic base (Figures 7 and 8).

Figure 7. Harvesting time in Indramayu
Source: IAARD 2015

Figure 8. Separating paddy seeds (gabah) from paddy crops in Indramayu
Source: IAARD 2015

Drying can reduce 24 percent to 27 percent of water content, depending on the frequency of rainfall during harvesting. The process requires complete sun exposure. Furthermore, the water content of gabah should be lower than 17 percent before it can be moved to storage. The next step is milling the gabah to produce rice. The produced rice is about 63 percent to 67 percent of harvested paddy, depending on the quality of rice produced. Rice of good quality is about 67 percent of the harvested paddy, while rice of poor quality is about 63 percent of the harvested paddy. Post-harvest losses due to behavior are mainly the result of the technology that the farmers used for post-harvest activities. For example, the use of a plastic bed as shown in Figure 8 can minimize losses as gabah will be collected in the plastic base. However, a rectangle separator may be added to the plastic bed to prevent the gabah from being scattered across the field. The use of a dryer can also minimize losses, but the machine is costly to farmers. The potential post-harvest losses in Indramayu are presented in Figure 9.

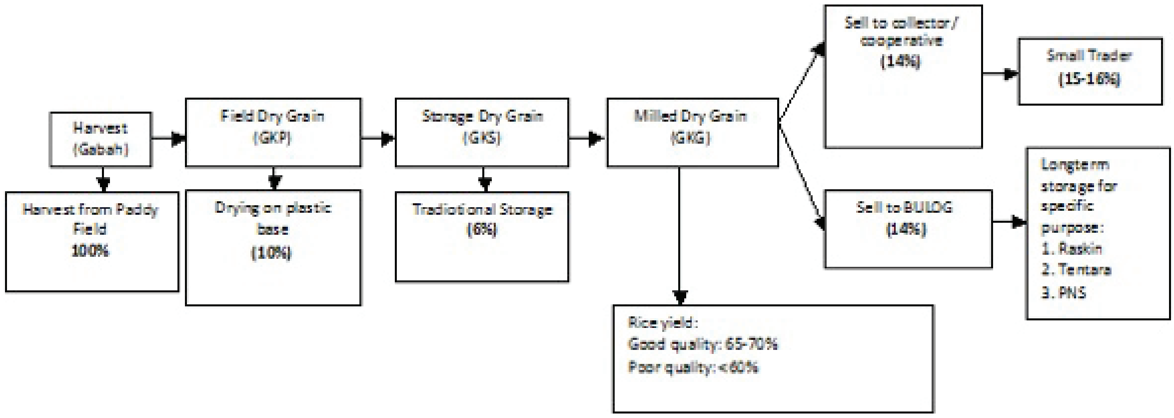

Figure 9. Potential losses during post-harvest in Indramayu

Note: The potential losses during the post-harvest processes from harvest to milled dry grain (gabah) are indicated by numbers in the brackets based on survey in Indramayu. After gabah, the numbers in the brackets indicated water content allowed by a buyer to buy rice.

Furthermore, as documented in the book Mekanisasi Pasca Panen Padi di Indonesia: Tinjauan dari Aspek Teknis dan Budaya (Mechanization of Post-Harvest Paddy in Indonesia: Technical and Cultural Aspects), post-harvest losses in the form of decreased yield or susut hasil can be categorized as absolute losses and relative losses (BBPMP 2011). In absolute losses, gabah losses are irrecoverable. In relative losses, losses can be recovered by using tools and technology (e.g., drying and milling machinery). All post-harvest losses from harvesting to storage are now lower than two decades ago. Losses can be reduced from over 20 percent to about 11 percent. As reported in the book, the farmers' behavior during harvesting and behavior during separating the seeds of paddy crop are the two components contributing to higher losses, which indicate the need for positive behavior change. The use of technology can also reduce losses, but the socio-cultural conditions of a region should be considered before a new technology is introduced. Such conditions vary per location.

For example, as discussed during the second national meeting, the farmers in East Java were more accepting of new technologies (e.g., dryer and thresher) than those in West Java. This can be attributed to differences in socio-cultural conditions as well as the costs associated with the use of machinery. Participants of the second national meeting proposed that the government of Indonesia should help the farmers access affordable machinery instead of subsidizing production inputs such as seeds and fertilizers. A representative of MoA responded that the government is already helping the farmers minimize post-harvest processes, particularly through technical guidance or bimbingan teknis given in training sessions or workshops. The government has been supplying machinery for production, depending on the farmers' requests. The farmers' needs vary depending on the location. Some devices, such as the thresher, can be produced by local machinery shops.

The application of technology to support rice production, including minimizing post-harvest losses, should be promoted. It will help farmers be more productive and thus improve their welfare.

III. REVIEW OF CLIMATE CHANGE IMPACTS AND VULNERABILITIES

The potential impacts of global climate change on Indonesia's climate as well as on the country's rice and maize production systems were reviewed based on available literature. Climatic trends and potential impacts were evaluated. Surveys were conducted during field visits to assess if the respondents were already experiencing the effects of climate change on rice and maize production. During the interview, questions were also asked to explore CCA practices that have been implemented. The team visited Indramayu and Jember.

The identified impacts of global climate change on Indonesia's climate were mostly based on temperature trends and changing rainfall patterns, which have caused devastating floods and droughts (MoE 2007). Floods in many parts of Indonesia are becoming more frequent, as evidenced by the 530 floods that affected the country in 2001–2004 (MoE 2007). In the last four decades, droughts have also become more frequent (Boer and Subbiah 2005). The increased frequency of floods and droughts may be a result of the increased frequency of climate extremes in Indonesia. Climate variability in the country is strongly influenced by the El Niño Southern Oscillation (ENSO), which is commonly known as El Niño and La Niña. Longer dry seasons that may cause droughts are often associated with the onset of El Niño, while high-intensity rainfall that may cause floods is often associated with La Niña. A study conducted by Timmermann et al. (1999) alarmed Indonesia, cautioning it to pay more attention to the potential impacts of future climate change on climate extremes, as the study reported that global warming may increase the frequency of ENSO events.

The impacts of global climate change on Indonesia's climate are already manifested in increasing air temperature and changing rainfall patterns, which are expected to continue. The available literature notes that air temperature has been increasing and will continue to rise. As for precipitation, it is difficult to draw a conclusion for rainfall trends as rainfall patterns vary over geographic locations. Rainfall variability is also changing, but the magnitude may increase or decrease depending on the area. Surveys conducted in Indramayu and Jember show that the respondents have also been experiencing warmer conditions and erratic rainfall. The rising sea level is projected to be even higher in the future, which may cause saltwater intrusion and loss of coastline in low-lying growing areas. The trends in climate variables in Indonesia are presented in Table 4.

Table 4. Historical and projected trends in climate variables in Indonesia

Variable	Specific climate risk/ opportunity	Historical trend	Projections	Confidence	References
Mean temperature	Increase in temperature	Increase	Increase of 0.5ºC–3.92ºC by 2100	High	Cruz et al. (2007) Hulme and Sheard (1999) UK Department of Energy and Climate Change (2011)
Minimum temperature	Increase in temperature	Increase	Increase of 0.04ºC–0.07ºC annually	Medium	Boer, Sutardi, and Hilman (2007)
Precipitation	Water stress Floods Droughts	Change	Annual rainfall increase of 5–10 percent in Kalimantan and 0–5 percent in Sumatra by 2100 Annual rainfall increase throughout Indonesia—except Southern Indonesia (including Java), which will experience a decrease of 15 percent—by 2100 Higher rainfall intensity and shorter rainfall duration in North Sumatra and Kalimantan Lower rainfall intensity and longer rainfall duration in the southern part of Java and Bali	High	Hulme and Sheard (1999) UK Department of Energy and Climate Change (2011) Naylor et al. (2007)
Sea level	Loss of coastline Saltwater intrusion	Increase of 0.8–1.6 mm/ year	Increase of 5 mm per year By 2050, the sea level will be 35–40 cm higher than the sea level in 2000	Medium	Cruz et al (2007) BAPPENAS (2013)

The Indonesian government, through Badan Perencanaan Pembangunan Nasional or the Ministry of National Development Planning, has already documented studies that assessed the potential impacts of climate change on Indonesia's climate. The report documented the current climatic trends and projections of air temperature, rainfall, sea level, and extreme climate events associated with ENSO (BAPPENAS 2013).

