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Climate Smart Actions "Saung Iklim" for Small Holders' Farmers in Subang District West Java Indonesia

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APN
ASIA-PACIFIC NETWORK FOR
GLOBAL CHANGE RESEARCH

Project Report:

Climate Smart Actions "Saung Iklim" for Small Holders' Farmers in Subang District - West Java Indonesia

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Background

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. Principally, CSA are directed to apply farming technologies and practices with regards to the needs of rice growth and development grown in an area with specific agro-ecosystem characteristics. The actions should provide benefits to improve yield or income, reduce emissions, enhance efficiency of production inputs, and achieve resilience (Rioux et al., 2016).

Principally, the CSA 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. Although CSA technology has many benefits, the technology also has challenges for its implementation at farm level so that not all farmers have been able to adopt the technology. Thus, the promotion to adopt the CSA nationwide should be supported by the government policies, regulations, and programs. The promotion to adopt the CSA nationwide should be supported by the government policies, regulations, and programs. In this case, the Ministry of Agriculture (MoA) should create favorable enabling condition to capacitate farmers with adequate guidelines and tools that can be accessed and used by farmers. The extension workers play critical role as part of the government institution to work together with farmers through training and assistantship facilitation. The farmers' institution such as farmers groups named GAPOKTAN should also be strengthened as a network to gain more farmers' confidence in adopting new initiatives.

4.2 1.1 Description of the Project

The Government of Indonesia is already paid a serious action to climate change issue since the late 1990s. Indonesia already submitted the Initial National Communication (INC) document to UNFCCC in 1999 and the Second National Communication (SNC) in 2010. At the same year, the GoI through the State Ministry of National Development Planning (BAPPENAS) has evaluated the potential impacts of climate change on various economic sectors (BAPPENAS 2010), and provided recommendations on the needs to mainstream climate change adaptation (CCA) strategies into development plan (BAPPENAS 2014). Recently, the GoI already submitted a document of National Determined Contribution (NDC) to the UNFCCC in the late of 2016 as a response to the ratification of Paris Agreement (Law No. 16/2016). The NDC highlights the commitment of the country to endorse climate change actions. Specifically for climate change adaptation, the NDC stated the needs to enhance the resilience of food, water, and energy. The NDC document also highlights the needs to reduce climate change risks through capacity building programs.

With refer to the NDC request, it is necessary to formulate capacity building programs that ensures the transfer of knowledge to the targeted recipients. This project strives to enhance directly the capacity of "Tim Iklim" and the rice farmers of Subang district. The Tim Iklim, composing of local government officers, extention workers, farmers' groups and local scientists/universities, has been established by the Regent Decree of Subang No. 600/Kep.251-BP4D/2017 as the forefront who will enhance farmers' capacity in managing climate risks on crop production. The involvement of Tim Iklim is aimed at sustaining the works to continually improve the farmers' capacity to properly employ climate information. The concrete actions of the proposed project are to provide capacity building through developed tools directed to improve farmers understanding and capacity on the implementation of climate smart actions to improve farming management. This idea is in line with the goal of NDC submitted to UNFCCC in 2016 that prioritize agriculture as one of the key development sectors, and is also relevant to the APN goal on research, capacity development, and science-policy agendas. This project that utilized the various forms of stakeholders' engagement is also relevant with the APN Strategic Plan specifically on interfacing the natural, social, and political science disciplines to improve community responds to climate change through the use of effective management tools to minimize or to avoid the negative impacts of climate extremes or hazards on crop production.

4.3 1.2 Concise Literature Review

Rice is considered the staple food in Indonesia. Rice production has serious challenges to the impacts of climate variation and change (Parry et al. 2005; Manzanilla et al 2011; Kamaladara et al 2015; Perdinan et al 2017). Several studies in Indonesia reported that shifting climate variability and extremes, indicated by changing rainfall pattern and intensity as well as higher temperature, adversely impact rice production (Hosang, Tatuh, and Rogi 2012; Syaukat 2011). Climate phenomena, e.g., ENSO and IOD phenomenon, can also impact negatively to delaying the beginning of the rainy season or declining the rainfall intensity (Apriyana and Kailaku 2015) in many areas of Indonesia, particularly those area with monsunal climate type such as Subang district. In addition, climate extreme events such as higher rainfall or prolong drought, which may lead i.e. floods and drought, respectively, will negatively impact rice production (Surmaini, Runtunuwu, and Las 2011; Sumaryanto 2012). To manage the climate impacts, climate adaptation should be well designed and implemented. Challinor et al. (2014) stated that without adaptation, climate change will decrease yields of major crops (mostly maize and rice) in tropical regions, e.g. Indonesia.

Providing tailor-made climate information for the rice farmers is a critical step for successful adaptation on farming management. For this purpose, the Indonesian Ministry of Agriculture (MoA) has developed a tool called "Integrated Cropping Calendar System (KATAM)" to support the goal of increasing crop production and to help farmers in adapting to the changing climate. The MoA has also initiated "Climate Field School" to encourage role of agricultural extension workers and the government to farmer (MoA 2011; Anggarendra et al. 2016). The KATAM provides useful information such as the prediction on appropriate planting time and recommendation on types of rice variety and fertilizers at the sub-district level. It also contains information on potential climate-related hazards, such as floods and droughts, which is provided to help farmers in minimizing climate risks. However, farmers are often unaware of the KATAM tool and how to translate the information for their farming activities. Thus, the main challenges are associated with communication media/strategy and farmers knowledge on utilizing climate information (Anggarendra et al. 2016). Sarie (2016) also mentioned that channeling climate information to farmers on how to cultivate rice while at the same time adapting to climate change has been relatively difficult. In response to the issue, the propose project strives to improve the capacity of extension workers and farmers on utilizing climate information through the implementation of Climate Smart Action 'Saung Iklim' using the Subang district as pilot project. This community-based adaptation is considered as one of proper ways to support the goal of sustainable rice production (Komaladara et al. 2015).

4.4 1.3 Relevance to APN's Strategic Plan

The aims of Climate Smart Actions "Saung Iklim" are generally to improve farmers skill and knowledge in planning and managing their farm activities. The project has relevant goal and are working on the strategic actions that APN is purpose on. With refer to the fourth strategic plan of APN 2015-2020, the project is relevance to the strategic plans as follows.

This project is an advanced activity of Climate Action Management Strategies (CAMS) that has formally established "Tim Iklim" (Climate Team) of Subang District. The project activities are directed to introduce "Tim Iklim" on a global level (APN) (Goal No.2). In accordance with APN's Fourth Strategic Plan, studies conducted in selected areas (Subang District) have been adapted to the issues particularly relevant to the region that is agriculture (Goal No.1). The Tim Iklim is established as an instrument for extension workers, key players and scientists interact and implement their ideas to farmers through extension workers. Thus, this goal that relevance to Third APN's strategic plan, means as strengthening appropriate interactions among scientists and policy makers, and providing scientific inputs to activity of the Time Iklim, formaly established by the Regent Decree No. 600/Kep.251-BP4D/2017.

The project is also purposed to enhance farmers' resilience on managing climate variability and climate change risks. One of the objectives is to improve knowledge and capacity of Tim Iklim on utilizing crop simulation model for tactical management on farming activities, which is relevance to the second APN's strategic Plan. Under its Fourth Strategic Plan, The project focuses on 3 out of 5 APN's scientific themes including: (1) Climate Change and Climate Variability; (4) Resources Utilization and Pathways for Sustainable Development; and (5) Risk Reduction and Resilience.

Objectives and Deliverables

4.5 2.1 Objectives

The project activities are generally intended to equip the Climate Task Force ("Tim Iklim") with climatic driven tools and to enhance the adaptive capacity of farmers to climate change. Specifically, the activities aimed at enhancing the knowledge and capacity of farmers to manage climate risks through the employment of climate smart actions. Particularly, the project are directed to:

1. Improve knowledge and capacity of Tim Iklim in utilizing crop simulation model for tactical management on farming activities
2. Provide climatic driven tools to enhance farmers' capacity in managing climate risks
3. Support the established Tim Iklim to apply climate smart actions in the farmers' fields selected as the demo plot as the learning-showcase
4. Enhance awareness of farmers and extension workers to collect and document farming issues and strategies through digital reporting system
5. Recommend lesson learnt for applying climate smart actions

In the end stage of the CAMS Project in 2017, the Tim Iklim has been established and mandated to provide climate-driven agricultural management strategies to raise the awareness of the local government and farmers on the importance of utilizing climate information. However, the capacity of the Tim Iklim is still lacking when the CAMS project ends. This CAPABLE-APN project attempts to work together with the Tim Iklim to equip them with the required capacity building materials to materialize proposed climate change adaptation options into actions.

4.6 2.2 Designed Deliverables

The project in general is expected to enhance the Tim Iklim and farmers' knowledge, attitudes, and practices on utilizing climate information for farming management and practices (i.e., climate smart actions). This expectation is a continuation of the CAMS 2016-2017 project, which has initiated the establishment of Tim Iklim through the issuance of the Regent Decree No. 600/Kep.251-BP4D/2017, who are responsible to implement climate change actions in the district. However, now the capacity of Tim Iklim is still lacking. With refer to the objectives, the designed activities are specifically designed to produce outputs that will equip the Tim Iklim with necessary materials to support their active role in utilizing climate information as follows.

1. Modules as learning materials for Tim Iklim in utilizing crop model for farming practices
2. Computer assisted learning model on farming management and practices derived from the outputs of crop simulation model with refer to various climate characteristics
3. Experimental showcase (Demonstration Plots) as field learning exhibition of Tim Iklim in promoting the use of climatic driven tools for farming management and practices
4. Application of developed-digital reporting system for collecting data and information as a way of data communication and sharing mechanism
5. Lesson-learnt of climate smart actions based on stakeholders' engagement in managing climate risks on crop production.

Project Approach and Methodology

The project utilized a combination of modeling techniques, literature review, and local wisdom explored based on engagement with the local stakeholders. The climatic driven tools accompanied by the modules are developed as the learning media for tactical management strategies. The proposed methods are directed to achieve the objectives and outputs that are directed to enhance the capacity and skills of Tim Iklim in utilizing the climate driven tools and the digital reporting system to help their works in promoting the needs for utilizing climate information for farming management and practices. Experimental fields are dedicated as demonstration plots of Tim Iklim and farmers. The new insight and capacity of Tim Iklim working together with agricultural development office is expected to enhance their service on promoting the use of climate related information in major crop growing centers in Subang District that compose of 11 (eleven) sub-districts (Binong; Tambakdahan; Blanakan; Ciasem; Compreng; Pabuaran; Pamanukan; Pusakanagara; Pusakajaya; Patok Beusi; and Legonkulon). Further details on the methodology are below.

3.1 Utilization of Crop Simulation Model

Well-known crop simulation model such as AquaCrop or DSSAT were employed to simulate the potential impacts of climate variability and change in different climate types of the Subang district. The simulation model provides information on the effects of climate fluctuations on planting time and productivity. As a case study, rice crop was selected for the model simulation. This selection was made considering rice is the major crop in Subang District, acknowledged as the third main rice producers in Indonesia. The distinguished climate types for the entire districts was referred to previous works that employed climate regionalization to differentiate climate regions expanded from south to north of the district as the part of CAMS project (2016-2017). With refer to the CAMS, the Subang district can be distinguished into several climate types according to rainfall pattern and magnitude. Crop model was used to simulate rice productivity for each climate type under current and future climate scenarios. Crop model simulation, i.e., DSSAT or AquaCrop, requires information on daily climate data, soil, and farming management as model inputs, assuming pest and diseases infestations are not included so resulted in attainable yield. Daily climate data for each climate type within the Subang District were prepared based on observations whenever is available. When a series of climate data are not available, available gridded climate data were employed. Soil and farming management were prepared with regards to general condition of each climatic region which may encompass a wide area. The simulation focused on assessing the impacts of future climate change on rice productivity in the region.

