Lesson learnt from Smart Rice Actions in Indonesia

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Data of the article

First received : 15 February 2018 | Last revision received : 25 November 2018
Accepted : 28 November 2018 | Published online : 26 December 2018
doi:10.17170/kobra-2018122067

Keywords

Climate change, rice production, smart agriculture, adaptation, NDC

Abstract

Smart Rice (SR) actions are innovative farming practices derived from climate smart agriculture (CSA) concepts and are directed to comply with mitigation and adaptation strategies to climate change. This study provided information about the plausible implementation of SR actions in Indonesia based on literature reviews and stakeholders' consultation with key informants working on crop management and climate information. The SR actions recommendations are a set of farming practices applied to fulfill the needs of rice growth and development set in specific agro-ecosystem areas. These include utilization of climate information for crop planning, selection of superior varieties and seed quality management, proper land preparation and soil nutrition management, application of water saving and efficient technologies, and integrated pest management. Policies and regulations in Indonesia supported the implementation of SR actions with regards to the government commitment in addressing climate change and targeting self-sufficiency of rice production. However, there were some challenges for farmers in adopting the SR actions because of limitation in knowledge and capacity, and availability of guidelines and tools. Coordination among key stakeholders (i.e., government, extension workers, universities, supporting partners, and farmers) within the rice sector should be institutionalized to address the challenges and to support the adoption of SR actions nationally. The recommendations were to a) improve the knowledge and capacity of the extension workers and farmers, b) promote the use of appropriate farming technologies and tools, c) integrate crop insurance with the weather prediction, d) modify the rule of government subsidy, e) apply crop simulation models and tools for measuring GHG emissions based on the agro-climate zonation, f) develop climate change impact assessments for measuring the benefits of SR actions under future climate change projections, and g) develop guidelines of the SR actions to ease the adoption of the proposed SR actions.

Introduction

Global climate change is expected to have a negative impact on crop production, in particular those grown in the low latitude areas (Cline, 2007). Downing et al., (2017) states that higher average temperatures could trigger plant diseases, as well as increase water stress, which leads to a decrease in crop productivity. This exposure could lead to increasing crop failures, which eventually decrease farmers' income. Generally climate change, indicated by rising air temperatures, changing rainfall patterns, and increasing intensity of extreme climate, poses a serious challenge to farming activities. Climate change, affecting the pattern of planting time

Citation (APA):
Perdinan., Dewi, N. W. S.P., Dharma, A.W. (2018). Lesson Learnt from Smart Rice Actions in Indonesia, *Future of Food: Journal on Food, Agriculture and Society*. 6(2), 9-20.

(Koide et al., 2013), may pose a challenge to increase the harvesting area (Lizumi et al., 2015; Duku et al., 2018). For example, the trend of a shortened rainy season and a higher intensity of rainfall is considered as a major obstacle in the efforts of increasing planting area for crop production in Indonesia (Perdinan et al., 2016).

As a country located in low latitude region, the impacts of climate change on crop production such as rice, the staple food of Indonesian people (Simatupang et al., 2004), may lead to serious challenges which threaten the countrys' food security (Motta et al., 2005; Sumaryanto, 2012). Climate change, which leads to shifts in climate variability and extremes, is estimated to significantly impact rice production in Indonesia (Hosang et al., 2012) . Higher temperature in combination with decreasing rainfall were estimated to decrease rice production in Indonesia from about 20% to 38% (Syukyat, 2011; Hosang et al., 2012; BMKG et al., 2013). Another challenge is the potential impact of climate change on increasing the frequency of climate extreme events, such as floods and droughts, that negatively impact rice production (Surmaini et al. 2011). Based on data and information from the Directorate of Plant Protection of the Ministry of Agriculture (2013), flood in 2010 and drought in 2011 resulted in a decrease of paddy production and could even lead to crop failure for the paddy production centers in Java (Perdinan et al., 2016).

Furthermore, the impacts of climate change on humid tropic areas such as Indonesia may create favorable conditions for pest and disease infestations. As an example, higher temperatures in combination with higher humidity supports the growth and development of the rice pest known as brown planthopper (BPH), named in bahasa "Wereng Batang Cokelat", which negatively impacts rice production. The BPH damages rice plants, through an extensive sucking of the cell sap. The pest also transmits viruses so that increased levels of BPH infestations occasionally are accompanied by substantial losses in rice production (Mejaya, 2014).

By understanding the impacts of climate change, this paper evaluates innovations and actions to address the negative impacts of climate change for rice production in Indonesia. The evaluation is based on literature review and consultations to key informants in the country. The explored actions are directed to support the "Climate Smart Actions" for supporting of self-sufficient rice production in Indonesia. Hereafter the "Climate Smart Actions" is named "Smart Rice" (SR). Principally, the SR actions are all actions that are part of Climate Smart Agriculture (CSA) strategies, which are directed at applied farming technologies and practices to fulfill the needs of rice growth and development in specific agro-ecosystem areas. The SR actions should provide benefits to improve yield or income, reduce greenhouse gases emissions, enhance efficiency of production inputs, and achieve resilience (Rioux et al., 2016).