As discussed above, the impacts of climate change on rice and maize production are associated with the occurrence of floods and droughts that can decrease crop yield or cause crop failure (puso). The effects of floods and droughts caused by climate extremes were already documented in the report, Pedoman Umum Adaptasi Perubahan Iklim Sektor Pertanian (General Guidance of Climate Change Adaptation for Agriculture Sector) (BPPP 2011). The adverse impacts of floods can also exacerbate the potential yield loss of paddy rice, since floods may increase pest infestations as described by studies documented in the report (BPPP 2011) and the ICCSR (2010). Increasing temperature and increasing humidity can also increase disease infestations such as Bulai, which was also mentioned by the respondents in Jember. The potential adverse impacts of climate change on crop production pose a serious challenge, especially when agricultural land conversion threatens food security. Boer et al. (2009) reported that paddy rice production in Java may decrease by 5 million t in 2025 and 10 million t in 2050 as a consequence of both the impacts of global climate change and agricultural land conversion.

Increasing temperature is expected to decrease both rice and maize yields (Tables 5 and 6). A higher temperature will trigger a higher transpiration rate, which requires higher water consumption or respiration that destroys accumulated biomass. Changing rainfall patterns can also delay post-harvest activities. Erratic rainfall makes the start of the growing season unpredictable. Rainfall during harvesting can also affect the quantity and quality of crops that require an adequate amount of solar radiation. The book Mekanisasi Pasca Panen (Mechanization of Post-Harvest) (BBPMP 2011) and the field surveys revealed that yield losses may occur during drying, milling, storage, and distribution. Climate conditions strongly

influence drying activities. The potential impacts of sea level rise were measured by estimating the inundated areas that may decrease planted areas, which will eventually decrease crop production. In addition to the potential increase in salinity, sea level rise can decrease crop production.

Table 5. Climate change impact assessment and vulnerability rating for rice production in Indonesia

System of interest	Geographic location	Climate change trend/signal	Biophysical impact	Socio-economic impact	Exposure	Sensitivity	Ability to respond	Vulnerability rating	References
Rainfed rice	Lowland	Increasing frequency of floods and droughts	Decreasing or failed yields	Decreasing production and increasing risk of food insecurity	High	High	Low	Very High	BPPP (2011) Field visit to Indramayu, West Java
	National	Increasing intensity and frequency of storms, floods, and droughts	Decreasing yields	Decreasing production by 2050	High	High	Low	Very High	Syaukat (2011)
Rice	Java Island	Increasing temperature and excessive rainfall	Affecting yields by 2030	Risk of food insecurity	High	Medium	Medium	High	Widiyanti (2009)
	Lowland	Increasing temperature	Decreasing yields	Decreasing production	High	High	Medium	Very High	Mathauda et al. (2000)
	National	Increasing temperature	Yield change ranging from -20 percent to +10 percent	Yield change	High	High	Medium	Very High	Lobell, Schlenker, and Costa-Roberts (2011)
Rice variety	Lowland and upland	Increasing temperature	Shifts of agro-ecological zones Introduction of new varieties	Decreasing yields (lowland) Increasing yields (upland)	High	Medium	Medium	High	Boer, Sutardi, and Hilman (2007)
Growing season	National	Shorter wet season Longer dry season	Floods (for the crops in the first season/wet season) Droughts (for the crops in the second season/dry season)	Shorter growing season and harvesting index	High	High	High	High	Naylor et al. (2007)

cont... Table 5. Climate change impact assessment and vulnerability rating for rice production in Indonesia

System of interest	Geographic location	Climate change trend/signal	Biophysical impact	Socio-economic impact	Exposure	Sensitivity	Ability to respond	Vulnerability rating	References
Delay of the onset of seasons	National	Shorter wet season Longer dry season	Flowering stage for the second planting of rice (April–June) may be exposed to droughts	Decreasing yields	Medium	Medium	Medium	Medium	Naylor et al. (2007)
Rice	National	Sea level rise	Decreasing planted areas	Decreasing production by 2050	Medium	High	Low	Very High	Handoko and Hardjomidjojo (2009)
	Lowland (Indramayu)	Increasing salinity	Decreasing yields	Decreasing production	Medium	High	Medium	High	Boer et al. (2009)
	Java	Higher rainfall and temperature (inter-annual climate variability)	Yield losses	Decreasing rice grain yields	High	Medium	Medium	High	Amien et al. (1999)

Table 6. Climate change impact assessment and vulnerability rating for maize production in Indonesia

System of interest	Geographic location	Climate change trend/signal	Biophysical impact	Socio-economic impact	Exposure	Sensitivity	Ability to respond	Vulnerability rating	References
Rainfed maize	National	Increasing intensity and frequency of storms, floods, and droughts	Decreasing yields	Decreasing production by 2050	High	High	Low	Very High	Syaukat (2011)
	National	Increasing temperature leads to increasing respiration	Decreasing yields	Decreasing production by 2050	High	High	High	High	Handoko and Hardjomidjojo (2009)
Maize	National	Sea level rise	Decreasing planted areas	Decreasing production by 2050	Medium	High	Low	Very High	Handoko and Hardjomidjojo (2009)
	Endemic in a district of West Kalimantan and East Java	Increasing temperature and humidity	Maize disease (Bulai)	Decreasing or failed yields	Medium	High	Medium	High	BPPP (2011) Field visit to Jember, East Java

The potential impacts of climate change described above are mostly based on the assessments of the potential impacts of changing climate variables (e.g., rainfall and temperature) on crop production using modeling approaches. The effects of recent climatic trends are already experienced in Indonesia. Climate-related disasters (e.g., floods and droughts) frequently occur and can decrease crop production or cause crop failure. DITLIN MoA reported that the floods that occurred in Indonesia from 2009 to 2011 damaged the following crop areas: 222,481 hectares (ha) in 2009; 307,809.6 ha in 2010; and 169,464.3 ha in 2011. Based on the report, the areas totally damaged by floods (failure or puso) were 67,821 ha in 2009; 93,929.4 ha in 2010; and 29,383.1 ha in 2011. The three flood events that occurred in 2010 were the largest in terms of affected area and crop failure. The spatial distribution of the total area affected by flood and crop failure in 2010 is presented in Figure 10.