3.2 Computer Assisted Climatic Driven Tools

The results of crop simulation model should be translated to a language or activity that can be understood and employed by farmers. The toolkits and/or instruments were deployed as a learning media to evaluate the effects of different planting time to crop productivity for each climate region. The learning media were developed in the form of off-line materials and on-line materials to revise the tools developed by the CAMS project as suggested by the stakeholders. After the CAMS project were ended, the government of Subang District organized a small workshops to understand the results of CAMS particularly the analysis on the effects of climate variation on rice productivity. The workshops suggested utilizing toolkits as a learning material to learn the effects of changing rainfall on rice productivity. The offline toolkits (i.e., wooden blocks) were developed considering current state of knowledge and capacity of the stakeholders. This APN-CAPABLE project revised and redesigned the use of wooden-blocks to visualize the magnitude of rainfall and rice production for each climatic region using a computerized web-based system. Inputs from the local stakeholders were used for the refinement. The digital media were designed to provide information on rice productivity for each climate type within the Subang District under current and future climate change scenarios. Thus, the users do not need to deal with the complexity of crop model simulation and analysis.

Modules for learning materials to support the use of the climate driven tools were included in the digital media. The modules were designed to explain steps by steps of utilization the climatic driven tools. The modules were written by considering inputs from the Tim Iklim and the other relevant stakeholders. The FGDs, workshops, and/or consultation meetings were conducted to gather inputs for writing the learning materials. A video of the project activities were also produced as a media campaign to raise awareness of the needs for managing climate change risks on rice production.

3.3 The Field Experimental Showcase (Demonstration Plot)

The project team accompanied by Tim Iklim and farmers' group selected farm fields operated by farmers to exhibit the practicing of climate smart actions as a showcase. Learning from the crop model simulation, the project team together with the Tim Iklim and farmers decided the best possible farming practices for managing climate risks in the targeted area. Concerning the budgets and allocated time, we selected five locations (with support from the local government of Subang and/or farmers' groups) for the demoplots. The locations are the sub-districts of Binong, Purwadadi, Pamanukan, Pagaden and Cijambe. In the demoplot area, the mechanism of "Saung Iklim" were tested by allowing farmers, extension workers, and the other parties to explore any issues related to rice farming activities. The demoplots were also introduced to the students of Department of Geophysics and Meteorology as part of the recent program installed by the Bogor Agricultural University to send students to do field practices named Kuliah Kerja Nyata (KKN) – Community Service Program.

3.4 The Digital Reporting System

The web-based system was deployed to allow for an online survey. The survey form consists of problems and strategies associated with crop production in Subang. The digital reporting system were developed using available freely-tools over the Internet and web-based programming. The survey system can provide information on issues reported by users for each area within the Subang district. As the system is developed on-line, the system can be further developed for users in the other areas. The plan to have the off-line and on-line toolkits as well as the survey system (web-based) was directed so that users can use the developed tools after the project ends. The BP4D and Agricultural Agency, are the main partner to direct for utilizing the system in Subang district.

3.5 The Lesson-Learnt through stakeholders engagement

The engagement is designed as capacity building programs through focus group discussion; workshop and training through a systematic approach named "Saung Iklim" (field communication sharing mechanism) in the demo plot. The engagement will be coordinated by the Tim Iklim to involve government officers, extension workers, farmers' groups and local scientists. We proposed the mechanism as one-shot workshop or training may not provide 'real impact' on the targeted beneficiaries. The Tim Iklim as mandated by the Regent Decree of Subang No. 600/Kep.251-BP4D/2017 is the forefront that is assigned to address climate change issues in the district. As case study, the Tim Iklim managed Saung Iklim as a sharing media to discuss issues on rice production with the purpose of enhancing farmers' capacity in managing climate risks. The project team also deployed dedicated observers for the demo plot as the 'laboratory' of the engagements, in addition a series of FGDs, workshops, meetings, and field visits.

The project team already discussed with the local government represented by the BP4D as the member of this project team on utilizing the local government or our university website to store the developed web-based toolkits and The other materials resulted from the projects. The web-based system is now available on www.piarea.co.id/timiklim. This approach is to maintain the availability and accessibility of the developed learning tools after the project ends.

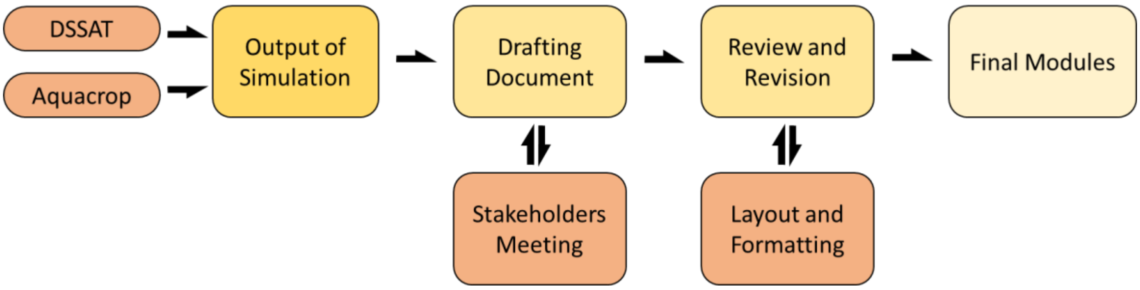
Project Outputs

4.1 Utilization of Crop Simulation Models

4.6.1 4.1.1 The Development of Learning Modules

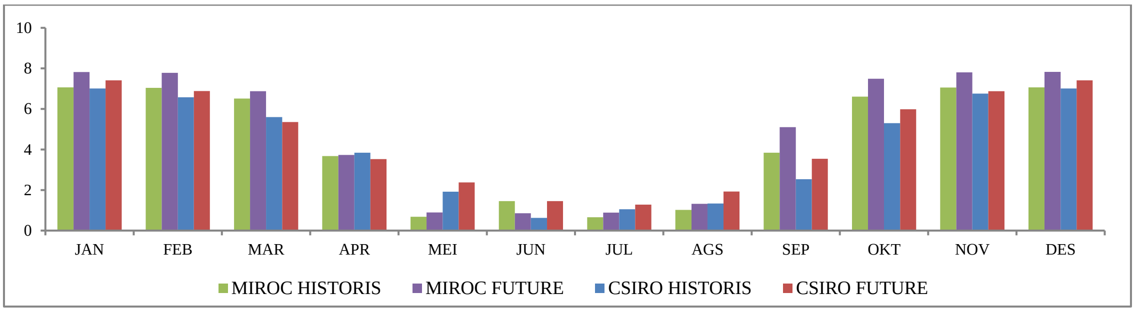
In essence, crop simulation model can help farmers to manage climate risks. However, the complexity of simulating the computer-based tools may cause difficulty to the end-users and farmers. Therefore, we trained the Tim Iklim and farmers' leaders to utilize two crop simulation models, Aqua Crop and DSSAT. Two modules were then developed as a reference for the users. The modules explain steps by steps on how to simulate rice production using the Aqua Crop and the DSSAT models. Understanding the local capacity should be considered when developing the modules, the following steps were taken. The step was started from crop model (DSSAT, Aquacrop) simulation, training the models to users, consultation meetings, and review/revision. The stakeholders' meetings were conducted to gather users' experience and inputs to finalize the modules (Figure 1).

Figure 1 Steps to produce the learning modules

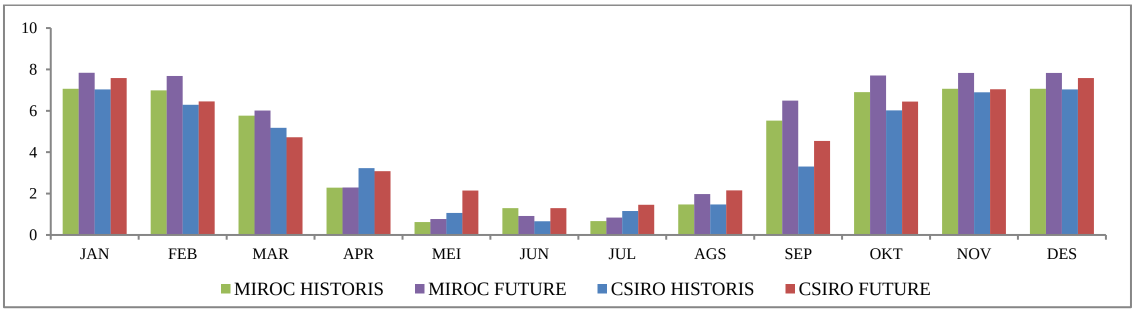


4.6.2 4.1.2 Crop Simulation Model Outputs

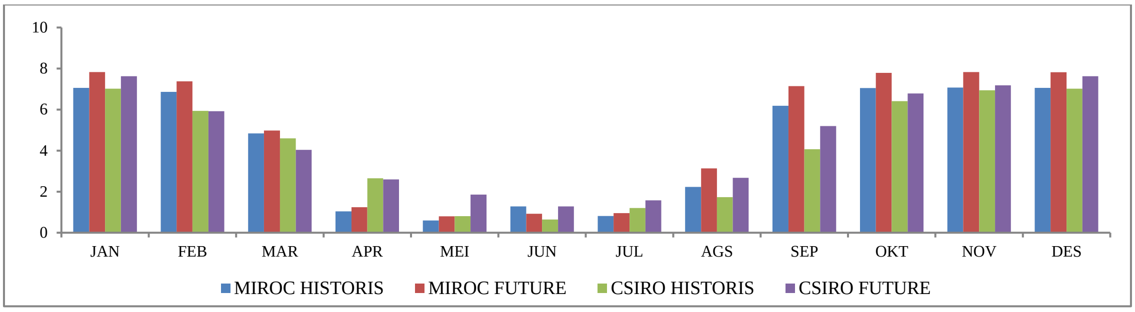
The learning module is directed to help users in understanding on how to utilize crop models such as Aqua Crop and DSSAT. The project team installed and run the Aquacrop and DSSAT to learn the impacts of climate fluctuations on crop growth and development. The graphs and table below are the examples of simulations for rice productivity delivered using Aquacrop model (Figure 2) and DSSAT model (Table 1). The details of crop model simulation is specified in Appendix A.



(a)



(b)



(c)

Figure 2 Average monthly rice productivity of baseline period (1986-2015) and future period (2021-2050) in cluster 1 during (a) Dekad 1, (b) Dekad 2, (c) Dekad 3 in rainfed crop area

Figure 2 shows the average monthly rice productivity of baseline period (1986-2015) and future period (2021-2050) in cluster 1 during dasarian 1, 2, and 3 in rainfed crop area. The three dasarians productivity has a similarity with the monthly rainfall pattern in Subang. The highest average potential rice productivity are in in the planting windows of Oktober – January, following the rainy season. The average potential rice productivity in the the first dasarian varies between 0,6 - 7,1 tons/ha for the baseline period, whereas, The productivity for the future period varies between 1,3 – 7,8 tons/ha. In the second dasarian, the average rice productivity varies between 0,6 – 7.1 tons/ha for the baseline and 0,8 – 7,8 tons/ha for the future period.

Table 1 shows the comparison of rice productivity and biomass on the five (5) demoplot locations with 4 different treatments for 1 growing season based on the outputs of DSSAT. The cropping area where irrigation and fertilizer are provided for the development and growth of the crop, the highest rice productivity falls on Binong by 8,5 tons/ha. The results matched with the field observation in Binong, which also has the highest rice productivity by 9 tons/ha. In the area without irrigation and fertilizer, Cijambe has the highest rice productivity by 1 ton/ha. In the area without irrigation only, Cijambe has the highest rice productivity by 4,6 tons/ha. The simulation results relatively suit well with the field observations. Cijambe is located in the highest elevation area compared to the other four sub-districts (Pamanukan, Pagaden, Binong, and Purwadadi) and irrigation is not needed considering the high precipitation in the first growing season (Oktober – Maret) and the location is near the water springs. In the area without fertilizer only, Purwadadi has the highest rice productivity compared to the other 4 areas. As this part is only to show how the computer simulation model can mimic the real word situations as inputs for development of the learning modules, interested readers can refer to Appendix A for more details on the crop model simulations.