The principles of SR actions are well suited with government targets for commitment in addressing climate change as articulated in the document of the National Determined Contribution (NDC) of Indonesia (Government of Indonesia, 2016) submitted to UNFCCC in 2016. The NDC prioritizes agriculture as one of the key development sectors in which rice production plays a major role in agricultural development, understanding rice production contributed to and affected by climate change. The adoption of the SR actions at a large scale or nationwide is also expected to contribute positively to support the self-sufficiency target of rice production in Indonesia (Sumaryanto, 2012). Thus, this paper reviews the initiatives on SR actions in Indonesia, particularly the potential benefits, the challenges, and the national supports for the implementation of SR actions, which can provide insight to define way forward strategies.

Overview of Climate Smart Agriculture

Climate Smart Agriculture (CSA) is a regional framework initiated by the Food and Agriculture Organization (FAO) as an effort in facing climate change. CSA has several principles, namely: (1) consideration of national development priorities and local context; (2) coordination across agricultural sectors (crop, livestock, forestry and fisheries) and with energy and water development sectors; (3) working across multiple levels and scales from farm to landscape, local to global, short and long term; and (4) promotion of synergies and multiple objectives and outcomes, which are context specific. Generally, direction of CSA is defining actions on climate change mitigation and adaptation to enhance the achievement of food security. Shirsath et al. (2017) suggests that the promotion of CSA requires an understanding of sustainability, both the costs and benefits, and the environmental impacts of various technological interventions in the local context on current and future climatic conditions.
The focus on this paper is on smart rice (SR) options, which is derived from the notion of CSA strategies (i.e., the adaptation and mitigation actions) for the rice sector. It is explored based on literature reviews and stakeholders' consultations. The reviews listed a number of actions directed to enhance rice production, such as the use of low-emission rice varieties, the use of ZA fertilizer to replace N fertilizer, application of no-tillage cultivation – "tanpa olah tanah" and intermittent (wetting and drying-WD) irrigation technology (Surmaini et al., 2011; Lamid, 2011). The planter method of "tanpa olah tanah" is a way of planting without treatment on land prepara-

ISSN-Internet 2197-411x OLCL 862804632

tion. For example, for ground reversing and extinguishing, only a hole is needed to immerse the seeds into the soil (usually using planter tools).

Liu et al., (2013) proposed adaptation options such as rice variety tolerance to high temperature, improved farming management, balanced soil fertility, and adjusted planting and harvesting time to changes in temperature and sunshine in order to increase yields and maintain high grain production. A review conducted by Perdinan et al. (2016) for rice production in Indonesia lists a numbers of climate change adaptation options that include climate field school called in Bahasa "Sekolah Lapang Iklim" (SLI), climate insurance, improvement of farming techniques, simulation technologies, resistant-superior varieties, planting calendar, prediction of harvesting time, and irrigation technologies.

Method

This study evaluated the initiatives on SR actions based on literature review and the stakeholders' consultation. The review was directed to explore advances on rice production strategies based on available data and information (i.e., articles, reports, etc.) in the country. The consultation was conducted through personal communication or interview key informants of the government officers working on rice production and climate actions, i.e. Ministry of Agriculture - MoA (Directorate Serealia, Directorate General of Food Crop; Research and Development; and Agricultural Services), Meteorological, Climatological, and Geophysical Agency-BMKG, Extension Workers, private sector and farmers). The interviewed stakeholders are listed in Table 1.

Literature Review

Literature review focused on climate change impacts on rice production and explored adaptation practices/technologies to address the impacts of climate change. We also reviewed specific information in the country related to 1) the existing regulations on rice sector to support farmers in addressing the negative impacts of climate change, 2) the technical guidelines related to rice sector (subsidy and farming practices), and 3) research papers/journals with the key words of climate change, adaptation, mitigation, climate smart agriculture, and rice production.

The Stakeholders Concultation

The stakeholders' consultation was conducted through personal interviews either in-person meetings or phone calls. The interviews employed a set of questionnaires focused on identifying CSA options and their implementation in the country. Specifically, the personal interviews were designed to explore information on the impact of climate change on rice production, current practices or technologies considered as SR actions, and challenges in adopting the proposed SR practices/technologies. Hereafter, we cited collected information from the stakeholders' consultations indicated as "personal communication".

The results of desk-reviews and stakeholders' consultations were then employed to formulate way forward strategies to endorse and support the adoption of the SR actions.

Findings and Discussion

The Government Supports

The government of Indonesia (GoI) essentially supports the implementation of the SR actions (i.e., CSA) nationwide through policies, programs and initiative actions. The regulations on rice sectors mandated to the Ministry of Agriculture (MoA) play a major role in promoting the implementation of the SR actions nationwide. The GoI mandated the MoA through regulations to support farming practices purposed to improve farmers' livelihoods. The regulations are required as a reference for devising programs that can be implemented in the country. There are numerous regulations associated with agriculture, in particular to support rice production in Indonesia, and this paper only explores those regulations that are related to support the implementation of CSA for sustaining rice production (i.e., the SR actions). The policies, programs, and actions explored are related to the proposed SR actions for improving the farming practices as listed in Table 2 and detailed in Table 3.

a. The Government Programs

The government provides financing supports for improving farming activities within the directorate of food crops (cereals production division). The allocation budget of the government subsidy for management activities of cereals production in 2017 was approximately Indonesian Rupiah (IDR) 3,747,436,486,000,-. The allocation for the rice sector was in the form of seeds, fertilizers, pesticides , agricultural tools and machinery, integrated pest management (IPM), organic fertilizer management unit (UPPO) and crop protection from the effects of climate change, which is named in Bahasa as "Penerapan Penanganan Dampak Perubahan Iklim" (PPDPI) (MoA, 2017).