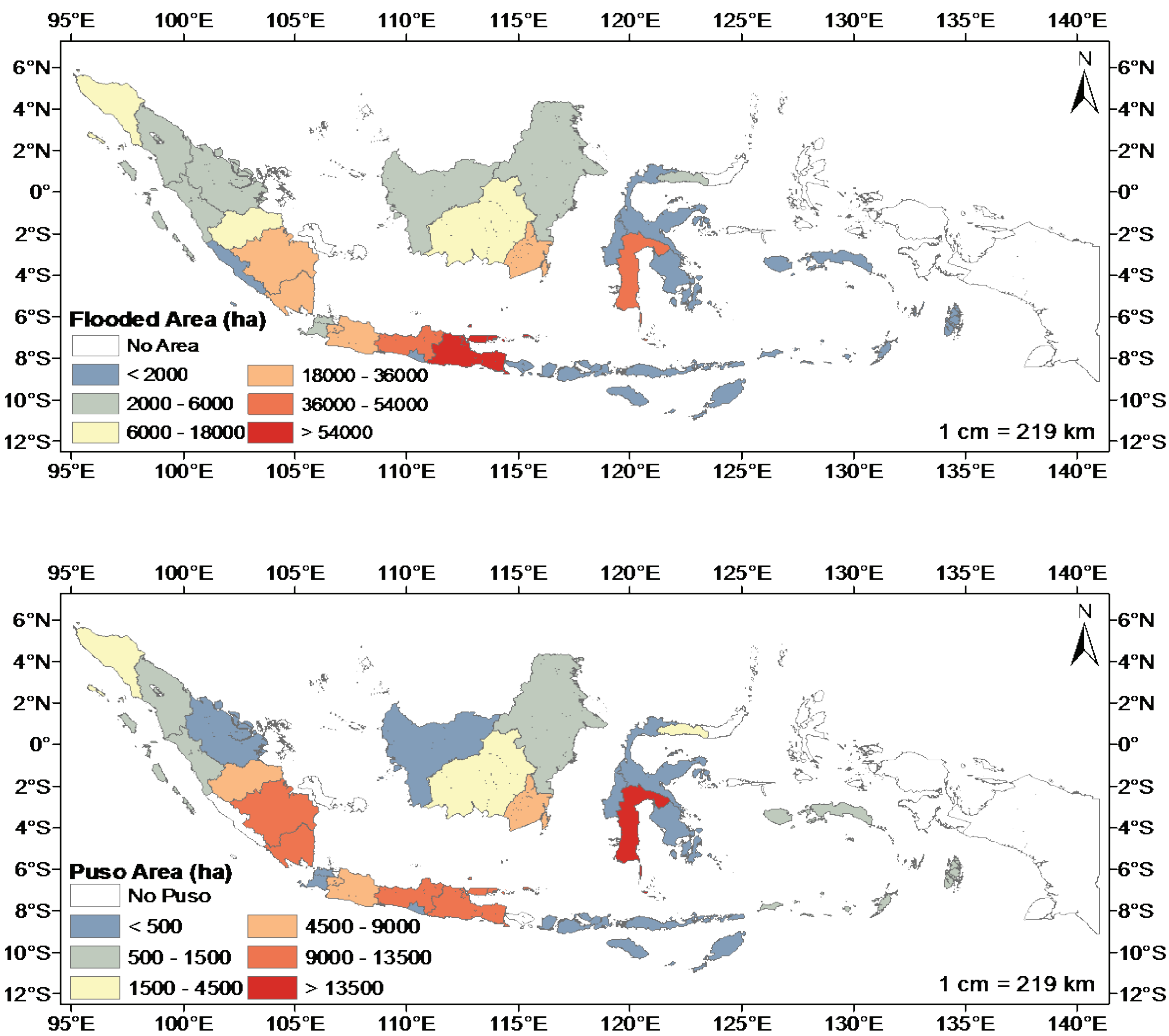

Figure 10. Total area of flood-affected paddy production (above) and resulting crop failure (below) in Indonesia, 2010

Note: Total crop failure is locally known as puso.

Source: MoA 2014

The flood event that occurred in 2010 affected more crop production areas in the western part of Indonesia than in the eastern part. The total area of crop production affected by flood was higher for Java Island, South Sumatra and Kalimantan, and West-South Sulawesi than for other areas such as Bali, Nusa Tenggara Barat, and Nusa Tenggara Timur. There is no information for Papua province because the data reported zero values.

West Java and East Java experienced higher losses in paddy rice production because of floods. East Java experienced more losses than West Java in 2010 and 2011. The total affected area for East Java in 2010 was about 60,000 ha. On the other hand, the total affected area for West Java in 2009 was about 40,000 ha (Figure 11). Flood frequently occurs in January and February as these are the peak months of the rainy season in both provinces (Figure 12).

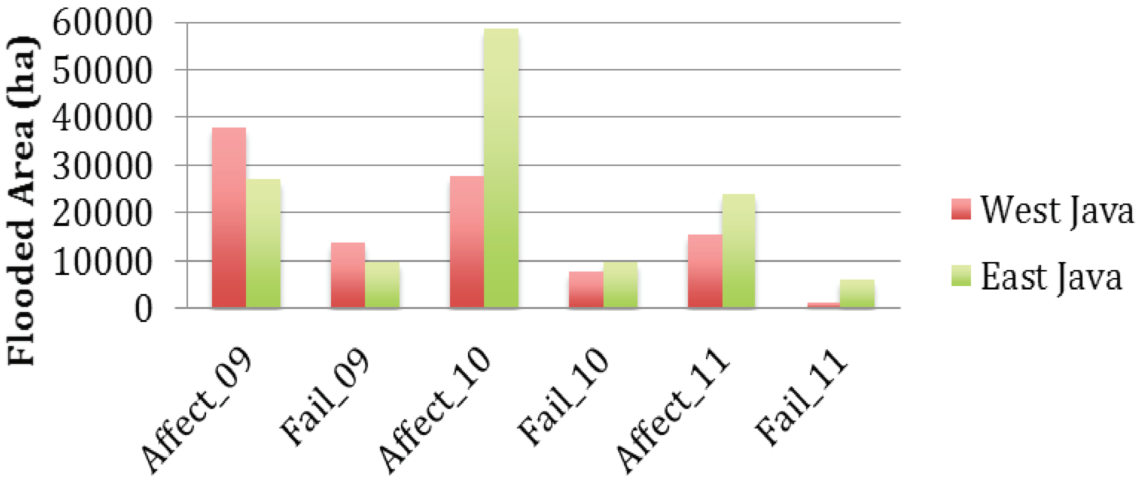

Figure 11. Annual total area of flood-affected paddy production (affect) and resulting crop failure (fail) in West Java and East Java, 2009–2011
Source: MoA 2014

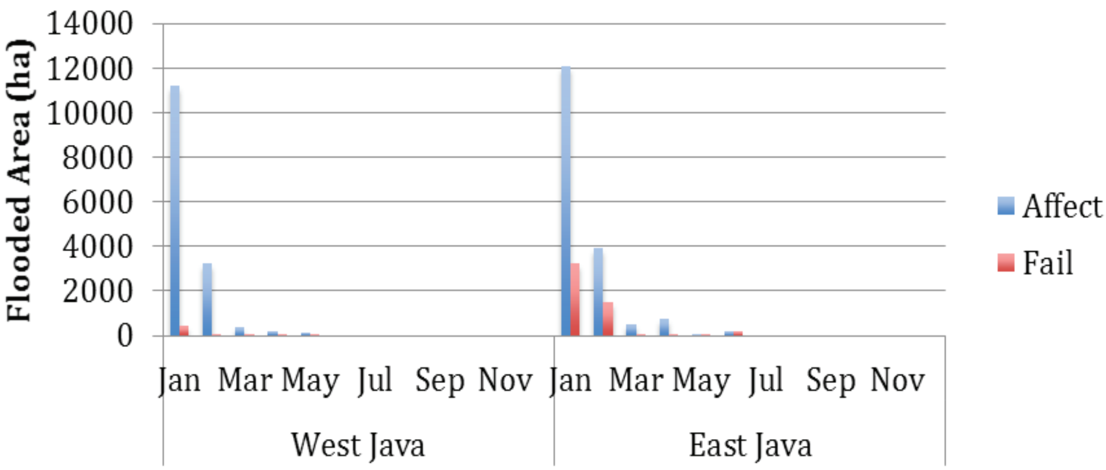

Figure 12. Monthly total area of flood-affected paddy production (affect) and resulting crop failure (fail) in West Java and East Java, 2012
Source: MoA 2014

DITLIN, MoA also reported that the droughts that occurred from 2009 to 2011 in Indonesia damaged the following crop areas: 231,912 ha in 2009; 96,721.3 ha in 2010; and 250,836 ha in 2011. Based on the report, the areas totally damaged by droughts (failure or puso) were 18,975 ha in 2009; 20,856 ha in 2010; and 53,127 ha in 2011. The spatial distribution of the total affected area in 2011 is presented in Figure 13. The distribution of the total drought-affected area is almost similar to the distribution of the total flood-affected area. This indicates that crop production regions, such as West Java and East Java, are considerably prone to floods and droughts.