Table 1 Comparisons of rice productivities and biomasses in 5 different locations

Variables	**With Irrigation and with Fertilizer**					**Without irrigation and without fertilizer**				
	Pamanukan	**Cijambe**	**Binong**	**Pagaden**	**Purwadadi**	**Pamanukan**	**Cijambe**	**Binong**	**Pagaden**	**Purwadadi**
Leaf biomass (kg/ha)	3224	2785	4067	4954	5503	345	332	337	528	530
Stem biomass (kg/ha)	2816	4375	3121	5466	4918	1291	876	579	940	931
Root biomass (kg/ha)	1518	1400	1869	1898	1977	261	274	152	219	206
Grain biomass (kg/ha)	6561	4526	8467	5412	6153	773	1040	290	273	238
Productivity (kg/ha)	6561	4526	**8467**	5412	6153	773	**1040**	290	273	238
Variables	**Without irrigation and with fertilizer**					**Without fertilizer and with irrigation**				
	Pamanukan	**Cijambe**	**Binong**	**Pagaden**	**Purwadadi**	**Pamanukan**	**Cijambe**	**Binong**	**Pagaden**	**Purwadadi**
Leaf biomass (kg/ha)	369	2845	879	950	1065	795	305	746	767	773
Stem biomass (kg/ha)	1491	4426	1342	1922	1790	2414	881	608	1058	463
Root biomass (kg/ha)	314	1419	1457	627	638	508	262	469	456	427

Grain biomass (kg/ha)	1023	4582	306	2117	2144	1564	1008	1503	1937	2210
Productivity (kg/ha)	1023	**4582**	306	2117	2144	1564	1008	1503	1937	**2210**

4.1.3 Drafting Modules

The drafting process involves translating the process of simulation using Aquacrop and DSSAT until the outputs are obtained into training modules. After making sure that the simulations using Aquacrop and DSSAT were successful (Figure 1 and Table 1), the modules were being drafted by team of experts and assistants. The drafting processes were divided in two times, the first time was for Aquacrop model in February 2019 and the second time was for DSSAT Model in July 2019.

4.1.4 Stakeholders' Meeting

After the drafting progress were done, the first stakeholders' meeting was held on October 22nd, 2018 at BPP Office Binong Sub-district, Subang District, West Java to determine the needs of information on rice productivity estimation in response to climate changes. The meeting was also held to determine what Tim Iklim needed to enhance the agricultural activities in Subang. After the first stakeholders' meeting, internal meeting was held on January 10th, 2019 at PSB Office, IPB, Bogor City, West Java. The internal meeting was held to determine the lists of training that are going to be held in Subang related to the estimation of rice productivity. Based on the internal meeting, it was decided that there would be two trainings that were going to be held in Subang, consisted of Aquacrop training and DSSAT training. The Aquacrop training was held on February 14-15th, 2019 at Fave Hotel, Subang District, West Java. The training was attended by 25 people and was held for two days. The training on the first day aimed to introduce the utilization of Aquacrop model in farming-practices and how to utilize it using climate data, soil properties, crop characteristics, and crop management (irrigation). The training on the second day aimed to analyze the response of rice productivity estimation after climate changes. The DSSAT training was held on July 11st-12nd, 2019 at Fave Hotel, Subang District, West Java at the same time with AUTP training. The training was attended by 25 people consisted of government officers, stakeholders, the students of Subang University, the team of experts, and assistants. The training on the first day aimed to introduce the utilization of DSSAT model and the importance of DSSAT model in farming-practices. The training on the second day aimed to introduce the utilization of AUTP.

4.1.5 Review and Revision

The team of experts and assistants revised the modules based on the review and revision that were being given at the stakeholders' meeting. A module is considered successful if the stated learning outcomes or objectives align with the activities. Both of the modules are designed to make the user especially farmers comprehend the progress to simulate rice productivity using either Aquacrop or DSSAT model. After going through review and revision

4.1.6 Layout and Formatting

A layout is a rudimentary setting up of the modules for print. After going through review and revision, the team of experts and assistants set up the layout to conform a particular size, spread, or layout for the modules. Formatting involves selecting the type for the text, setting line spacing, specifying spacing, and assigning styles to various elements to make the modules more legible and appealing.

4.1.7 Final Modules

The list of final modules are below:

1. Training Module of Tim Iklim for Agricultural Extension Workers
2. Training Module of Tim Iklim for Association of Farmers
3. Training Module for Predicting Rice Productivity using Aquacrop Model
4. Training Module for Predicting Rice Productivity using DSSAT Model
5. Observation Module of Paddy's Phenology, Climate Variable (rainfall, air temperature, air humidity, and evapotranspiration), and Plant Pests
6. Utilization Module of Website and Web-Tools Tim Iklim, consisted of:
    - Prediction of Rice Productivity Based on Climate Variability and Climate Changes

- Analysis of Rice Plant Business – AUTP Calculator
- Survey of Agricultural Conditions and Problems
- Tim Iklim Communication Forum
- Report of Activity and Simulation Results

All modules are available on Appendix C (can be accessed at https://pi-dev.co.id/timiklim/)

4.2 Computer Assisted Climatic Driven Tools

4.6.3 Development of Website Tim Iklim

The "Tim Iklim" web is an information media that functions as a disseminator of information and a media for exchanging ideas between teams. The Tim Iklim website contains general explanations related to the activities carried out by the Tim Iklim such as team background, team activities, training modules, and agricultural simulation applications. The development of this website is based on the needs of the Tim Iklim in terms of the dissemination of information, especially from the government in Subang Regency, represented by BP4D Subang Regency Economic Section, Subang Regency Agriculture Office with agricultural extension workers and farmer group associations (Gapoktan) in all districts in Subang Regency. So far, climate information is not the main reference in agricultural activities, but it cannot be denied that the failure of agricultural activities in Subang is mostly caused by these climatic conditions. Therefore, we need media that contain agricultural information related to climate. Currently, climate information on agriculture can be accessed on the Tim Iklim website, where this information can be utilized by agricultural actors in Subang to be able to increase their agricultural productivity.

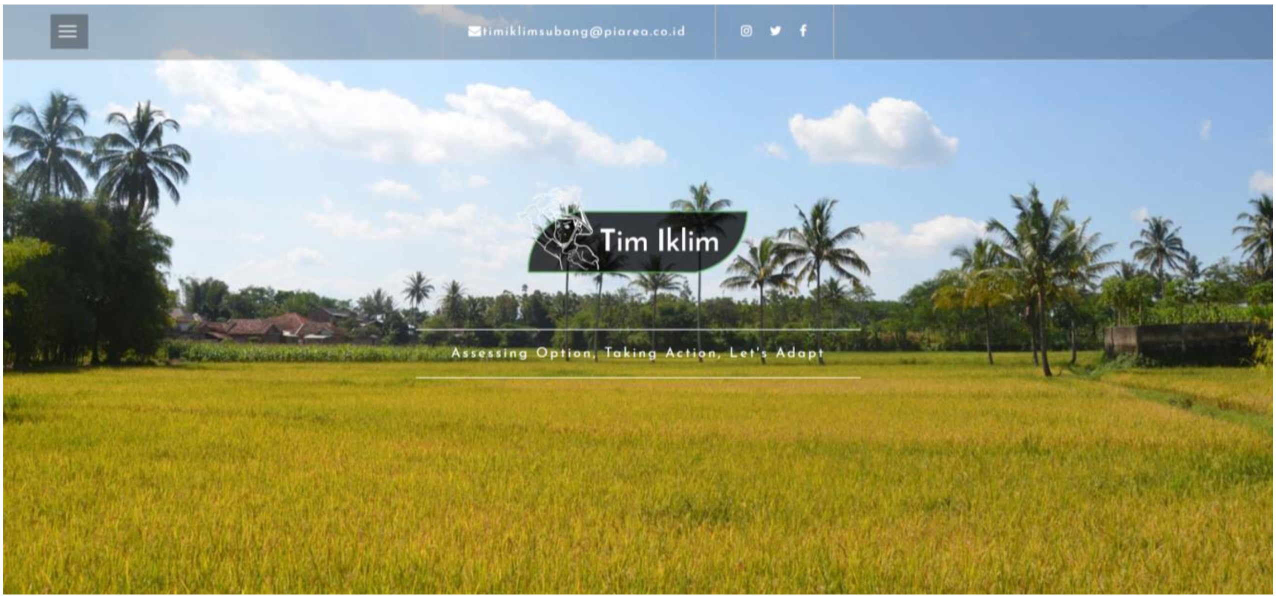


Figure 3 The main page of the Tim Iklim website (Source: http://piarea.co.id/timiklim)

The Tim Iklim website can be accessed via the link http://piarea.co.id/timiklim. This website consists of several menus consisting of background activities of the Tim Iklim, Tim Iklim programs, innovations and products produced by the Tim Iklim, galleries and publications. In the background section on the activities of the Tim Iklim, explains the background of community capacity building activities in Subang, especially agricultural activities that pay attention to climate information as a form of adaptation to climate change. The Tim Iklim program section, describes the activities carried out by the team. In the innovation and product section, this section is the main part of the Tim Iklim website which contains a climate based agriculture simulation system based on Aquacrop and DSSAT agricultural simulation results, a decision letter on the formation of a Tim Iklim in Subang, training modules, agricultural impact surveys, and product reports Tim Iklim activities. The gallery section contains photos of the Tim Iklim's activities while carrying out activities in Subang. The last part is publication, providing the results of scientific publications from studies and research conducted in Subang.

4.6.4 Online Module

The module was made to be a reference and guide in the implementation of climate-based agricultural activities in Subang Regency. Various modules have been made, from guidelines for implementing climate-based agricultural activities to training in the use of agricultural simulation software, which is one of the supports in increasing the capacity of farmers and extension workers. The module is then converted into a digital form and can be read directly through the Climate Team website, so that it is hoped that the module available online will make it easier for users to read the module. Besides being read directly on the website, the module can also be downloaded, so users can print the module. All modules that have been created in this activity can be accessed through the Climate Team website in the Innovations & Products section of the Modules sub-menu.

4.6.5 Simulation of Aquacrop and DSSAT Model through the Online System

Simulation of the agricultural model is used to estimate the value of rice productivity based on climate information. The simulation is done using two software tools, namely Aquacrop and DSSAT. Both software uses climate information in the form of rainfall, maximum temperature, minimum temperature, evapotranspiration, solar radiation, and the level of carbon concentration in the air. Specifically Aquacrop software simulates using the principle of water availability, so that irrigation and soil data become additional data needed. Slightly different, for DSSAT software uses more detailed information that is irrigation data, soil, and fertilizer application. Both software will both predict the productivity value of rice according to the data input. The use of the two software is considered too complicated for agricultural instructors, so we need a system that is easier to use but can provide the same information as the results of the simulation of the two software. An online simulation system was made based on Aquacrop and DSSAT simulation outputs.

The online simulation system is a simplification of simulations performed by Aquacrop and DSSAT software. Online simulations require some information before releasing the results of predictions of the value of rice production. The information needed is in the form of:

a. Regional climate cluster information
In this section, the user will choose the type of climate cluster based on the information contained in the map section (Figure 1). The entire area of Subang Regency has been divided into 5 climate clusters namely JanSep, JanAgu, DesSep, MarSep, and DesAgu clusters. The cluster is divided based on the highest and lowest rainfall values in the past 30 years. The user chooses climate clusters according to the location of the fields to be simulated.