Integrated Pest Management (IPM) in Indonesia has been regulated through Indonesian Government Regulation No. 6/1995 with respect to Plant Protection. The GoIs has introduced the IPM technology to control pests

Table 1: Consulted Key Stakeholders

Number	Name	Institution
1	Ari and Gatot	Directorate of Crop Protection, Ministry of Agriculture
2	Ali Jamil	Directorate of Cereals, Ministry of Agriculture
3	Suismono	Post Harvest Research and Development, Ministry of Agriculture
4	Woro Estiningtyas and Pramudia	Agricultural Research and Development, Ministry and Agriculture
5	Astrina Yulianti	Center for Assessment and Development of Agricultural Technology, Balai Besar Pengkajian dan Pengembangan Teknologi Pertanian (BBP2TP), Ministry of Agriculture
6	Ismail Wahab	Indonesian Center for Rice Research, Ministry of Agricul-ture
7	Darmadi	Center for Assessment of Agricultural Technology-Balai Pengkajian Teknologi Pertanian (BPTP), Jember
8	Utema	Unit of Food Crops and Holticulture, North Sumatra
9	Marjuki	Meteorological, Climatological, and Geophysical Agen-cy
10	Purwono	Bogor Agricultural University
11	Mahesh Nimje	PT Olam Indonesia
12	Haryanto	PT Sang Hyang Sri
13	Novika Rukmi	Subang Regency Agriculture Office
14	Endang Rukayat	Subang Regency Agriculture Office
15	Tati Hartati	Trainer
16	Mastam	GAPOKTAN (Farmers group)
17	Cahyana (FIELD)	Implementing Partner-CSA-FAO
18	Ade and Cahyana	Deutsche Gesellschaft für Internationale Zusammenar-beit GmbH (GIZ)

Table 2: Consulted Key Stakeholders

Farming practices	**The approach**
Crop planning	Use the integrated cropping calendar tool (KATAM) and other assessment tools, such as LKP, to gain information for planning the cultivation activities.
Selection of rice varieties and seed quality man-agement	Selection of rice variety should consider climate forecast and other agro-ecosystem condition, followed by proper seed treatment
Land preparation and planting	Strongly encourage proper land levelling while choosing tillage practices and planting tech-niques based on local conditions
Water management	Water saving technologies, not continues flood-ing
Soil nutrition management and pest control	Site specific fertilization, use assessment tools, such as paddy soil test kit (PUTS) and Leaf colour chart (LCC), to realize fertilization needs
Pest management	Integrated pest management (IPM) which focus on prevention rather than extermination

ISSN-Internet 2197-411x OLCL 862804632

Table 3: The policies, programs and initiatives on climate Smart Rice (SR) actions

Farming Practices	Policy	Program	Action
Crop planning	• Law no. 12 Year 1992 Plant Cultivation System • Minister of Agriculture Regulation no. 3 Year 2015 UPSUS PAJALE General Guidelines through Irrigation Networks and Other Supporting Facilities • RI Minister of Agriculture Regulation no. 40 / Permentan / SR.230 / 07/2015 Facilitation of Crop Insurance	• KATAM Terpadu (2700 district/10 province)->75 mil/BPTP (80% farmers adopt KATAM) • Jajar Legowo Super (JARWO) • Climate Field School (SLI) IDR 200 million/SLI 3 • Crop insurance	• Integrated KATAM online monitoring system using CCTV • Integration of rice standing crop on integrated KATAM information system • Jajar Legowo raw-spacing • The insurance was subsidized about 80%/ Ha • Flood and dorught season prediction
Selection of rice varieties and seed quality management	• Law no. 12 Year 1992 Plant Cultivation System • Minister of Agriculture Regulation no. 3 Year 2015 UPSUS PAJALE General Guidelines through Irrigation Networks and Other Supporting Facilities • Minister of Agriculture Decree No. RI. 1397 / RC.110 / C / 2016 Technical Guidelines Distribution of Government Support Scope of Directorate General of Food Crops T.A 2017	• Seed Subsidy IDR 298.000.000.000 • Jajar Legowo Super (10000 Ha/10 Provinsi)	• Release more than 300 paddy variety (VUB), especially, superior varieties (VUB) (resistance of flood (Inpari 29 & 30), dorught (situ bagendit, Inpari 42, 43), salinity (Inpari 34 & 35) • Use low-emission variety
Land preparation and planting	• Law no. 12 Year 1992 Plant Cultivation System • Minister of Agriculture Regulation no. 3 Year 2015	• Farming facilitation Subsidy (4,6 Billion) • JARWO Super	• Shed of biodecomposers on second tillage • Land management information system
Water management	• Law no. 12 Year 1992 Plant Cultivation System • Minister of Agriculture Regulation no. 3 Year 2015	• PPDPI (Biopori and "Sumur Pantek" (IDR 389.825.000,-) • JARWO Super	• Intermitten irigation • Support to making "embung" • "Tetes" irigation • Pump assistance
Soil nutrition management and pest control	• Law no. 12 Year 1992 Plant Cultivation System • Minister of Agriculture Regulation no. 3 Year 2015 • Minister of Agriculture of the Republic of Indonesia Regulation no. 69 / Permentan / SR.310 / 12/2016 Needs and Highest Retail Price (HET) of Subsidized Fertilizer for Agriculture Sector Budget Year 2017 • Regulation of the Minister of Agriculture Number 48 / Permentan / OT.140 / 10/2006 concerning Guidelines for Good and True Cultivation of Food Crops • Minister of Agriculture Decree No. RI. 1397 / RC.110 / C / 2016 General of Food Crops T.A 2017	• KATAM Terpadu • JARWO Super • Balance fertilizer, using soil test kit (PUTS) • Fertilizer subsidy In-organic: 7.654.000 Tons Organic : 895.288 Tons • UPPO (Organic Agriculture) (IDR 262.5 billion)	• Prediction of soil fertility • Site specific nutrient treatment (using software) • Organic fertilizer subsidy
Pest management	• Law no. 12 Year 1992 Plant Cultivation System • Minister of Agriculture Regulation no. 3 Year 2015 • Minister of Agriculture Decree No. RI. 1397 / RC.110 / C / 2016 Technical Guidelines Distribution of Government Support Scope of Directorate General of Food Crops T.A 2017 • RI Minister of Agriculture Regulation no. 40 / Permentan / SR.230 / 07/2015	• Integrated Pest Management (40-45 million/IPM): IDR 12.712.000.000 • Pesticide subsidy IDR 70 billion • Crop insurance	• Use of biological agents for pest control • Motion control example • Control of pest with organic pesticide • IDR 6 million compensation, if OPT> 75%