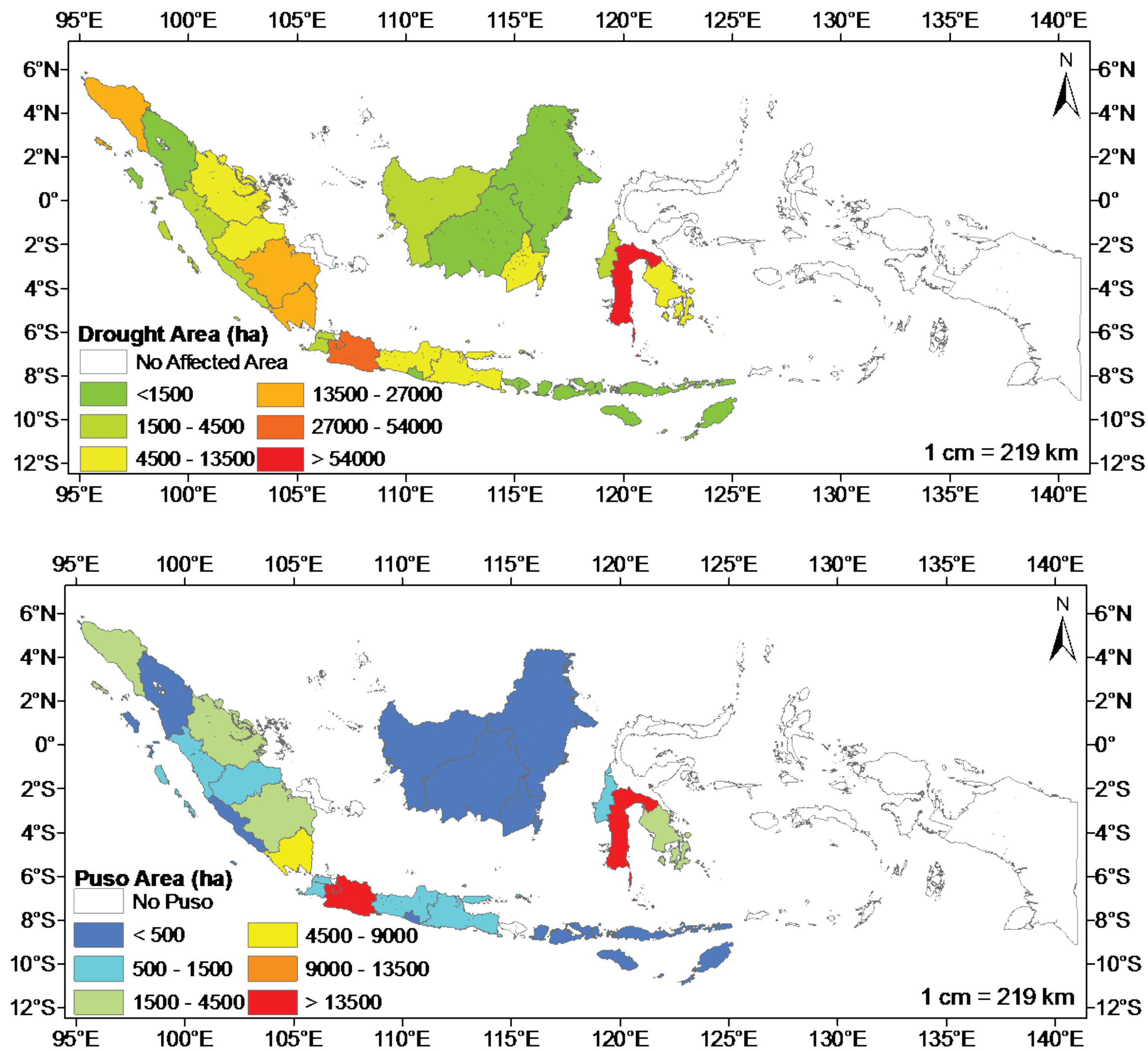

Figure 13. Total area of drought-affected paddy rice production (above) and resulting crop failure (below) in Indonesia, 2011

Note: Total crop failure is locally known as puso. Source: MoA 2014

West Java suffers more from droughts than East Java. The drought that occurred in 2011 affected over 50,000 ha of paddy fields in West Java and caused about 14,000 ha of crop failure (Figure 14). Nevertheless, since the two provinces have similar climate types (i.e., monsoonal), droughts frequently occur during the dry season spanning June to September, with the peak months being July and August (Figure 15).

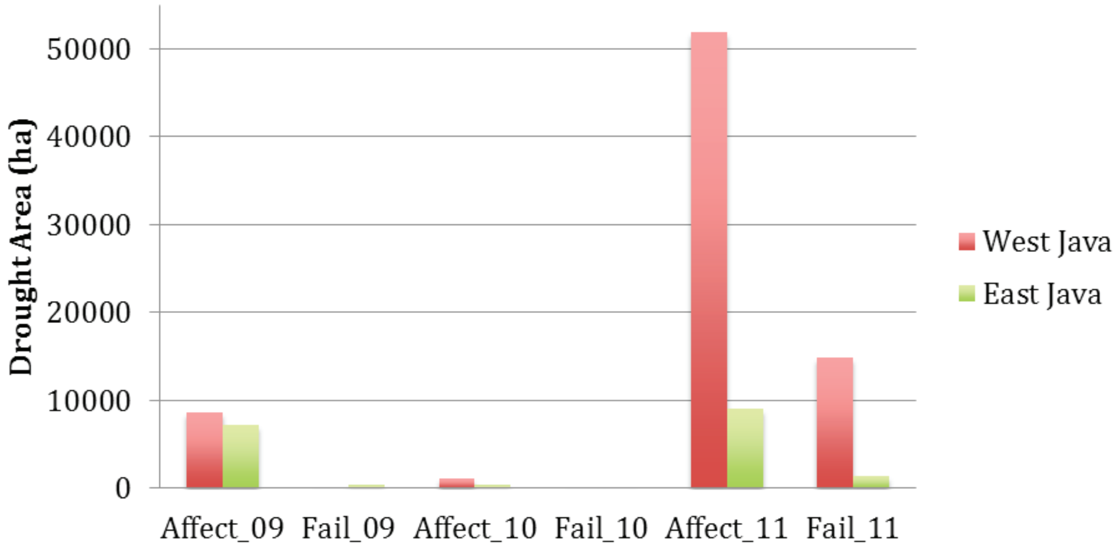

Figure 14. Annual total area of drought-affected paddy production (affect) and resulting crop failure (fail) for West Java and East Java, 2009–2011