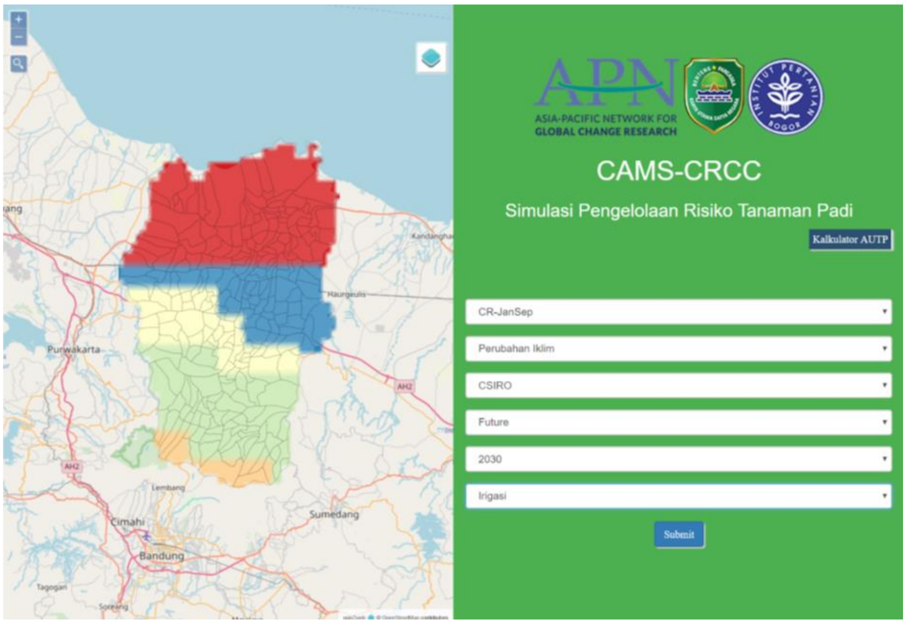
b. Climatic Conditions
In this section, the user chooses climate conditions which are divided into two conditions namely Climate Change and Climate Variability. Climate change divides the simulation into current and future conditions, while climate variability divides the simulation into three conditions namely El Nino, La Nina, and Normal.

c. Model Data
Specifically for climate change conditions, users need to choose the model used. There are two models available, namely CSIRO and MIROC.

d. Data Period and Year
As explained in point b, for climate change conditions the user needs to choose a data period which is divided into two periods, namely Baseline and Future. After selecting the data period, a data year list will appear that can be selected, for the Baseline period the data year has a range between 1986 and 2015 while for the Future period, the data has a range between 2020 and 2050.

e. Type of irrigation
The last part is the selection of behavior in the rice fields, which consists of two choices, irrigation and without irrigation.

The online simulations can be found in the Climate Team Website and Web-Tools training module (can be accessed at https://pi-dev.co.id/timiklim/).



CAMS-CRCC

Simulasi Pengelolaan Risiko Tanaman Padi

CR-JanSep

Perubahan Iklim

CSIRO

Future

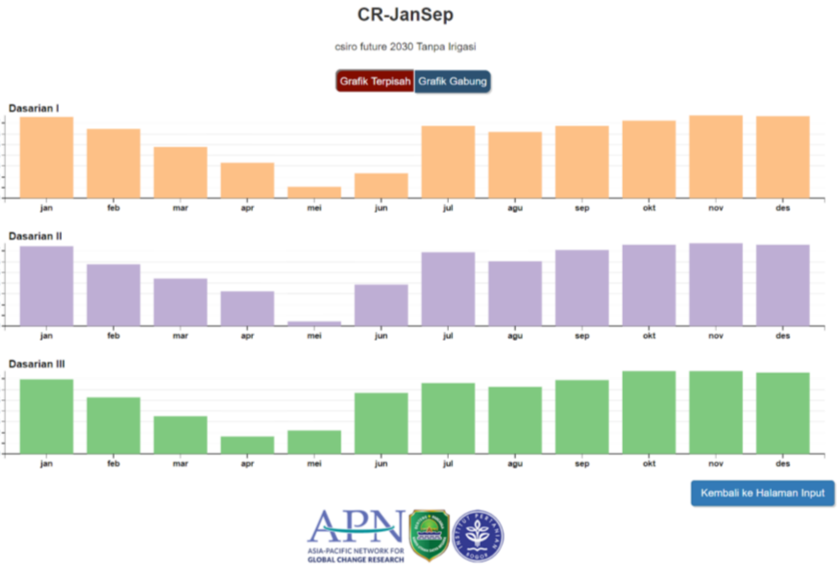
2030

Irigasi

Figure 4 Website appearance simulating paddy productivity using the Aquacrop model

(Source: http://piarea.co.id/timiklim/apnTools)

The simulation results to be released by the system will be in the form of a graph of rice production value as shown in Figure 4. The graph is divided into three dekads, dekad I has a date range of 1 to 10, dekad II has a range of dates 11 to 20, and dekad III has a date range 21 to the end of the month. The Dekad signifies the time of planting rice and the results that can be obtained if planting on that date. Users can see the results of production separately using the "Grafik Terpisah" or can be compared using the "Grafik Gabung".



CR-JanSep

csiro future 2030 Tanpa Irigasi

Figure 5 Graph of rice productivity based on simulation using the Aquacrop Model

4.6.6 Training and Testing Online System

To ensure the Climate Team website system can be used properly, a training program was held to use the system. In addition to training the team, the training is also used to test the system, to find various deficiencies and errors that exist. All forms of system deficiencies and errors will then be corrected and refined so that the system can run better. The training was held twice, on July 12, 2019 and on August 15, 2019 with participants in agricultural extension, the Subang District Agriculture Service, a joint farmer group, Subang University, and the Subang Regency BP4D. The first training (July 12, 2019), taught participants how to use the online simulation system, in the form of how to enter information and interpret the results of the simulation. From the results of the training, suggestions were obtained in the form of adding information about changes in the productivity value of rice plants in the future period and adding information in the form of irrigation use. The second training (August 15, 2019), participants practiced the results of the previous training and presented the results of the online simulation. The final stage in testing an online simulation system is to look for errors in the system. To ensure the system runs well, various combinations of simulation inputs are tried to see if there is an error in the system. After all combinations have been tested and there are no errors, the simulation system can already be used by users in conducting prediction simulations of rice production in Subang Regency.

4.7 The Field Experimental Showcase

4.7.1 Field Observation

a. Determination of Observation Location

Determination of the location of the demonstration plot was carried out by conducting a field survey in Subang District conducted from September 2019 to December 2019. The survey was conducted to determine the location of the demonstration plot, taking into account the location (Lowland and Plateau), climate conditions, and characteristics of rice plants. Based on the results of the survey, set 5 locations for demonstration plots, namely Pamanukan, Binong, Pagaden, Purwadadi (locations in the lowlands) and Cijambe (locations in the highlands). In addition to determining the location of the demonstration plot, coordination was also conducted with agricultural instructors and farmer groups combined at each demonstration site. This coordination is to provide preliminary information about the purpose of the demonstration plot. The preparation of observation tools and various components of observation are carried out to facilitate the observation. Placement of a simple weather station at the location of the demonstration plot is made to facilitate the observation of climate variables, so that climate information can be collected properly.

b. ***Observation of Plant Phenology, Climate Variables, and Plant Pests***

Observations were carried out on January 18th – May 10th, 2019 in 5 different locations. The locations are consisted of Cijambe, Pamanukan, Pagaden, Purwadadi, and Binong. The field observations were done to calibrate and validate the results of DSSAT model with the actual events in the field. Observations were made of the team of experts accompanied by 1 farmer from each demonstration plots. The area of demonstrations plot is 0,2 Ha in Pamanukan, 0,35 Ha in Binong, 0,13 Ha in Pagaden, 0,1173 Ha in Purwadadi, and 0,3038 in Cijambe.

4.7.2 Climatic Zone

According to the research of Nurhasanah (2017) in analysing the climate zones in Subang based on the type of rainfall patterns, there are 7 clusters in Subang. The demonstration plot in Pamanukan is classified into cluster 1 which hit the the peak of wet season in January and has the smallest amount of rainfall during the dry season in JJA. The demonstration plot in Binong is classified into cluster 2 which has the similar rainfall pattern with cluster 1 with the difference in dry season that have more amount of rainfall than the cluster 1. The demonstration plot in Purwadadi is classified into cluster 3 which hit the peak of wet season on January and the peak of dry season on JJA. The demonstration plots in Pagaden and Cijambe are classified into cluster 4 which has the similar rainfall pattern with cluster 3 but has the smaller amount of rainfall during dry season compared to cluster 3.

4.7.3 Observation methods for the Parameters

The field observations were done to observe climate, crop phenology, and irrigation. The climate parameters observed in this research are rainfall, air temperature, air humidity, and evapotranspiration. The rainfall data was taken with a simple rain gauge measured for 2 days. The air temperature was measured using thermometer every day. The air humidity was measured with a wet and dry bulb thermometer and then a calculation was made. The evapotranspiration was observed using paint cans and plastic bottles, the plant samples are taken on paint cans and weighed for 2 days.

The phenology parameters in this research are plant height and tillers. The plant height and tillers were measured sing tape measurement and calculators once a week in the vegetative phase and 4 days in generative phase. The irrigation parameter observed in this research was soil water level. The soil water level was measured by tape measurement following the phenological measurement. The observation method for each parameter can be seen in Table 2 and the summary of observation results can be seen in Table 3.

Table 2 Observation methods used for collecting climate, crop phenology, and irrigation data

No	Data	Parameter	Observation Method	Tools
1	Climate	1. Rainfall 2. Air temperature 3. air humidity 4. evapotranspiration	1. Rainfall data is taken with a simple rain gauge measured 2 days 2. Measured using a thermometer every day 3. Measured with a wet ball and dry ball thermometer then a calculation is made 4. Plant samples are taken on paint cans and weighed 2 days	1. Simple Rain Gauge 2. Wet and dry bulb thermometer 3 Digital scales 4. Paint cans and plastic bottles
2	Phenology	Plant height and tillers	Measured using tape measurement and calculators once a week in the vegetative phase and 4 days in the generative phase	1. tape measurements 2. calculator
3	Irrigation	Soil water level	Measured by tape measurement following phenological measurements	1. tape measurement

Table 3 Summary observation results

Demoplot (Varietas)	Variabel						Productivity (ton/ha)*
	T Average (°C)*	Rainfall (mm)*	RH (%) **	Tillers (stem) *	Plant Height (cm)*	Water Requirement (mm)**	
Binong (Ketan)	29	600	86	38	123	1134	9
Purwadadi (Inpari 32)	28	536	88	29	112	897	7
Pamanukan (IR42)	29	633	87	49	140	1242	6
Pagaden (Tarabas)	31	542	84	24	134	1216.	7
Cijambe (IR64 Jumbo)	25	971	85	30	104	690	4

Note: *Field Observation from January to May 2019; **Result of analysis

The rice productivity in five demonstration plots both from observation and DSSAT simulation are relatively close. The validation of rice productivity using cultivar IR64 in Cijambe and IR42 in Pamanukan, Pagaden, Purwadari, and Binong from the models and field observation can be seen in Table 4.

Table 4 Validation of rice productivity

Demonstration plots	DSSAT	Field observation
Pamanukan	6,6 ton/ha	6 ton/ha
Cijambe	4,5 ton/ha	4 ton/ha
Pagaden	5,4 ton/ha	7 ton/ha
Purwadadi	6,2 ton/ha	7,2 ton/ha
Binong	8,5 ton/ha	9 ton/ha

DSSAT simulations on demonstration plot in Cijambe using IR64 planted on January 9th, 2019 with irrigation and fertilizer provided for the crop produced rice productivity by 4,5 tons/ha, closed with the observed rice productivity in the field which is 4 tons/ha. The simulation in Pamanukan using IR42 planted on December 31, 2017 with irrigation and fertilizer provided produced productivity by 6,6 tons/ha, while the observed rice productivity in the field is 6 tons/ha. The simulation in Pagaden using IR42 planted on January 15th, 2019 with irrigation and fertilizer provided produced productivity by 5,4 tons/ha, while the observed rice productivity in the field is 7 tons/ha. The simulation in Purwadadi using IR42 planted on January 15th, 2019 with irrigation and fertilizer provided produced productivity by 6,2 tons/ha, while the observed rice productivity in the field is 7,2 tons/ha. The simulation in Binong using IR42 planted on December 24 th, 2019 with irrigation and fertilizer provided for the crop produced rice productivity by 8,5 tons/ha, while the observed rice productivity in the field is 9 tons/ha.