ISSN-Internet 2197-411x OLCL 862804632

that is inline with the CSA concept. Diratmaja (2015) described that the basic principle of IPM is to apply an-organic pesticide only if other controls cannot reduce pest populations. Others controls are parasites, predators, pest pathogens, and biological pesticides (Diratmaja, 2015).

The program initiated by the GoI that implemented the IPM and UPPO is the innovative farming practices on modifying row and spacing named "Jajar Legowo (JARWO) Super". Based on the technical guideline of JARWO Super (MoA, 2016), the JARWO Super promotes the application of balancing fertilizers (i.e., anorganic and organic fertilizers). The technique suggests that the application of urea fertilizer of about 200 kg/Ha and Phonska NPK 300 kg/Ha will potentially reach rice productivity levels of more than 10 tons dry grain/Ha. The Phonska is applied at about 100% at planting and urea is about 1/3 at 7-10 days after planting, 1/3 parts at the age of 25-30 days after planting, and 1/3 parts at the age of 40-45 days after planting. To improve soil fertility, farmers can apply manure that has been cooked perfectly at a dose of 2 ton/Ha or Petroganic organic fertilizer at a dose of 1 ton/Ha, which is distributed during the second tillage, in addition to the chemical fertilizers.

b. The Benefits of The Programs

The government initiatives on farming practices provide incentives for farmers, although no cash subsidy is distributed. For example, the rice row and spacing technology, also known as the JARWO Super program, recommends applying new rice varieties, such as Ciherang Sub-1 (the new variety of Ciherang), Inpari-32 HBD, and Inpari-33, whose potential yields are higher than the existing Ciherang varieties. The potential yields of the superior varieties are about 13.9 ton/Ha (Ciherang Sub-1), 14.4 ton/Ha (Inpari-32 HBD), and 12.4 ton/Ha (Inpari-33). Meanwhile, Ciherang varieties yield only about 7.0 ton/Ha. The net income of rice farming with the JARWO Super can reach IDR 42,487,222/Ha; whereas, the conventional technique is only about IDR 17,568,333/Ha, boosting profits of about 141.8% in average of all varieties (MoA, 2016).

The other program that is strongly linked to climate change response is modifying the Planting Calendar or in bahasa is named "Kalendar Tanaman" (KATAM). The interview with the key informant of KATAM producer (Annex 2) claimed that farmers applying the KATAM can alleviate the potential negative impacts of climate exposure up to 80% higher than those who do not apply KATAM. Another program focuses on capacity building activities on the use of climate information for rice production, also called Climate Field School or in bahasa is named "Sekolah Lapang Iklim" (SLI). This program was firstly introduced over a decade ago under coordination of the Directorate Plant Protection of the MoA to improve farmers' understanding on climate fluctuations and its impacts on rice productivity (Boer et al., 2004). Based on our communication with the organizer of SLI, which now is running by BMKG, the SLI program can increase rice yield up to 30%.

c. The Obstacles of The Programs

The government's initiatives to support farmers for improving farming practices to some extend have not been effective due to constraints in subsidy distribution and financing mechanisms. The main benefit of the subsidy is to reduce the burden of farming costs to farmers, However, funding for the government programs is not evenly distributed at the local level because of the budget limitation, lack of socialization or knowledge, and lack of available farming tools. These concerns limit the ability of agricultural services at the regional level to implement the national programs as explained by Utema when we conducted the personal interviews (Annex 2). Additionally, access to the resistant rice varieties to environment stress that is released by the government is still limited. Also, the private companies that sell seeds mostly do not sell the resistant varieties to environmental stress.