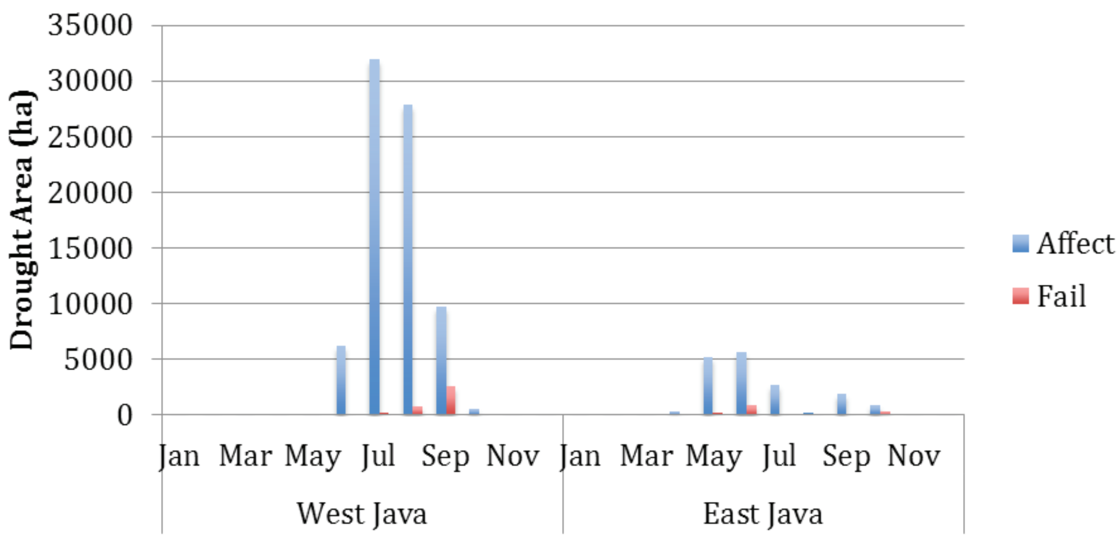

Figure 15. Monthly total area of drought-affected paddy production (affect) and resulting crop failure (fail) in West Java and East Java, 2012

To minimize crop losses caused by droughts, farmers regularly use water pumps to obtain water from soil or river to irrigate their paddy farms. Based on data from 2010 to 2012, the government already supplied 6,760 units of water pumps. Water pumps are primarily distributed to the main production regions, such as those located in Java Island, including West Java and East Java. Most of the water pumps are distributed to Sumatra Island, particularly South and North Sumatra, Nusa Tenggara Timur, and Southwest Sulawesi (Figure 16).

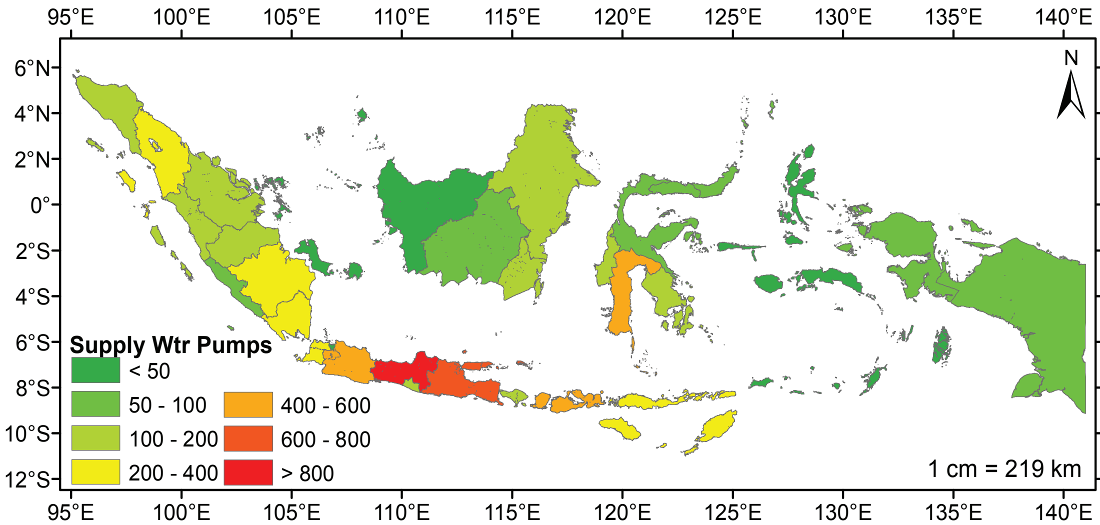

Figure 16. Distribution of total water pumps supplied by the government in Indonesia, 2010–2012
Source: MoA 2014

In the context of gender, the impacts of climate change are not disproportionately felt by men and women. This was found during the literature review, national consultation meetings, and field visits to Indramayu and Jember. Farming decisions are made by men as the head of the family, although the women (i.e., wife and daughter) can also contribute their ideas as they usually help in farming activities, particularly in post-harvest activities.

3.1 Farmer Groups and Stakeholder Consultations (Field Visits)

In Indonesia, farmers usually live in certain areas or regions with farmer groups called Kelompok Tani (POKTAN). Many farmer groups then form a larger group called Gabungan Kelompok Tani (GAPOKTAN). Agricultural programs from either the government or the private sector are usually communicated through the leader of a GAPOKTAN or POKTAN. Farmers usually decide what farming practices they will employ, but they often discuss plans and options with other farmers within their POKTAN. Given that the main production areas are located in Java Island, the majority of POKTAN are formed in Java, expanding from West Java to East Java (Figure 17). Based on data from 2011, there are now about 299,759 POKTAN throughout Indonesia. Approximately 25,802 (about 8.6%) POKTAN are in West Java, while about 30,128 (about 10.1%) POKTAN are in East Java.

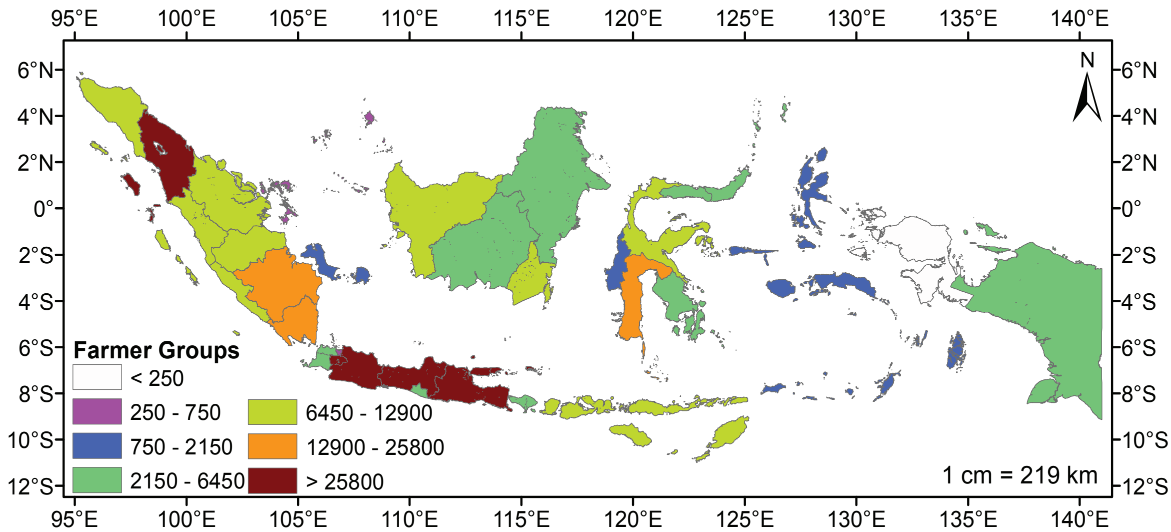

Figure 17. Distribution of farmer groups in Indonesia, 2011
Source: MoA 2014

Extension workers, who could be permanent government employees, hired labor, or private labor, are those who work closely with farmers. Extensions workers who are familiar with working with farmers are usually involved in introducing new technology through training sessions and workshops, including the climate field school, which teaches farmers how to use climate information to support farming practices. Based on data from 2012, there were 58,091 extension workers in Indonesia, distributed mostly in the main agricultural areas. There were approximately 5,002 extension workers in West Java and 7,348 extension workers in East Java.