According to Suprihatno et al. (2009), IR64 and IR42 produced the average rice productivity of 5 tons/ha, so the simulation results using DSSAT model in Cijambe and Pagaden could represent the actual rice productivity in the field. The various productivity is caused by the differences in temperature, altitude, soil, water, fertlizer application, cultivars, and planting dates in the five demonstration plots which affect the result of simulation. The altitude of the location is also a factor that determines rice productivity. Demonstration plot in Cijambe is located in the altitude of 648 meters above sea level which tends to have low rice productivity. The altitude of the location is one of the climate control factors that has a strong influence on air temperature. The air temperature affect the speed of metabolism, especially photosynthesis and respiration. The demonstration plot in Pamanukan, Pagaden, Purwadadi, and Binong are located in the altitude under 100 meters above sea level. The rice productivity tends to be high in there because the intensive maintenance in the demonstration plots such as adequate fertilizer and irrigation despite the low rainfall during the simulation. In addition to the altitude and air temperature factor, the differences in cultivars between IR64 and IR42 also contributed to the rice productivity. The age of IR64 according to Suprihatno et. al (2009) is 110-120, while the IR42 is 135-145 days. This results in the difference in plant biomasses where the biomass of IR42 is higher along with the longer age of the plant, so the rice productivity in Pamanukan, Pagaden, Binong, and Purwadadi is also higher than the biomasses of IR64 rice plant in Cijambe.

4.8 The Digital Reporting System for Data Collection

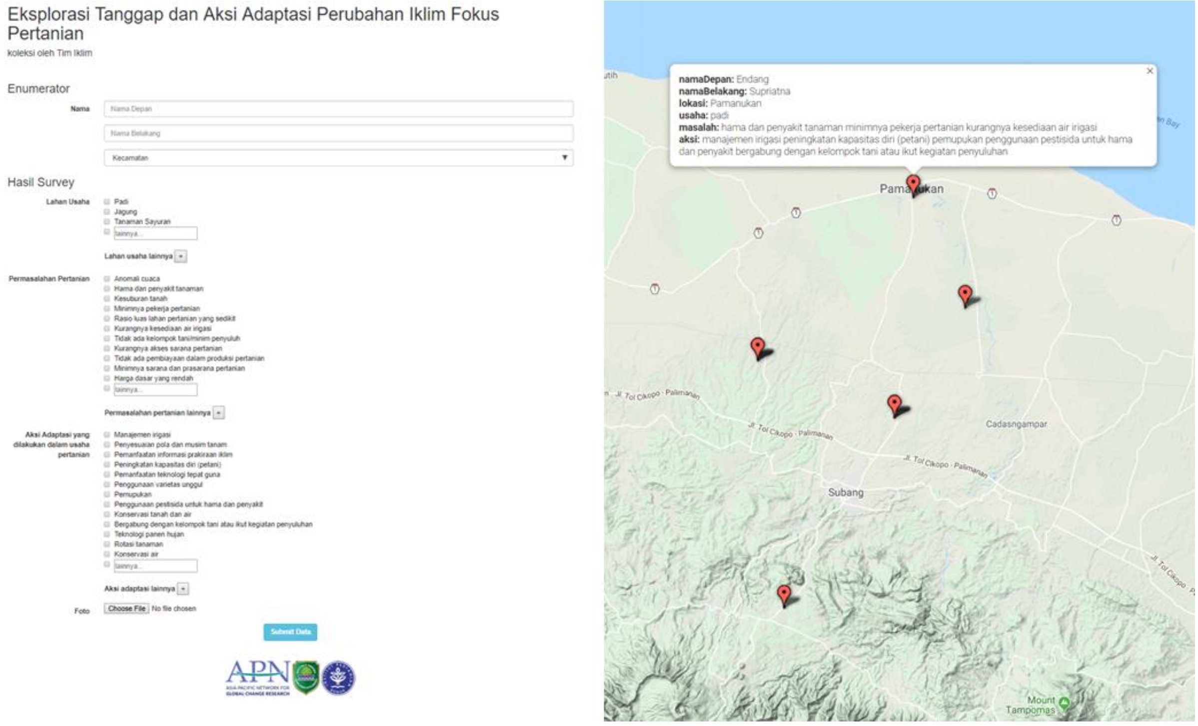
4.8.1 Development of Digital Reporting System

Supporting agricultural extension activities and monitoring of online activities requires an online reporting system related to agricultural constraints and problems faced by farmers in the field. The reporting system is formed in an online system so that information can be quickly received and can be responded to quickly by relevant agencies. In addition, with the online reporting system, a database can be made related to various agricultural constraints and problems that occur, so that various adaptation options that are appropriate for these problems can be formed. This reporting system is used by agriculture instructors and farmers to make reports, and incoming reports are received directly by the relevant agencies (example: the agriculture department) and the Subang Regency BP4D. All incoming reports can be directly responded by related agencies by providing various solutions that can solve existing problems.

Maximizing online reporting systems, guidelines for using the system are made. The making of this manual is intended for system users as a guide and procedure for using the system. In addition to the manual, to maximize the online reporting system, training in the use of the system was provided to the entire Climate Team consisting of the Association of Farmers Groups, Agricultural Extension Workers, Agricultural Services, University, and Subang Regency BP4D. This training is intended to provide practices for making reports online, to display the results of these reports in the form of digital maps. The digital map contains information on the results of the reporting, which consists of location information, obstacles and problems encountered and the adaptation measures that have been taken.

4.8.2 Online Survey System

One of the forms of online reporting system is an online survey system. The survey was conducted in the form of an online survey system that is integrated with the website system. This system can be accessed using a computer and also an android, making it easier for users to conduct surveys. This survey contains survey locations, types of plants, climate impacts on agriculture, and adaptation actions taken to deal with these impacts. All survey results will be stored in a database so that incoming data will be stored and can be processed for other needs. One form of processing database survey results in the form of making an interactive map of the survey location. The map displays the results of the survey in the form of an online map that contains locations as well as information on the results of the survey such as the impact of agriculture and adaptation measures taken (Figure 5). The interactive map can also be used by the government to see the location of agriculture affected by climate constraints. Actions taken can be compiled and used as a reference for use in other locations with the same agricultural impact. Thus, the exchange of information and handling the impact of agriculture due to climate change can be resolved properly in terms of government assistance and disaster response by these farmers.

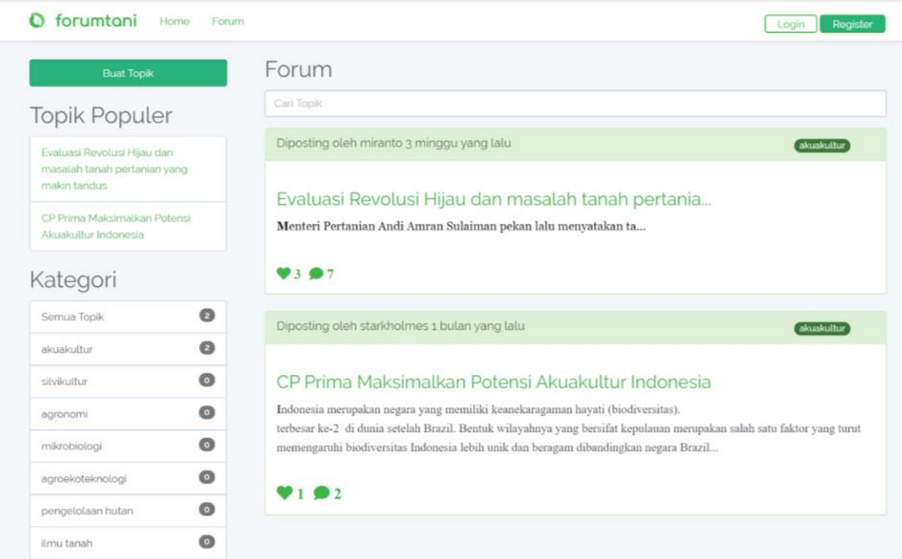


namaDepan: Endang
namaBelakang: Supriatna
lokasi: Pamanukan
usaha: padi
masalah: hama dan penyakit tanaman minimnya pekerja pertanian kurangnya kesediaan air irigasi
aksi: manajemen irigasi peningkatan kapasitas diri (petani) pemupukan penggunaan pestisida untuk hama dan penyakit bergabung dengan kelompok tani atau ikut kegiatan penyuluhan

Figure 6 Online survey system and map displays of result survey

4.8.3 Forum for Farmers System (ForumTani)

ForumTani is a communication system in the form of an online discussion forum, which provides a place to exchange information based on specific topics related to the impact of climate change in agriculture. In this forum, users can inform various things related to the impact of agricultural climate change, and other users can provide comments in the form of available information. Forum topics are created with a categorization system, which makes it easy for users to find information related to a particular topic. There is also a topic search system, so users can easily search for all topics in the discussion forum in accordance with the keywords entered by the user. The forum is expected to be a place for literacy in various agricultural issues related to climate change. Researchers and government institutions have access to provide input and responses to existing problem topics, so that synergies occur in dealing with the impacts of climate change in agriculture.



Evaluasi Revolusi Hijau dan masalah tanah pertanian yang makin tandus

CP Prima Maksimalkan Potensi Akuakultur Indonesia

Kategori	
Semua Topik	2
akuakultur	2
silvikultur	0
agronomi	0
mikrobiologi	0
agroekoteknologi	0
pengelolaan hutan	0
ilmu tanah	0

Diposting oleh miranto 3 minggu yang lalu

Evaluasi Revolusi Hijau dan masalah tanah pertania...

Menteri Pertanian Andi Amran Sulaiman pekan lalu menyatakan ta...

♥ 3 💬 7

Diposting oleh starkholmes 1 bulan yang lalu

CP Prima Maksimalkan Potensi Akuakultur Indonesia

Indonesia merupakan negara yang memiliki keanekaragaman hayati (biodiversitas).
terbesar ke-2 di dunia setelah Brazil. Bentuk wilayahnya yang bersifat kepulauan merupakan salah satu faktor yang turut memengaruhi biodiversitas Indonesia lebih unik dan beragam dibandingkan negara Brazil...

♥ 1 💬 2

Figure 7 Online forum system for farmers (ForumTani)

4.8.4 Analysis of Rice Plant Business – AUTP Calculator

Net farm income or profit is the difference between farm income and total farm expenditure, including calculated costs such as labor costs and production facilities. To calculate the economic value of a rice crop business activity, an R / C ratio can be used. R / C stands for Return Cost Ratio. R / C Ratio analysis is used to compare revenues and costs. In agricultural activities the main expenditure is in the form of fulfillment of production facilities and labor, while for the main income from the rice crop itself. Based on these two information, the profit value of one rice planting season can be calculated.

Calculation of analysis of farming can be made in a simple tool in the form of a calculator. Users only need to enter information on production and labor costs as well as predictions of results that can be produced within one planting period. Then, the value of R / C from the results of the rice plant business will be generated. To facilitate the calculation of the analysis of the farming business, a website-based tool was made, the online AUTP calculator. This tool can calculate the amount of profits from farming with information that can be entered by the user. In this system there are two scenarios, namely manual and Jarwo Super. For manual scenarios, farmers can freely enter information on the number of production facilities and labor requirements and the prices of each component. As for Jarwo Super, information on the number of production facilities and labor needs has its own value that follows government regulations related to the Jarwo Super program. Users only need to enter price information from each of these components. Both of these scenarios will later produce R / C values based on information entered by the user. In full, the procedure for using the online AUTP calculator can be viewed on modules hat can be accessed at https://pi-dev.co.id/timiklim/.