Furthermore, farmers may not continuously adopt the initiatives on SR actions after the program ends. This situation may happen due to lacking in supporting tools and infrastructures as well as institutionalization mechanism to support the programs at the local level. For example, the KATAM has been released, but this system is a one-way approach as farmers cannot interactively use the system to tailor properly the required farming practices for the specific climate fluctuations at the field levels. For the modification of proper farming practices, the Rice Agro Advisory Service or in bahasa named "Layanan Konsultasi Padi Indonesia" (LKP) should be combined with the KATAM. The LKP offers farmers more informative knowledge about farming practices than KATAM.

Unfortunately, a study conducted in three villages of Central Java located in the three districts (i.e., Banyumas, Purwokerto, Banjarnegara) explained that farmers and extension officers still rarely used both KATAM and LKP (GIZ, 2017b). Another study conducted in six villages in Pasuruan, East Java, revealed similar facts that KATAM was almost unknown to farmers, while the extension workers have limited knowledge on KATAM which may be due to long communication chain required for disseminating the updated information in the KATAM system (Anggarendra et al., 2016).

ISSN-Internet 2197-411x OLCL 862804632

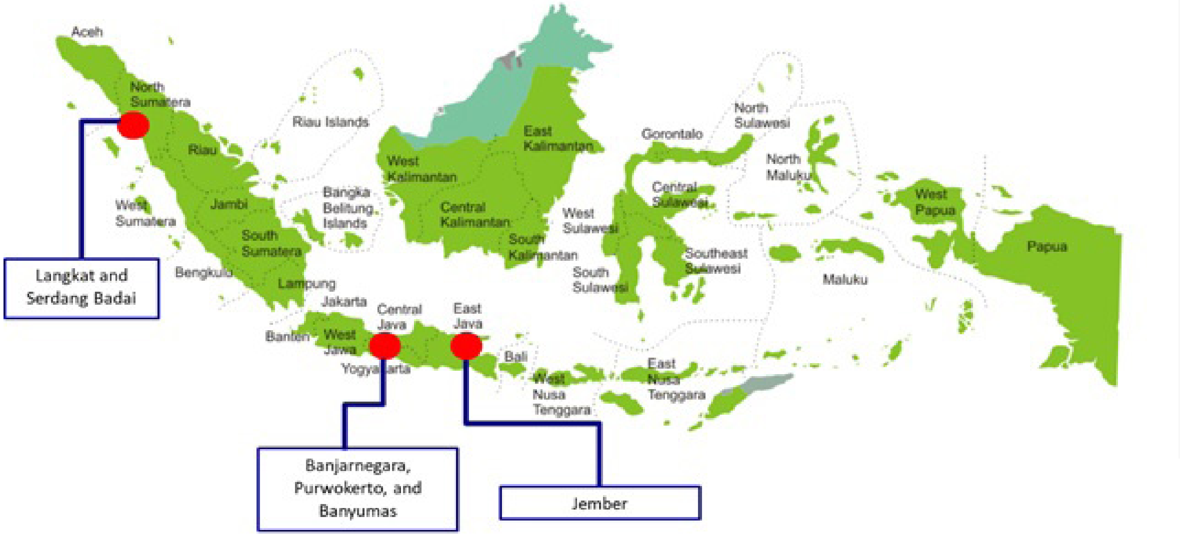

Figure 1: The map of GIZ project locations in Indonesia

Another example of the introduced program is crop insurance. This program is one of the government programs to support farmers to adapt with climate disasters (MoA Regulation No. 40 / Permentan / SR.230 / 07 / 2015 on Facilitation of Crop Insurance). In general, the main objective of this program is to increase farmers' resilience towards climate change. Crop insurance helps farmers in reducing risks to climate change impacts, increasing farmer's income, ensuring available costs for production inputs, as well as availability of working capital. The GoI through MoA supports the execution of crop insurance through a numbers of pilot projects, in cooperation with an insurance company named JASINDO. For the pilot studies, the insurance premium was subsidized about 80% so that farmers pay lower premium (BB Padi, 2015). Additionally, farmers must comply with the insurance requirements, such as paying premiums on time. However, it was found based on a case study in the North Sumatera and East Java that the capacitated staff of JASINDO, who should do the risk assessment, was not widely available (GIZ, 2017a). Understanding the challenges, stakeholders' involvement to build comprehensive and reliable information is important foundation to pass the challenges. The engagement of multi-stakeholders to accelerate farmers' adoption on recommended SR actions should also be proposed and institutionalized.

Stakeholders Analysis

Stakeholders' engagement is a critical aspect to endorse the adoption of SR actions, directed to achieve the goals of CSA i.e., increase yield, income, resilience, input production efficiency, and greenhouse gas reduction (GHG reduction), by farmers. The stakeholders referred in this paper are government (Ministry of Agriculture-MoA and Meteorological, Climatological, and Geophysical Agency-BMKG), extension workers, supporting partners, universities and farmers.