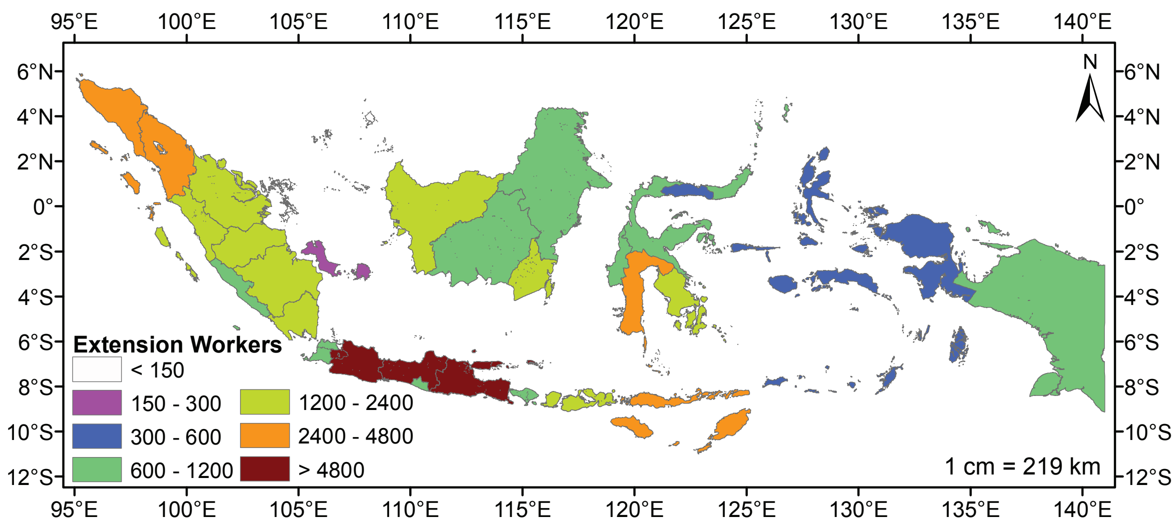

Figure 18. Distribution of extension workers in Indonesia, 2012
Source: MoA 2014

As an attempt to explore the role and connection among stakeholders of rice and maize value chains, sites in Indramayu (as a representative of West Java) and Jember (as a representative of East Java) were visited and surveyed. The surveys were conducted on 12 May 2014 in Indramayu and on 12–15 May 2014 in Jember. The study team decided to spend more time in Jember, since it is the main rice and maize cultivation area in East Java. In addition to the respondents from the local government, Dinas Pertanian, BULOG, and Trade Agency, the study team interviewed other stakeholders within the value chain (Table 7).

Table 7. Stakeholders interviewed during the field visit to Jember

Stakeholder	Location	Crop	Water source
Collectors	Upland	Maize	Irrigation
Farmer group leader	Upland	Paddy/Maize	Rainfed
Farmer group leader	Upland	Paddy/Maize	Rainfed
Farmer	Upland	Maize	Irrigation
Farmer group leader	Upland	Paddy/Maize	Irrigation
Seller	Upland	Paddy/Maize	Irrigation
Seller of agricultural inputs	Upland	-	-
Cooperatives	Upland	-	-
Seller	Upland	Maize	Irrigation
Farmer group leader	Upland	Maize	Rainfed/Wells
Farmer	Upland	Maize	Rainfed/Wells
Farmer	Upland	Maize	Rainfed/Wells
Storage owner	Lowland	-	-
Farmer	Lowland	Paddy/Maize	Irrigation/Wells
Collector	Lowland	Paddy/Maize	Irrigation/Wells
Farmer	Lowland	Paddy/Maize	Irrigation/Wells
Famer	Lowland	Paddy/Maize	Irrigation/Wells
Seller of agricultural inputs	Lowland	-	-
Farmer	Lowland	Paddy/Maize	Irrigation/Wells

The interviews explored issues related to production inputs, and the flow of harvested rice and maize from farmers to consumers within each value chain. There is minimal difference between rice and maize value chains in terms of production inputs and flow of harvested crops. As discussed during the first national meeting, the difference is reflected in the efforts of the national government to support the production of the two crops. The government of Indonesia prioritizes rice because it is a staple food for the majority in the country. The main findings from the interviews are summarized on Table 8.

Table 8. Impacts of climate change on rice production

Input and actor	Description
Seeds	There is no problem in obtaining seeds because farmers can purchase them in the market. Farmers have already used new cultivars that are resistant to pest and drought stress.
Soil fertility	Soil fertility has diminished because of chemical fertilizers. Organic fertilizers are now used to recover soil fertility.
Irrigation	Irrigation is used to supply water to support crop growth and development.
Pesticides	Higher rainfall at harvesting time can trigger pest and disease infestations. Pesticides are used to manage such infestations. Warming conditions may kill parasites and bacteria as well as improve grain quality.
Government	Irrigation is controlled by the local government agency. The national government provides subsidy for organic fertilizers, although the availability sometimes becomes an issue.
Storage	Storage is used to control price at harvesting time. Java is known as the rice production center in Indonesia. At the peak of harvesting, the supply increases and the price is low. Storing a portion of the supply will help stabilize supply and price. If a portion of the supply is not stored, the lack of supply will induce an increase in price. As distribution to provinces outside Java requires higher transportation costs, consumers in those provinces will face even higher prices.
Rice distribution	Rice is distributed through partnerships between farmers and millers (about 10%), selling to collectors in the field (about 40%), selling after drying (about 35%), and selling after milling (about 15%).

Table 9. Impacts of climate change on maize production

Input and actor	Description
Seeds	Farmers use seeds that are tolerant to droughts or pests and diseases. These seeds are varieties with shorter maturity.
Government	The government of Indonesia runs reforestation programs and promotes the use of maize cultivars with shorter maturity. It also provides subsidized seeds, but farmer groups (GAPOKTAN) may refuse as they do not want to take any risks that could affect their members.
Water resources	These are rainfall and wells used by farmer groups. The government supports the development of wells.
Miller	Farmers can rent mobile milling machinery.
Storage	Harvested maize that has been milled will be sold to storage or a feed factory.
Collector	A collector (penebas) can purchase maize directly from farmers or collect maize from the field themselves. The collector can also give loans to farmers in the form of seeds and fertilizers. Farmers pay the debt by selling harvested yield to the collector. The collector is also connected with the seller of agricultural inputs, storage owner, and factory of feeds for chickens or cows.

Table 10. Role of each actor in rice and maize production

Actor	Description
GAPOKTAN leader	The GAPOKTAN leader is responsible for gathering farmers for information dissemination, counseling, and training, among others. The leader may serve as a facilitator for government programs directed to farmers and provide load or credit to farmers in some regions. The credit system has the following steps: (1) the farmers will provide a list of required production inputs, (2) the leader will collect the list from the farmers, (3) the leader will purchase the requested production inputs and distribute them to the farmers, and (4) the farmers will pay the debt to the leader after harvesting (at a price that is 7%–10% higher than what they owe).
Cooperatives (KUD)	A cooperative can be an alternative financial institution (saving and lending) for farmers. It can provide production inputs for farming activities and serve as a collector. Farmers can sell their farming products to KUD.
Collectors	Collectors gather harvested yield. They can also be the owner of machinery for farming and post-harvest activities.
Farmers	Farmers are people who cultivate land for crop production. Crop production is usually dominated by men. Women help their husbands in farming activities or do the farming themselves if they are widowed. Women can influence decisions in farming activities such as seed selection.
Small agricultural shops (kios)	Agricultural shops supply production inputs and tools for farming activities. They also supply fertilizers, including those subsidized by the government.
Maize storage owners	Storage owners obtain maize from collectors or buy from other provinces when quality and price are considerably better and cheaper.
Government (agricultural agency)	The government helps farmers boost their crop production through counseling, which is done by extension workers, and supply/control irrigation. It may subsidize seeds and fertilizers. The national government often works with agricultural agencies to introduce new varieties that were produced by the Research and Development Agency, MoA.