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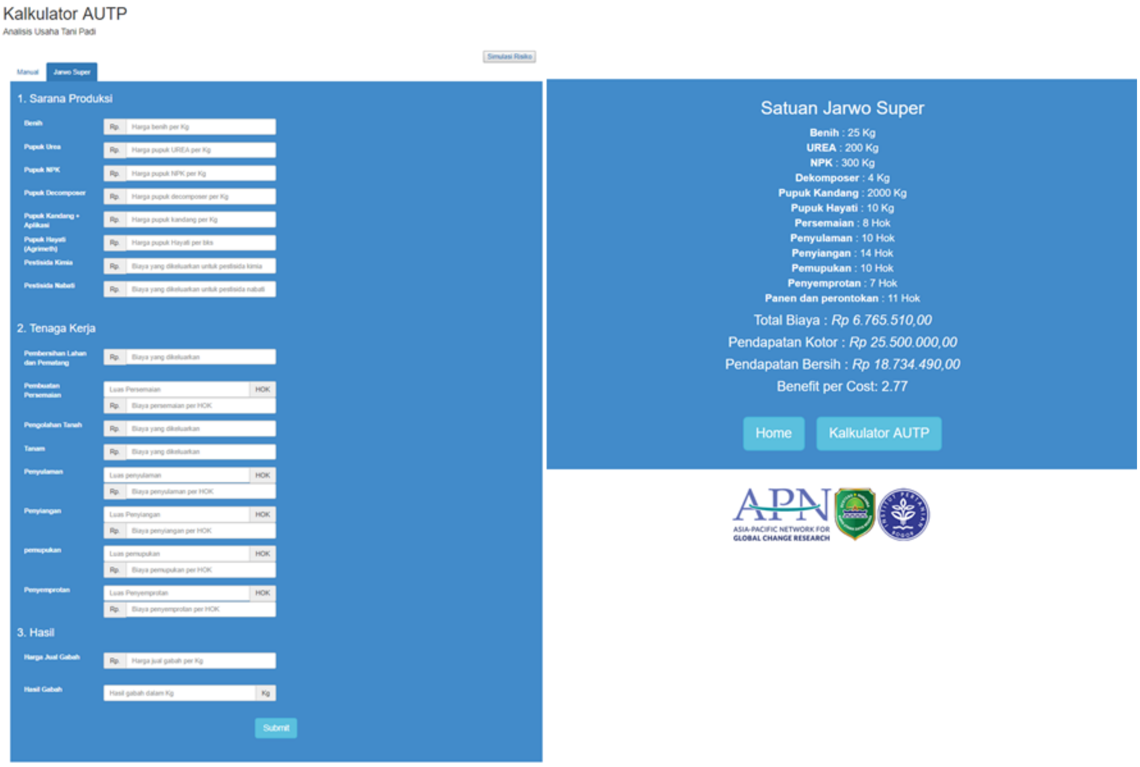

Satuan Jarwo Super

Benih : 25 Kg
UREA : 200 Kg
NPK : 300 Kg
Dekomposer : 4 Kg
Pupuk Kandang : 2000 Kg
Pupuk Hayati : 10 Kg
Persemaian : 8 Hok
Penyulaman : 10 Hok
Penyiangan : 14 Hok
Pemupukan : 10 Hok
Penyemprotan : 7 Hok
Panen dan perontokan : 11 Hok

Total Biaya : *Rp 6.765.510,00*
Pendapatan Kotor : *Rp 25.500.000,00*
Pendapatan Bersih : *Rp 18.734.490,00*
Benefit per Cost: 2.77

Figure 8 System analysis of rice plant business, input of analysis (left) and output of analysis (right)

In Figure 5, an example of the results of the calculation of rice farming analysis using the Jarwo Super scenario is shown. The number of production facility needs has followed the directions from the Jarwo Super program, so users only need to enter information related to prices. After all prices of each farm business need are entered, it will produce output in the form of Total Costs, Gross Income, Net Income and Benefit per Cost of the farm (Figure 5). From the example, it can be seen that the amount of costs needed for a planting period with an area of 1 hectare requires a total cost of Rp 6,765,510,- with a gross income of Rp. 25,500,000,- and a net income of Rp. 18,734,490,-. From the results of the rice farming it can be concluded that the comparison of benefits per cost is 2.77.

4.9 The Lesson-Learnt through stakeholders engagement

4.9.1 Stakeholders' Engagement

A series of activities on climate-based agricultural management strategies had been carried out well in Subang Districts, but the stakeholders' engagement is still needed to ensure the planning of the future climate-based agricultural activities. The Focus Group Discussion (FGC) were held to discuss the various achivements of the activities that had been carried out and plan the following activities in the future. Finalization of the modules that had been made by Tim Iklim were also discussed in the FGD. The FGD was held on August 15th, 2019 at Fave Hotel of Subang and on August 16th, 2019 in Bappeda of Bandung District.

4.9.2 Lesson-Learnt of Climate Smart Actions Based on Stakeholders Engagement

There are three activities discussed on the FGD consisted of the finalization of the modules, the climate information, and Tim Iklim websites. The targeted audiences are consisted of the agricultural extension workers, officers of Department of Agriculture, and students from universities. The targeted audiences were given questions below:

1. Are the available modules understandable enough?
2. Which parts of the modules that are easy to understand?
3. Which parts of the modules that are hard to understand?
4. What is the utilization of the modules in farming practices according to you?
5. Can you give us a review to improve the modules (structures, content, languages)?

The answers of the given question based on targeted audiences are that the modules are understandable enough. The part of modules which are easy to understand are the modules which is filled with pictures (agricultural tools), and the modules that are hard to understand are Aquacrop and DSSAT Training Modules. The modules are very helpful in planning management, monitoring, and evaluation of farming practices. Based on the answer of the targeted audiences, the modules will be more applicative if there are more examples and trainings. The structure of the modules are already good and complete, the contents are aligned with the needs, and the languages should be easier to understand.

The targeted audiences consisted of Gapoktan (Association of Farmers), extension workers, and sub-district officers were given questions below:

1. How is the availability of agricultural production facilities in the demonstration plot area? Are there any difficulties in supply? Is there government assistance?
2. Does the saprotan schedule followed the suggestion of agricultural extension workers?
3. Do you use the climate information for agricultural management?
4. Where did you get the climate information?
5. What are the main challenges in managing your farm land? Where do you report when you have a problem (example: pest attack, crop failure, collapse)?
6. Do you observe and record plant growth and development (number of tillers, flowering time, etc) and agricultural problems during the growing season?

The answers of the given questions to the targeted audiences are that the agricultural production facilities in the demonstration plot area are available and complete. There are no difficulties in the supply because the supply is available around the area. The government in Cijambe from agricultural officers such as seeds. The saprotan schedules followed the suggestion of agricultural extension workers through socialization and application. The audiences used the climate information because rice cultivation was affected by the climate very much. The climate information was obtained from KATAM, IPB, Department of Agriculture, and BMKG. The main challenges in managing farmland based on the answers of the targeted audiences were pests (POPT and PPL), and the problem was reported to the the markets (officers, collectors), and the capitals (bank). The plant growth and development are observed, recorded in the report, and documented in the video.

The first day of FGD was attended by the representatives of BP4D of Subang District, Officers of Agricultural Department, extension workers, farmer groups, and representatives of several sub-districts. The results of the disscussion were obtained that the Aquacrop, DSSAT, and AUTP modules provided were quite easy to understand and useful but should be given an easier explanation of the pictures and graphics contained in the modules to make it easier for the user to understand the modules. Based on the FGD, the farmers are currently utilizing climate information, considering that climate is affecting agricultural output. Challenges in agricultural activities in Subang District is pest (OPT) and weather and climate tools aren't yet available. Tim Iklim websites is considered useful for farming activities because the field conditions can be reported by the officers quickly and accurately. Currently there are too many applications that aren't utilized but will be integrated in the future so that the application can be more efficient and can be followed by the workers. The second day of FGD took place at BP4D Bandung as a continuation of the activities on the first day. The second day activity was filled with an explanation of the agriculture conditions in Subang District lately.

APPENDIX

4.10 APPENDIX A. Simulation of Paddy Productivity in Subang District

Introduction

Rice production is a vital contribution to the reduction of hunger and poverty in Indonesia. Rice has been the main staple food for the majority of people in Indonesia. The need of rice is increasing every year with the increasing rate of population. This leads to the high consumption of rice and shows how important rice production is to meet people's rice needs. Many households in Indonesia grow rice because rice-farming provides employment for many people and it can be the source of income for the people (Satria *et al.* 2017). Rice production in Indonesia can be seen from the harvested area and the average yield of rice per hectare or commonly called productivity. The development of rice harvest area in Indonesia in 1980 – 2016 shows a fluctuating pattern. The patterns tend to increase but has a relatively small growth rate of 1,48% per year (Kementan 2016). Rice production in Indonesia in 2015 was 75,4 tons (BPS 2015) with population at that time was 258,2 million people. Fluctuations in food availability, especially rice, are caused by climate variability (Hadija and Miriam 2015) and an increase in population.

Subang is the 3rd highest rice-producing center in West Java after Indramayu and Karawang, with rice production in 2015 was 1.028.009 tons (BPS West Java 2018). The cultivation of rice extends from uplands to lowlands in Subang Regency, West Java, Indonesia. Generally, rice productivity in Subang varies between 5,5 tons/ha and 6 tons/ha (Kementan 2015). Rice productivity based on Kementan (2015) showed a decreasing productivity by 8 % in 2010. The decreasing rice productivity can be affected by climate, soil conditions, crop management, and pests. Climate factors such as temperature, rainfall, atmospheric CO_2, and solar radiation affects rice production (Nyang'au *et al.* 2014). Among the climate factors, rainfall and temperature have the most effect to the rice productivity. The estimation of rice productivity is needed to ensure adequate food productivity in the future against climate change.

Crop simulation models can be used to estimate rice productivity. Crop simulations models can provide a quantitative tool for estimating rice productivity in relation to climate, soil, and crop management data. Crop simulation models have been widely used to assess the impact of climate change on agriculture and analyze adaptation strategies to reduce the negative impacts. In this report Aquacrop and DSSAT (Desicion Support System for Agrotechnology Transfer) were used to estimate rice productivity in Subang. Aquacrop model was used to estimate rice productivity in response to climate change, whereas DSSAT model was used to estimate rice productivity in Pamanukan, Binong, Purwadadi, Pagaden, and Cijambe for one planting season.

Materials and Method

Study Site

The simulation was divided into two areas. The first area was for Aquacrop simulation and the second one was for DSSAT simualtion. Aquacrop simulation was conducted in 5 clusters in Subang Regency, West Java, Indonesia, which is located at 6.3S latitude, 107.725W longitude for cluster 1, 6.75S latitude, 107.625W longitude for cluster 3, 6.5S latitude, 107.625W longitude for cluster 4, 6.7S latitude, 107.625W longitude for cluster 5, 6.5S latitude, 107.825W longitude for cluster 7. The field experiments for DSSAT simulation was conducted in 5 demplots in Pamanukan, Pagaden, Purwadadi, Binong, and Cijambe.

Meteorological and Soil Data

Aquacrop requires daily precipitation, maximum and minimum air temperature, reference evapotranspiration, and the mean annual carbon dioxide (CO2) concentration as standard weather inputs. Daily precipitation, maximum and minimum air temperature data were obtained from global climate model of MIROC and CSIRO for baseline period (1986-2015) and future period (2021-2050). The reference evapotranspiration (Eto) data was derived from weather station data using Penman-Monteith equation (Allen *et al.* 1998) and Eto calculator (FAO 2009) available in Aquacrop. The past and current mean annual carbon dioxide (CO2) concentration values are measured by the Mauna Loa Observatory in Hawaii and can be chosen by the user (Steduto *et al.* 2009). Soil properties for Aquacrop simulation are obtained from Subang Regency.

DSSAT requires daily precipitation, maximum and minimum air temperature, and solar radiation as standard weather inputs. Daily precipitation, maximum and minimum air temperature data are from observational data for 1 cultivationg season in five demplots in Pamanukan, Pagaden, Purwadari, Binong, and Cijambe, combined with corrected nasapower data. The solar radiation data is obtained from nasapower. Soil properties vary with depth. The soil samples are taken from five demplots and the information of soil properties are tested in ICBB (Indonesian Center for Biodiversity and Biotechnology).