The government initiatives, such as the KATAM and the JARWO Super, are designed to be established country-wide. For example, the KATAM provides information on the planting calendar and recommended farming practices up to the sub-district level across the country. Meanwhile, the JARWO Super has been demonstrated in a number of locations (about 11 provinces in Indonesia; BB Padi, 2017)). Those initiatives are promising actions in response to climate change. However, the implementation of the options should be recommended for the right place and time with reference to farmers' capacity. In addition, the potential benefits of applying the options should also be clarified by understanding that the implementation will require capacity development and financial investments.

For this purpose, the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) initiated activities to promote the CSA in some Asian countries, including Indonesia (Figure 1). The projects of GIZ, named Green Economy and Locally-Appropriate Mitigation Actions in Indonesia (GE-LAMA-I) and the Better Rice Initiative Asia (BRIA) have piloted the potential use of CSA to farmers. The GE-LAMA-I is a project to implement the CSA conducted in Banjarnegara, Purbalingga and Banyumas (Figure 1). The actions undertaken in the GE-LAMA-I were (1) crop planning (utilization of crop calendar with updated climate information); (2) use of a high yield and climate resilient variety; (3) seed quality management before planting; (4) Jajar Legowo (row-spacing) technology; (5)

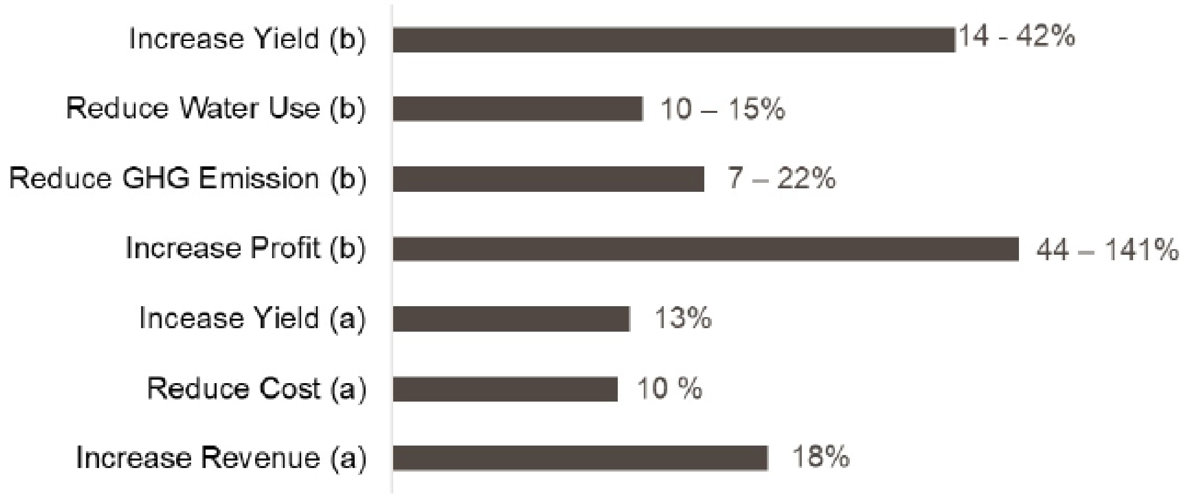

Figure 2: The estimation of benefits for applying the recommended options applied in the BRIA indicated by the letter of "a" and the GE LAMA-I study indicated by the letter "b" in comparison to conventional farming practices. Source: (GIZ, 2017a; GIZ, 2017b).

water saving technology (local assessment); (6) integrated pest management (IPM), such as using bio-pesticide, planting of pest barrier plants, reduced pesticide use, the use of natural enemies, and (7) site-specific nutrient management (PUTS). The benefits of the cultivation technologies applied in the GE-LAMA-I study are about 14-42% higher yields, 44-121% higher profits, 7-22% less greenhouse gas (GHG) emissions and 10 – 15% lower use of water (Figure 2).

As for the BRIA, the proposed options for the SR actions are likely to similar with those of GE-LAMA-I Project. The options are (1) seed treatment technology (use superior varieties, in Bahasa namely "Varietas Unggul Baru" (VUB); (2) row spacing technology like Jajar Legowo (use transplanter); (3) soil and nutrient management based on soil test kit, and (4) integrated pest management (IPM). GIZ introduced the BRIA project in North Sumatera and East Java. The BRIA study revealed promising results indicated by higher yields and revenue received by the farmers following the BRIA recommended options (hereafter named as BRIA-FARMERS) in comparison to the farmers which applied the conventional farming practices (hereafter named as NON-BRIA-FARMERS). The BRIA study conducted in North Sumatra and East Java supported the GE-LAMA-I study as the SR actions provided higher yields and lower production costs (Figure 2).

In addition, the role of key stakeholders also determines the success of adoption of SR actions at the farm level. The extension workers are one of the key elements understanding they are working closely with farmers. Therefore, equipped the extension workers with the knowledge and skills on SR actions should be promoted through training or workshops. The private sectors, which are responsible for producing and supplying production inputs, should also be actively engaged in accelerating the adoption of the SR actions. The private sectors can include information associated with the SR actions as a direction in using their products. They also can work with the farmers' group in order to consolidate the farming practices to be followed by farmers. Finally, the universities or research institutions can direct their research to handle issues faced by farmers. A collaborative communication should be established among the key stakeholders. The interviews conducted in this study also revealed that the cooperation between stakeholders is very important in order to promote new inventions (e.g. SR actions) to be adopted by farmers. The key stakeholders on rice sector in Indonesia and the proposed linkages or relation among the stakeholders in supporting the implementation of farming practices categorized as the SR actions is shown in Figure 3.