IV. AREAS WHERE REGIONAL COLLABORATION CAN STRENGTHEN APPROACHES

The availability of human resources, specifically extension workers, is a critical element in promoting the adoption of CCA options. Extension workers and farmers have a long history of working together. Extension workers are present whenever a new technology or practice from the government or the private sector will be introduced to farmers. Farmers usually decide what farming practices they will employ, but collaboration between extension workers and farmer groups could influence the farming activities in a particular region or location. The majority of extension workers are currently located in the major crop cultivation areas (e.g., Java Island), where many farmers who need their guidance are located (Figure 19).

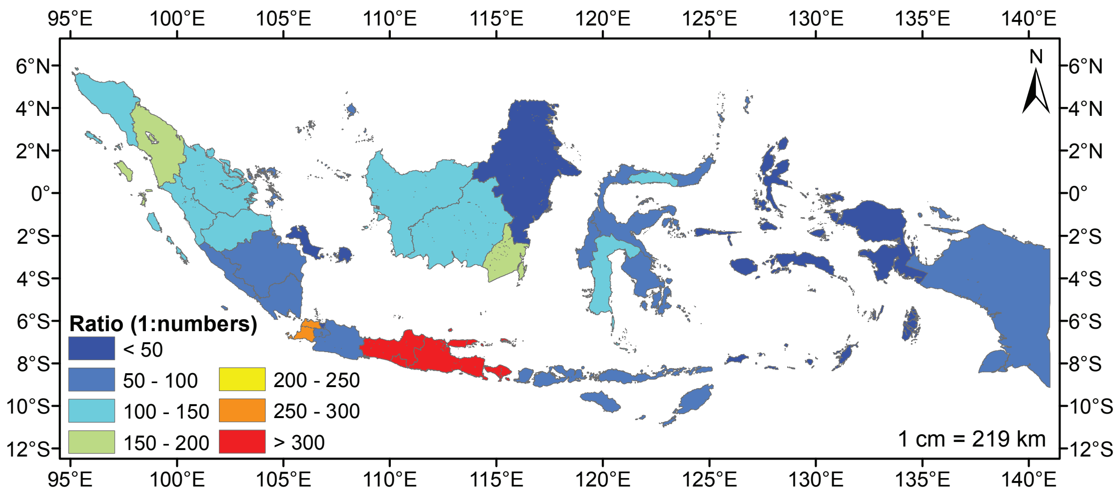

Figure 19. Distribution of ratio of extension workers to members of farmer groups in Indonesia
Note: *T*he image was created using data on extension workers and members of farmer groups at the provincial level. It was assumed that there was a minimal change in the number of farmers between 2011 and 2012 considering data availability. "Members of farmer groups" refers to farmers from all farmer groups in a province.
Source: MoA 2014

The ratio of extension workers to farmers shows that a single extension worker counsels tens to hundreds of farmers. The study did not intend to measure the sufficiency of available extension workers, but Figure 19 can provide a configuration on how to disseminate new information on agricultural techniques or practices to farmers in Indonesia. Given the critical role of extension workers in disseminating agricultural information to farmers, it is advisable to consider the distribution of extension workers in Indonesia during the introduction or implementation of CCA options.

The challenges for agricultural development in relation to CCA and mitigation measures were discussed during the second national meeting. The meeting highlighted thefollowing issues that should be considered:

(1) The farmers' adoption of new crop varieties is still low. The farmers prefer varieties with high market and consumer demand, such as the Ciherang rice variety that is slim and long.

(2) MoA already made efforts to develop new varieties and disseminate the results to farmers. The Agency of Assessment Technology (Balai Pengkajian Teknologi Pertanian), MoA is responsible for the adoption

of innovations (e.g., introducing new varieties to farmers).

(3) The local government should be engaged in agricultural activities or programs, and increase farmers' knowledge through counseling, training sessions, and workshops, among others.

(4) The supply system for seeds should promote local development of a production region.

(5) Information on the availability of agricultural machinery should be included in the planting calendar to construct a web-based system named Agrowebinfo.

(6) Farmers' land ownership and workers should be considered to ensure the successful implementation of CCA programs.

(7) The local government should promote and support the web-based planting calendar developed and maintained by MoA. Extension workers play a crucial role in disseminating farming activities recommended by the online system.

(8) Gender perspectives may not be a formal issue, but it may need to be addressed depending on the socio-cultural conditions of a specific region.

The team also identified institutional challenges and requirements in implementing good practices. The following challenges should be considered:

(1) The capacity of both farmers and extension workers is a challenge in implementing CCA options. The government of Indonesia should consider the farmers' socio-economic conditions and educational background. For instance, the farmers' low education and poor economic conditions may hinder the successful implementation of crop insurance and the web-based planting calendar developed and maintained by MoA. The use of both programs requires familiarity with the system and knowledge of its functions. Financial institutions dedicated to agriculture are still lacking. There are approximately 29,013 farmer groups in 451 districts or cities of 33 provinces. These groups can create a network and link with financial institutions to optimize farmers' financial access. Crop insurance is also new to farmers and the local government, and purchasing the premium remains a challenge for farmers. Avenues for training and socialization are needed to increase the capacity of both farmers and local government officers (extension workers).

(2) The government has already made efforts to support farmers' agricultural activities. Extension workers of agricultural agencies guide farmers about farming practices, but farmers who are members of farmer groups usually have their own farming preferences. Traditional farming practices are still followed because the machinery needed to mechanize post-harvest activities (e.g., dryer) is either insufficient or too expensive for farmers.

(3) The farmers' adoption of new farming technologies and practices is low. For instance, new rice varieties have been developed and released in the market, but only a few of them are popular among consumers. The farmers only adopt those that are popular because wholesalers and collectors prefer varieties with high market and consumer demand. Trading and production systems are highly influenced by market and consumer preferences. CCA can also be seen as a new paradigm in Indonesia compared to mitigation. Information, education, communication, and capacity-building activities are needed to increase understanding and adoption of CCA strategies at the local level.

V. CASE STUDIES ON GOOD PRACTICES

Farmers in Indonesia are already familiar with the consequences of climate-related hazards. For instance, farmers in Indramayu will plant again, if possible, after their lands are affected by floods. In drought conditions, farmers will seek various water sources to irrigate their farms. Water pumps are frequently employed to obtain water from soil or river. The government also provides assistance by giving farmers access to water pumps. The two practices can be seen as CCA options implemented by farmers to address the challenges posed by climate extremes. These practices show that farmers are familiar with the concept of CCA.

CCA aims to minimize the risks and maximize the benefits of the changing climate. CCA options for crop production aim to adjust current cropping practices and implement innovations (e.g., new crop varieties and farming technology). Through MoA, the government of Indonesia has already made efforts to improve crop productivity (KEMENTAN 2011). Potential CCA options, specifically for crop production, were described in documents published by the government (BPPP 2011; ICCSR 2010). The general approaches for CCA include improving crop seeds by developing new cultivars; increasing water supply, including its availability and accessibility; and improving post-harvest processes to minimize loss. The answers of respondents from Indramayu and Jember were also considered in identifying CCA options for rice and maize (Table 11). A number of CCA options that can be scaled up nationally and regionally in ASEAN were selected for further consideration (Table 12).