Table 5 Soil properties of Subang District for Aquacrop's input

Soil type	**Thickness (m)**	**Soil Water Content (%)**			**Total Available Water**	**Saturated hydraulic conductivity (mm/d)**
		Saturation	**Field Capacity**	**PWP**		
Silt loam	0.15	38	16	8	80	800
Silt loam	0.15	38	16	8	80	800
Sandy clay loam	0.15	46	31	15	160	250
Sandy clay loam	0.15	46	31	15	160	250
Clay loam	0.15	50	31	15	160	100

Table 6 Soil properties of Pamanukan Sub-District for DSSAT's input

Parameter	0-5 cm	6-15 cm	16-30 cm	31-35 cm	36-40 cm
Clay (%)	40	51	52	54	55
Silt (%)	12	14	15	17	18
Stone (%)	0	0	0	0	0
Bulk density (gr/cm^3)	1.35	1.35	1.34	1.42	1.42

Table 7 Soil properties of Cijambe Sub-District for DSSAT's input

Parameter	0-5 cm	6-15 cm	16-30 cm	31-35 cm	36-40 cm
Clay (%)	40	51	52	54	55
Silt (%)	12	15	17	18	19
Stone (%)	0	0	0	0	0
Bulk density (gr/cm^3)	1.35	1.35	1.34	1.42	1.42

Table 8 Soil properties of Binong Sub-District for DSSAT's input

Parameter	0-5 cm	6-15 cm	16-30 cm	31-35 cm	36-40 cm
Clay (%)	34	41	42	44	45
Silt (%)	16	18	19	21	22
Stone (%)	0	0	0	0	0
Bulk density (gr/cm^3)	1.35	1.35	1.34	1.42	1.42

Table 9 Soil properties of Pagaden Sub-District for DSSAT's input

Parameter	0-5 cm	6-15 cm	16-30 cm	31-35 cm	36-40 cm
Clay (%)	46	53	54	56	57
Silt (%)	10	16	17	19	20
Stone (%)	0	0	0	0	0
Bulk density (gr/cm^3)	1.35	1.35	1.34	1.42	1.42

Table 10 Soil properties of Purwadadi Sub-District for DSSAT's input

Parameter	0-5 cm	6-15 cm	16-30 cm	31-35 cm	36-40 cm
Clay (%)	38	45	46	48	49
Silt (%)	16	22	23	25	31
Stone (%)	0	0	0	0	0
Bulk density (gr/cm^3)	1.35	1.35	1.34	1.42	1.42

Agronomic Practices

Field experiments with rainfed and irrigated management are simulated to know the impact of climate changes on rice productivity in Subang Regency. The field management parameters for 5 different location can be seen in Table 1

Table 11 Calibrated crop characteristics for Aquacrop's input

Crop characteristics	Calibrated value
Sowing rate (kg/ha)	25.00
Initial canopy cover (%)	2.50
Maximum canopy cover (%)	85
Maximum effective rooting depth (m)	0.60
Crop coefficient	1.10
Base temperature (°C)	10
Upper temperature (°C)	30
Water productivity (g/m^2)	25
Reference Harvest Index (%)	40

Reference: Sethi *et al.* (2016)

Table 12 Calibrated crop management for DSSAT's input

Parameter	**Pamanukan**	**Cijambe**	**Purwadadi**	**Pagaden**	**Binong**
Planting date	December 31st, 2018	January 9th, 2019	January 15th, 2019	January 15th, 2019	December 24th, 2018
Planting method	Dry seed	Dry seed	Dry seed	Dry seed	Dry seed
Planting distribution	Rows	Rows	Rows	Rows	Rows
Plant population at seeding/m2	250	100	100	150	100
Row spacing	20 cm	30 cm	30	25	30
Planting depth	5 cm	10 cm	10	10	10
Row direction	0	0	0	0	0
Irrigation	200 mm at 2,9,15, and 20 DAP; 150 mm at 25 DAP; 100 mm at 30 DAP; 70 mm at 41, 51, 62, 65, 68, 74 and 77 DAP	90 mm at 9 and 17 DAP; 150 mm at 27 DAP	80 mm at 4 DAP; 60 mm at 11, 17, 24, 31, 39, 42, 47, 55, and 66 DAP; 70 mm at 71 DAP	70 mm at 6 DAP; 60 mm at 13 and 20 DAP; 50 mm at 27, 34, and 36 DAP; 40 mm at 38 DAP; 45 mm at 51 DAP; 50 at 56, 60, 64, 68, and 74 DAP	60 mm at 32 DAP; 50 mm at 39 DAP; 60 mm at 48 DAP; 50 mm at 58 , 67, 76, 82, and 89 DAP
Urea	220 kg / ha at 10 DAP	310kg/ha at 17 DAP; 95 kg/ha at 41 DAP; 95 kg/ha at 47 DAP	310 kg/ha at 13 DAP; 220 kg/ha at 21 DAP	310 kg/ha at 13 DAP; 220 kg/ha at 21 DAP	220 kg/ha at 47 DAP; 110 kg/ha at 56 DAP

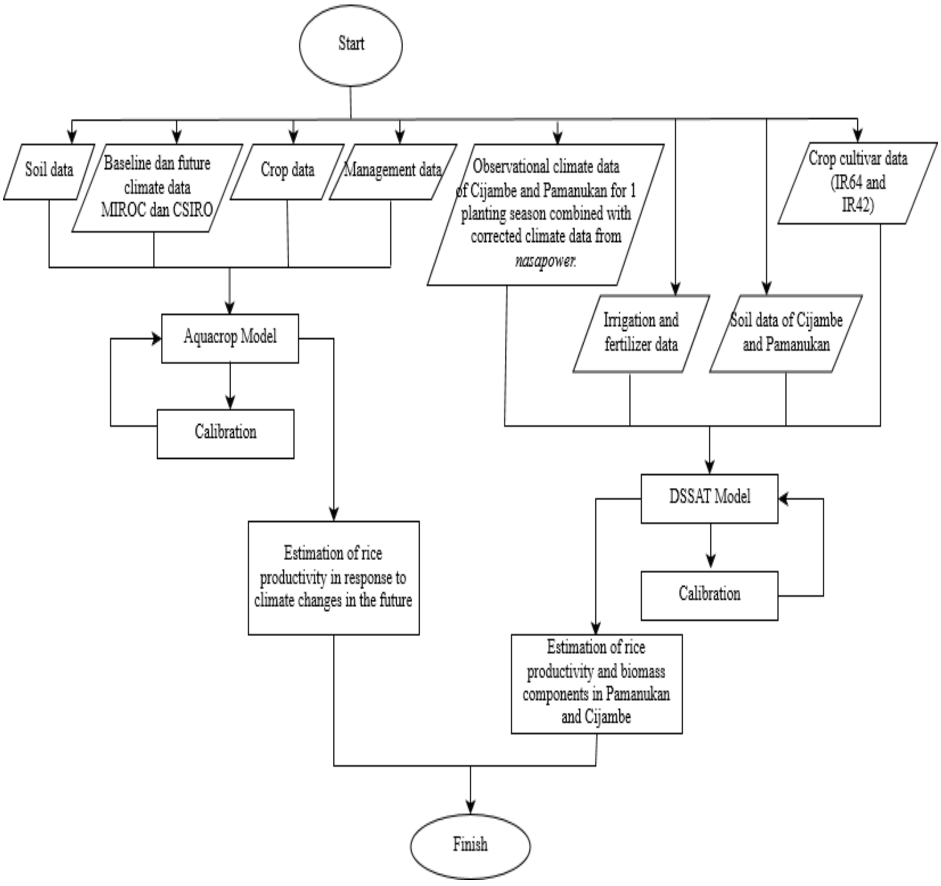

Figure 9 Research flowchart

Aquacrop Model

Aquacrop is model released by FAO to predict the productivity of agricultural crop which is affected by water availability. The output of Aquacrop can describe the productivity response due to water availability. Although based on basic and complex biophysical processes (Steduto *et al.* 2009), Aquacrop requires relatively less input data compared to other crop models. Aquacrop integrates 4 parameters consisting of soil, plants, atmosphere, and crop management that requires climate data, date of planting, plant growth data and each stage, crop management data, and soil properties. The soil components in Aquacrop are used for water balance analysis. Crop components are used to simulate the effects of temperature, rainfall, evapration, and carbon dioxide concentration. The menagement component used is irrigation. Daily weather data in this research that are unfortunately not available is potential evapotranspiration data. Therefore, the potential evapotranspiration data is derived from weather station data using Penman-Monteith equation (Allen *et al.* 1998) and Eto calculator (FAO 2009) available on Aquacrop.

DSSAT Model

DSSAT is a crop simulation model originally developed by an international network of scientists in collaboration with the International Benchmark Sites Network for Agrotechnology Transfer (IBSNAT 1993; Tsuji *et al.* 1998) to facilitate the application of agricultural models using an agronomic approach. This simulation model was developed with the aim of integrating soil, climate, crop, and agricultural land management systems for better decision-making so that the utilization of production technology in the area can be placed from one location to another where soil and climate conditions are different (Tsuji *et al* 1998).

DSSAT model requires climate data, soil properties, and crop management data. Plants that can be modeled in this simulation have different genotype data depending on the cultivar of plants that wants to be modeled (Hoogenboom *et al.* 2010). In this research, the plant used is rice. The model used to simulate rice plant in DSSAT 4.7 is CERES-rice. The phenological components of CERES-rice based on the research of Singh and Ritchie (1993) is described as the development of plants through a life cycle based on the accumulation of degree days (heat units). The duration of development stage depends on the cultivars, species, and genetic coefficients used as input to the model. The rice cultivars used in this simulation are IR42 (for lowlands) and IR64 (for uplands) which have genetic coefficients in the CERES-rice model.

Results and Discussion

Simulations using Aquacrop model were carried out on 5 different clusters in Subang District consisted of cluster 1, 3, 4, 5, and 7 to analyze the effect of climate change on rice productivity. The simulations are divided into two simulations. The first simulation produces the average monthly rice productivity in the area where irrigations are provided for the development and growth of the crop (Fig. 1, 2, 3, 4, and 5). The second simulation produces the average monthly rice productivity in the rainfed crop management (Fig. 6, 7, 8, 9, and 10). The average monthly rice productivities in both field management (irrigated and rainfed) are the average of 30 years in baseline period (1986 – 2015) and future period (2021 – 2050).