Way Forward Strategies

The Smart Rice actions are promoted to understand the potential benefits of the actions in order to increase yields, income, resilience, and to decrease production costs and GHG emissions. These benefits are compromised with the studies conducted by GIZ in North Sumatera and East Java. These identified benefits encourage the needs to up-scale the SR actions.

The promotion of up-scaling the SR actions can support the achievement of the NDC targets committed by the

ISSN-Internet 2197-411x OLCL 862804632

GoI that prioritize agriculture as the key development sector (GoI, 2016) and the self-sufficiency rice production target. The NDC is a part of the Indonesian commitment following the ratification of Paris Agreement through Law No.16/2016. The NDC is basically the national commitment to contribute in emission reduction as efforts to limit rising global temperature of less than 20C. The SR actions are also in line with the concept of Sustainable Rice Platform (SRP). Sustainable Rice Platform (SRP) have three approaches, i.e. (1) promote resource efficiency and sustainability in trade flows; (2) promote production and consumption operations; and (3) promote supply chains in the global rice sector (SRP, 2017).

Moreover, it is important to sustain rice production through actions that are environmentally friendly and able to adapt with the environmental stresses, such as higher temperature and erratic rainfall. Although SR actions have many benefits, the SR actions also have many challenges for their implementation at the farm level. The challenges pose difficulty to farmers in adopting the actions. This study reveals that the challenges are (1) the activities undertaken by farmers do not always follow the government recommendations, such as farmers difficult to adopt new-climate tolerance varieties; (2) the new technology is more difficult than the existing cultivation system; (3) farmers may not well be capacitated to use the tools subsidized by the government, such as farming facilitations, soil test kit "Perangkat Uji Tanah Sawah" (PUTS); (4) available funding is limited at the local level (i.e., district level); (5) specific diseases that harm for rice (Kerdil Hampa) is in searching for treatment; (6) homemade organic fertilizer does not meet the standard; (7) KATAM should be updated and contains prediction error, causing crop planning to be inaccurate; (8) lack of evaluation for recommended application of KATAM at the farm level; (9) uneven distribution of new superior varieties (VUB); and, (10) the supporting facilities are not well supplied to ease farmers access to climate change information. For example, available climate information cannot be accessed due to limited internet connection at the village or remote areas. We also found there is a lack of climate change information and technologies that is understood by farmers and extension officers.

With reference to the GIZ study (GIZ, 2017b), another issue is that farmers did not implement the Jajar Legowo. The reasons are 1) the additional labor costs are relatively expensive to farmers , 2) the system are not well-known by farmers, 3) the system requires more time, and 4) lack of guidance or supervision. About 90% of farmers in Jember, Langkat, and Serdang Badai, the targeted areas of GIZ study, did not do any seed treatment (GIZ, 2017a). The other challenge is the implementation of Integrated Pest Management (IPM) that requires farmers to use Personal Protection Equipment (PPE). It has been known that PPE are important to protect farmers from negative impacts of pesticide exposure. However, most of the farmers do not use any protection equipment while spraying pesticides.

Essentially, the challenges of adopting SR actions are associated with the needs for tools to properly assign suitable SR actions with respect to climate fluctuations affecting growing conditions at the field level. Chhetri et al. (2017) justified that the major challenges for scaling-up the CSA in a diverse agro-ecological zones are identification, prioritization, and promotion of available CSA technologies with regards to local climatic risk and required technology. Evaluation of the farmers' preference is also important to improve the farmers' adoption to the recommended practices or technologies. For example, Chhetri et al. (2017) found that the five farmers' preferred adaptation options in all rainfall zones, namely crop insurance, rainwater harvesting, fodder management, weather-based crop agro-advisory, contingent crop planning, laser land leveling, agroforestry, climate smart housing for livestock, and site specific integrated nutrient management (Chhetri et al., 2017).
Understanding the identified challenges, coordination and cooperation among key stakeholders is an important element to enhance the adoption of SR actions by farmers. The SR actions for Indonesia include: 1) selection of rice varieties and seed quality management, 2) soil nutrition management and pest control, 3) water management, 4) pest management, 5) land preparation and planting, and 6) crop planning.

The promotion to adopt the SR actions nationwide should be supported by the government policies, regulations, and programs. In this case, the MoA should create favorable and enabling conditions to capacitate farmers with adequate guidelines and tools that can be accessed and used by the farmers. The extension workers play a critical role as part of the government institution by working together with farmers through training and assistantship facilitation. The farmers' institution, such as farmers groups – named in bahasa "Gabungan Kelompok Tani" (GAPOKTAN) – should also be strengthened as a network to increase farmers' confidence in adopting new initiatives. The other stakeholders and their role or contribution to support the adoption of SR actions in Indonesia are clarified in Figure 3.

Recommendation

The implementation of SR actions face several challenges, especially when upscaling the SR actions. To address these challenges, the following recommendations can be considered.