Table 11. Identified adaptation options for rice and maize production in Indonesia

Crop	Hazards related to climate change		Good practices to address these hazards	
	Hazard	Description	Good practice	Description
Rice	Increasing frequency of floods and droughts	Higher rainfall intensity and shorter rainy season can cause floods and droughts in crop-growing regions (e.g., Indramayu in West Java). Floods may also increase the occurrence of pest infestations.	Crop insurance	Early planting is chosen as a technique to minimize potential losses caused by floods. The idea is to have a relatively mature paddy when flood occurs. For droughts, farmers choose rice varieties with shorter maturity and use water pumps to irrigate paddy fields. Crop insurance based on indemnity loss and climate index was introduced to protect farmers from yield loss. Crop insurance based on indemnity loss is designed to provide a claim of yield loss due to floods, droughts, and pest infestations. Crop insurance based on climate index allows farmers to claim for a guarantee when a specific climate index (e.g., a range of rainfall amounts over a specific period) is not reached over the period.

cont.. Table 11. Identified adaptation options for rice and maize production in Indonesia

Crop	Hazards related to climate change		Good practices to address these hazards	
	Hazard	Description	Good practice	Description
	Erratic rainfall patterns	The onset of the rainy season is changing over the years. As such, farmers could not use their prior experience or local knowledge to determine the beginning of the rainy season to prepare for planting.	Planting calendar	Climate field schools were introduced about a decade ago to teach farmers how to use climate information for their farming activities. Recently, a web-based planting calendar was developed and introduced to provide guidance on planting season, farming practices, and management at the sub-district level.
	Rainfall patterns during harvesting	Rainfall that occurred at harvesting time poses problems in post-harvest activities.	Adequate amount of solar radiation	An adequate amount of solar radiation is needed to dry paddy yields during harvesting. If it rains, farmers will compile paddy yields on their farm and wait until the rain stops. At the farm level, a simple technique for drying paddy is also practiced using solar radiation as the source of energy. Farmers utilize plastics as a pedestal to minimize the yield loss caused by drying. The mechanization of post-harvesting activities (e.g., use of dryers) is recommended.
	Increasing temperature as well as changing rainfall patterns and intensity	Increasing temperature leads to increasing evapotranspiration that demands more water for crop growth and development. Changing rainfall patterns may reduce water availability for paddy fields.	Innovations on cropping strategies	Innovations on cropping strategies include the application of new "superior" paddy varieties that are tolerant to environmental exposures (e.g., floods, droughts, and salinity), use of balanced fertilizers or organic fertilizers for specific locations, and improvement of row spacing (Jajar Legowo). The application of balanced fertilizers is proposed to improve land fertility. Jajar Legowo is employed to optimize fertilizers applied to soil and increase solar radiation acceptance.
Maize	Increasing temperature	It is estimated that increasing temperature, along with insufficient water supply, can decrease maize yields.	Application of new "superior" cultivars	New "superior" drought-tolerant cultivars include Bima, Lamuru, Sukmaraga, and Anoman. Dupont-Pioneer, a private company, has already worked with farmers to introduce and increase the use of hybrid varieties.
	Changing rainfall and temperature patterns	Current climatic changes challenge innovations on planting practices of maize to increase maize production and optimize the use of production units.	Relay cropping strategy	Relay planting is proposed to increase the frequency of maize planting in main maize-growing areas in Indonesia. One of the advantages of relay cropping is lower moisture depletion. The additional maize production will supply base materials to produce silase for animal feed (cows).
	Increasing occurrence of disease infestations (e.g., Bulai) due to increasing temperature and humidity that may cause yield loss	High rainfall during the early vegetative stage can negatively affect maize growth and development.	Innovations on pest- and disease-tolerant varieties	The invention of flood-tolerant varieties is also offered to help farmers cope with higher rainfall during the vegetative stage. The new varieties are developed through breeding technologies.

cont.. Table 11. Identified adaptation options for rice and maize production in Indonesia

Crop	Hazards related to climate change		Good practices to address these hazards	
	Hazard	Description	Good practice	Description
	Erratic rainfall and temperature patterns	Climatic changes push farmers to select a crop that is suitable for the climatic conditions experienced by their region to minimize the potential risks. Post-harvest activities are also challenging due to insufficient facilities and location of maize-growing regions.	Crop selection and planting calendar	Crop selection and planting calendar should be used to decide what crops are suitable for a specific growing season. Maize is usually planted to replace rice in the second dry season. In dry areas, maize may be planted twice. Beyond climatic conditions, some of the main problems of maize production in Indonesia are the lack of infrastructure and facilities in maize-growing regions located in remote areas. If farmers do not have a dryer for post-harvest processing, maize quality will deteriorate before the crops reach the storage facility or market. Storage facilities can only maintain maize quality for a maximum of about one month.

Table 12. Proposed adaptation options for rice and maize production

Crop	Key good practice	Description
Rice	Crop insurance	The introduction of crop insurance based on indemnity loss has been tested through field trials in some districts in Indonesia. Crop insurance is declared as a way to protect farmers from yield loss in Law No. 19 issued in 2013 on "Protection and Empowerment of Farmers" ("Perlindungan dan Pemberdayaan Petani"). Crop insurance aims to protect farmers from losses caused by crop failure resulting from natural hazards, pest and disease infestations, impacts of climate change, and other risks ruled by ministerial decree. For the trial of crop insurance, a subsidy of about 80 percent is given to purchase premium issued by JASINDO, a state-owned crop insurance company. Research on crop insurance based on climate index is in progress in Indramayu. The majority of research activities aim to teach farmers and train local government officers about the climate index insurance.
	Web-based planting calendar	MoA operates a web-based planting calendar. The system will provide a nationwide map to guide farming practices at the sub-district level based on seasonal climate prediction for each growing season. There are three growing seasons in Indonesia starting with the rainy season. The information available online includes planting dates, areas prone to floods and droughts, pest and disease infestations, and seed and fertilizer recommendations. The web-based system is updated thrice a year, and the online information can be accessed through the website and short message service on smartphone.
Maize	Silase production for animal feed (cows)	Silase is produced using maize stalks as base material. Based on a discussion with a representative of Dupont-Pioneer, a private company, cows eat less silase (25 kg/day) than green grass (70 kg/day), which minimizes feeding costs. Silase production can also be seen as a way to optimize the use of additional maize production resulting from successful farming innovations or adaptation practices. Silase production can also create new business opportunities that will endorse the development of private-public partnership to benefit farmers. Milk producers such as Nestle visited and partnered with Dupont-Pioneer to supply silase for them.
	Maize farming practices	In Indonesia, maize is regularly planted after rice. Climatic changes could alter cropping patterns. Relay planting is introduced to increase the frequency of maize planting from once a year to four times a year. To support maize adaptation to environmental exposures, new cultivars that are tolerant to droughts and have shorter maturity were created. Bima, Lamuru, Sukmaraga, and Anoman are examples of drought-tolerant varieties. Hybrid cultivars have already been introduced to farmers. Farmers are also encouraged to use the planting calendar to select their cropping pattern following climate prediction.

VI. CONCLUSION

Global climate change already poses numerous challenges to crop production in Indonesia. A number of studies have already revealed the impacts of climate change on crop production, especially since climate variability significantly affects crop productivity. Most of the studies in the country evaluated the impacts of climate change on crop yield using modeling approaches. There is no information on the impacts on phenological stages identified through literature review or site visit. Nevertheless, the government of Indonesia has been serious in identifying measures that will help the country adapt to and mitigate the potential negative consequences of climate change on crop production. Research activities on cultivars have been conducted to develop crop varieties that are tolerant to floods, droughts, salinity, and pests and diseases. The main challenge is the farmers' low adoption of new crop varieties.

Crop insurance, web-based planting calendar, silase for animal feed, and climate-smart farming practices are the CCA options that can be scaled up nationally and regionally. These CCA options have already been tried or implemented in Indonesia, but the benefits of each should still be explored. It is imperative to implement these strategies because global climate change also threatens national food security. Agricultural land conversion and price stabilization are the other two biggest challenges that threaten domestic crop production in Indonesia, but a detailed discussion of these two issues are beyond the scope of this study. Further research can be directed towards the formulation of agricultural policies that are designed to specifically address the multiple interactions between and among agricultural issues.

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