Modification of existing initiatives or programs

1. Improve the capacity of extension workers and farmers to use the Information and Communication Technology such as KATAM and LKP for crop-climate advisory.
2. Improve the use of KATAM with respects to farmers' needs, for example: the use of climate regionalization for KATAM. The mechanism of accessing updated information on KATAM and its interpretation at the farm level should directly involve extension workers and farmers' groups. Interactive communication technology should be advanced so that KATAM is not only a one-way direction, rather a collaborative work between extension workers and farmers. Thus, it should be endorsed to interpret the KATAM at specific farm fields.
3. Integrate crop insurance and/or weather-based insurance into climate field schools to support the adoption of new innovations on farming practices and technologies. The Climate Field Schools should be institutionalized and run by farmers' groups accompanied by the extension workers who has sufficient capacity on CSA.
4. Modify the rule of access or distribute irrigation to farm fields considering the SR actions supply water with respect to crop needs in order to enhance water use efficiency. The users should also be equipped with adequate knowledge regarding the techniques.
5. Develop tools to evaluate the adoption of SR actions and the benefits of the actions. The tools can be used to survey farmers' preferences to adopt the SR actions as well as the required facilitation to identify target locations and farmer' criteria to adopt the SR actions.
6. Encapsulate government programs on economic incentives, such as subsidies with the insurance scheme, and/or access to micro-finance, but do not subsidize the production inputs (i.e., fertilizers, seeds). The subsidy on insurance can offer benefits to boost the adoption of new invention that may be embedded in the terms and conditions of the insurance scheme.

Development of new initiatives or programs

1. Agro-Climate Zonation: provide spatial information on agro-climate zonation where suitable SR actions can be allocated. The application of crop simulation model applied to the agro-climate zonation can also be employed to provide information on the suitable areas for farming the new resistant varieties or the other farming practices, i.e., helping for tactical farming management.
2. Provide tools to measure GHG emissions and to properly allocate SR actions with reference to agro-climate zonation and climate change scenarios to improve the resilience of rice growing areas in the future. The estimation can clarify the contribution of rice sector to agriculture as one of the key sectors in the NDC, and eventually to the achievement of sustainable rice production.
3. Provide the baseline of climate change impact assessments for each specific agro-climate zone over the country so that estimation of the benefits of applying SR actions for future climate change can be evaluated.
4. Develop guidance on determining farming actions as climate change adaptation with respect to the regional climate change impact assessments and the contribution to resilience-pathway
5. Improve the role of farmers' groups (GAPOKTAN) on devising farming practices applied to a large area, for example by collated the cultivation areas owned by farmers (formation of rice farm management unit) to apply recommended SR actions to reach the efficiency in terms of economic of scale.

Conclusion

Farmers face challenges maintaining rice production exposed to climate change exposure. One of the strategies that can be applied to address the impacts of climate change on rice sector is by adopting "Climate Smart Actions" for rice production hereafter named "Smart Rice" (SR). Principally, the SR actions are directed to apply farming practices and management with regards to the needs of rice growth and development grown in an area with specific agro-ecosystem characteristics. This study suggested that the benefits of SR actions include increase yields; reduce greenhouse gas (GHG) emissions and rice production inputs; and, increase farmer's incomes and resilience.

Many initiatives have been introduced and released by the Government of Indonesia (GoI) to boost rice production, which are also relevant to support the adoption of SR actions. The SR actions include: 1) selection of rice varieties and seed quality management, 2) soil nutrition management and pest control, 3) water management, 4) pest management, 5) land preparation and planting, and 6) crop planning.

However, the adoption of SR actions faces many challenges due to mainly lacking of knowledge, capacity,

ISSN-Internet 2197-411x OLCL 862804632
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guidelines, and tools. To address these challenges, a number of strategies are grouped into two broad and recommended categories, namely: 1. Modification of existing initiatives or programs and 2. Development of new initiatives or programs. These recommendations focus on designing actions directed to a) improving the knowledge and capacity of the extension workers and farmers; b) promoting the use of appropriate farming technologies and tools (e.g. KATAM) with respects to farmers' needs; c) integrating crop insurance with the weather prediction; d) modify the rule of government subsidy; e) applying crop simulation models and tools for measuring GHG emissions based on the agro-climate zonation; f) developing climate change impact assessments for measuring the benefits of SR actions under future climate change projections; and, g) developing guidelines of the SR actions to ease farmers adaption to the proposed SR actions.

The identified reccomendations encourage the plausible adoption of the SR actions by understanding the government responses on climate change actions and the needs for sustaining rice production in Indonesia. Finally, active engagement among key stakeholders (i.e., government, extension workers, universities, and farmers) with regards to their capacity and role (Figure 3) on rice sector is an essential element to ensure the adoption of the SR actions.

Acknowledgments

This study was supported by GIZ through research grant on "Policy Recommendations for a Climate Smart Rice Sector in Indonesia" for initial review and APN grant #CBA2018-09SY-Perdinan for final version. The authors also want to thanks to the key stakeholders for their invaluable insights and the reviewers for their comments in assisting the revision process of this paper.

Conflict of Interests

The authors hereby declare that there are no conflicts of interests.

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ISSN-Internet 2197-411x OLCL 862804632