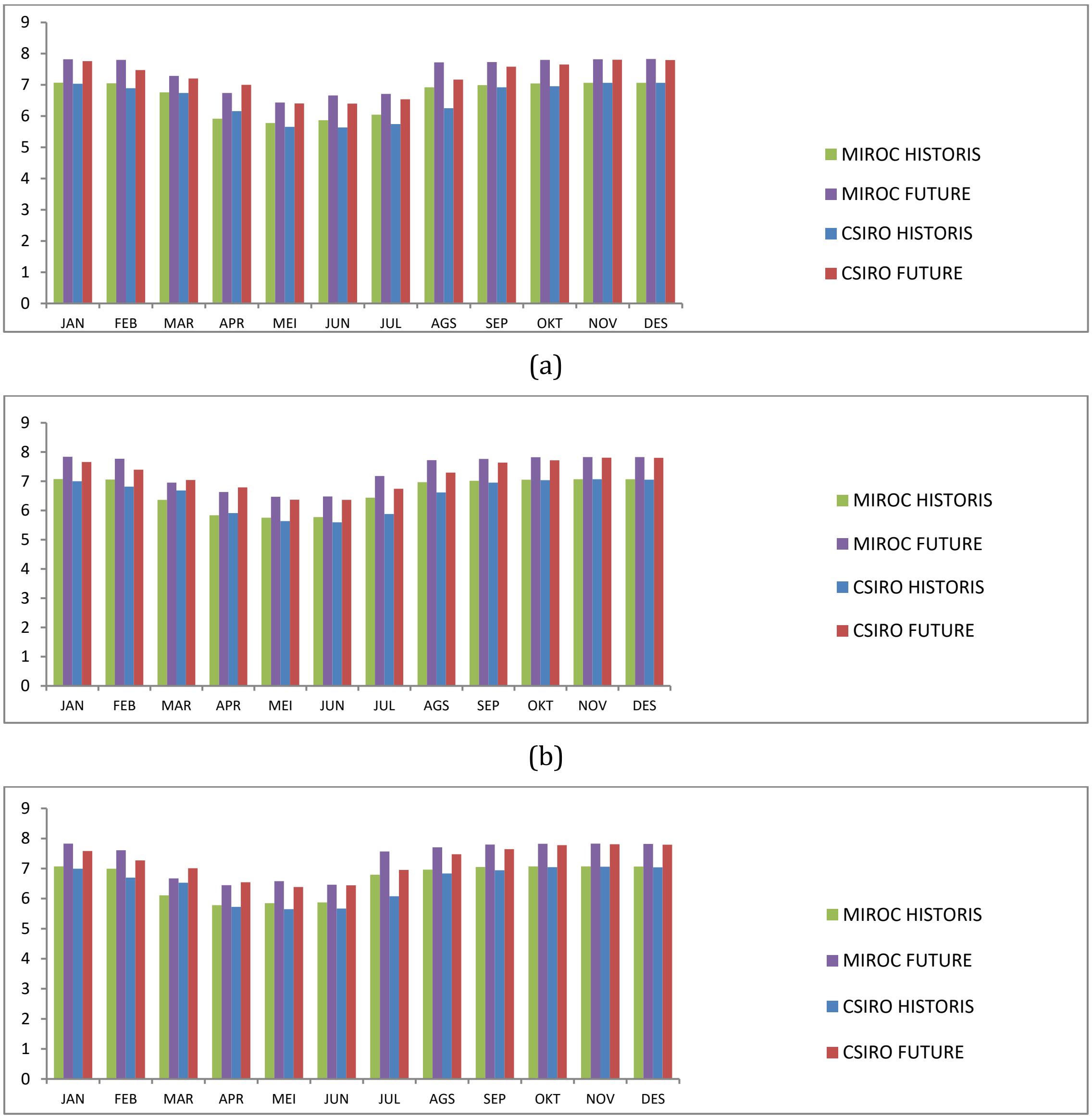

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Figure 10 Average monthly rice productivity of baseline period (1986-2015) and future period (2021-2050) in cluster 1 during (a) Dasarian 1, (b) Dasarian 2, (c) Dasarian 3 in irrigated crop area

Figure 6 shows the average monthly rice productivity of baseline period (1986-2015) and future period (2021-2050) in cluster 1 during dasarian 1, 2, and 3 in irrigated crop area. The three dasarians productivity shows a relatively similar pattern regardless of the different planting date. The high productivity tend to be in September – February planting date and the low productivity tend to be in April – July planting date. Based on the simulated results, the average monthly rice productivity in the the three dasarians varies between 5,6 - 7,1 tons/ha in the baseline period, wereas in the future period result shows higher productivity. The productivity in the future period varies between 6,4 – 7,8 tons/ha.

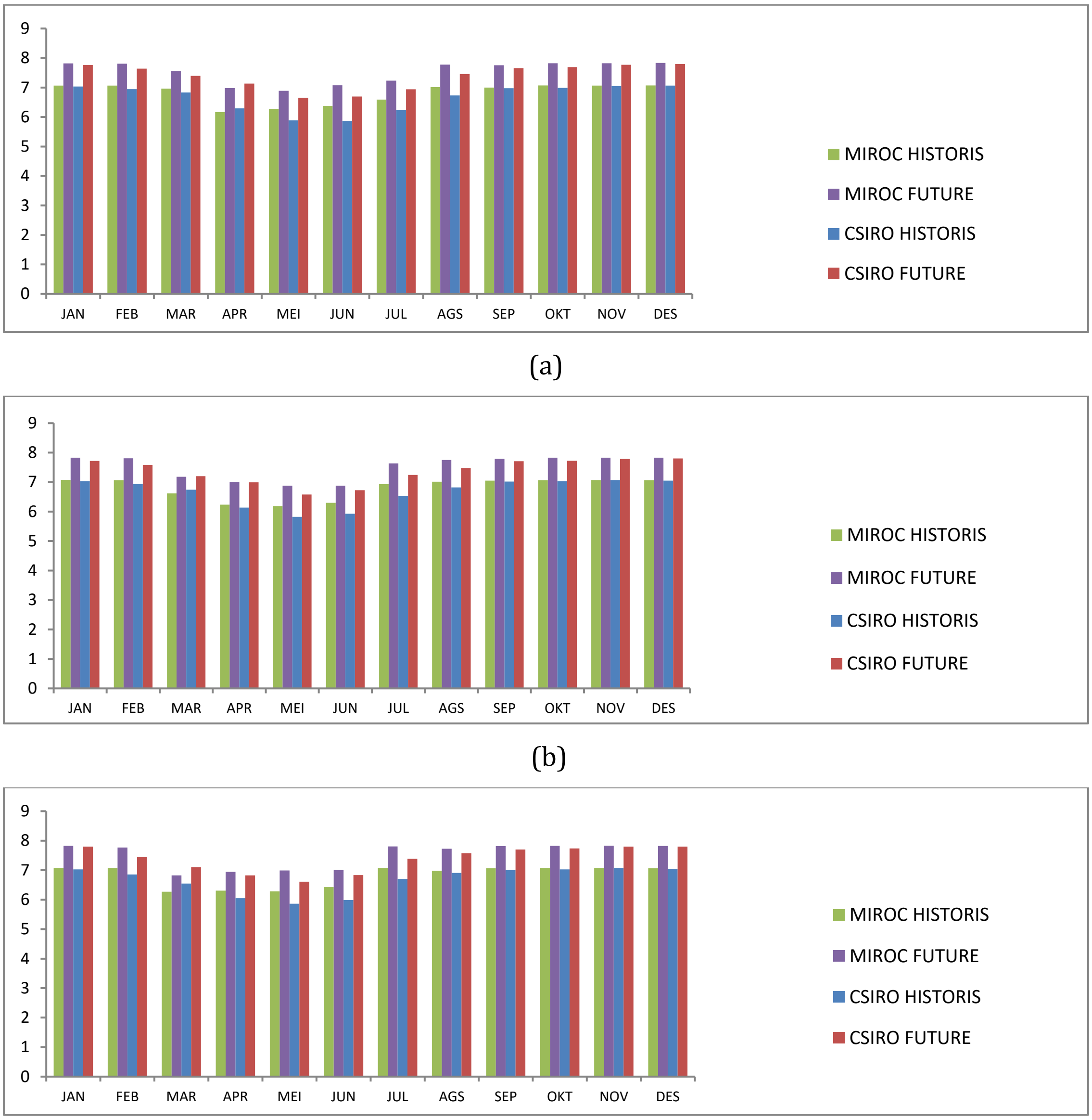

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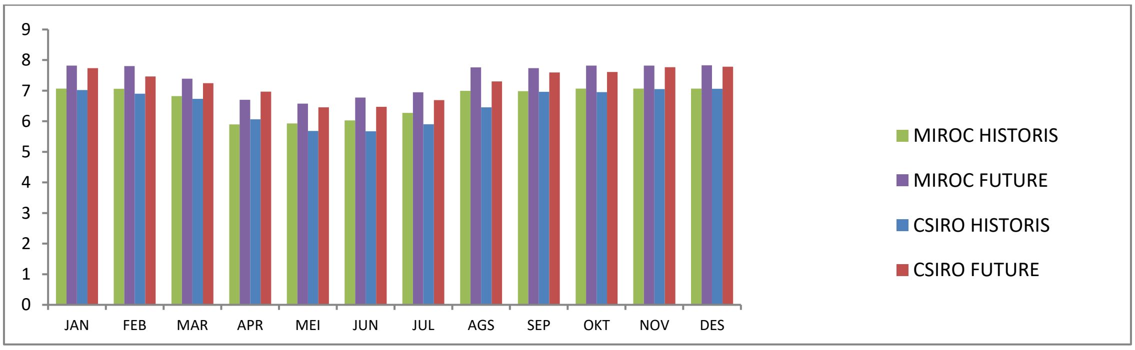
Figure 11 Average monthly rice productivity of baseline period (1986-2015) and future period (2021-2050) in cluster 3 during (a) Dasarian 1, (b) Dasarian 2, (c) Dasarian 3 in irrigated crop area

Figure 7 shows the average monthly rice productivity of baseline period (1986-2015) and future period (2021-2050) in cluster 3 during dasarian 1, 2, and 3 in irrigated crop area. The three dasarians productivity shows a relatively similar pattern with the highest productivity tend to be in August – February planting date and low productivity in April – June planting date. Based on the simulated results, the average monthly rice productivity in the the first dasarian varies between 5,9 - 7,1 tons/ha in the baseline period, wereas in the future period result shows higher productivity. The productivity in the future period varies between 6,7 – 7,8 tons/ha. In the second dasarian, the monthly average rice productivity varies between 5,8 – 7.1 tons/ha in the baseline period and 6,6 – 7,8 tons/ha in the future period. In the third dasarian, the monthly average rice productivity varies between 5,9 – 7.1 tons/ha in the baseline period and 6,6 – 7,8 tons/ha in the future period.



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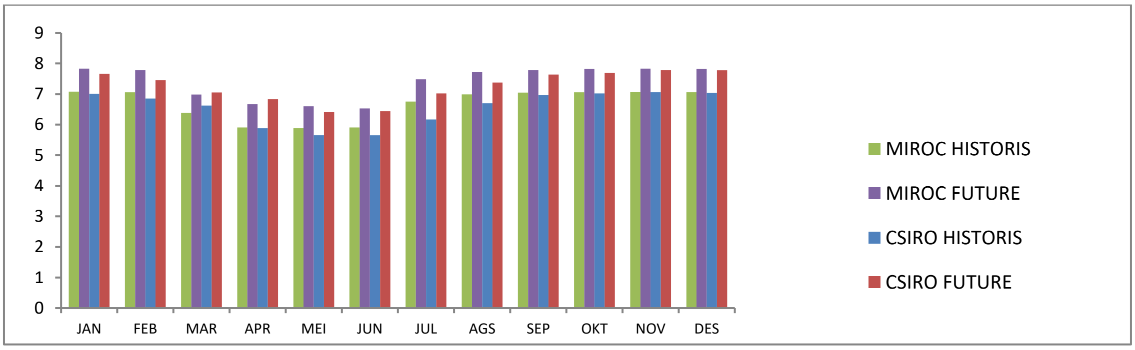

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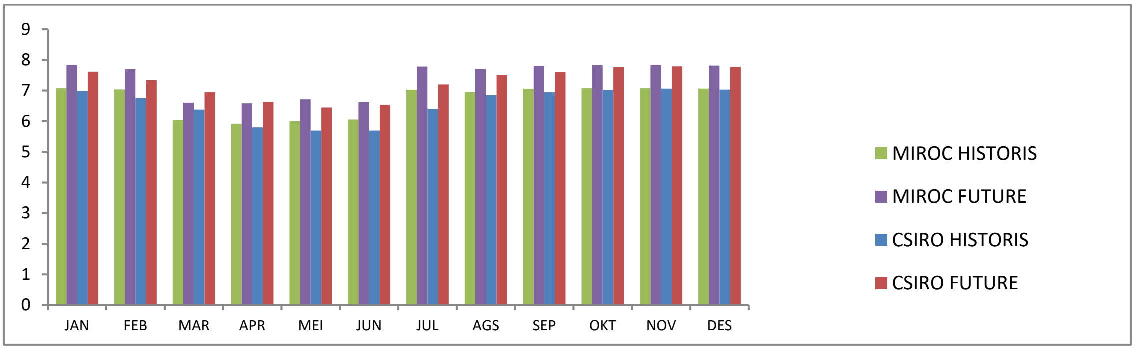

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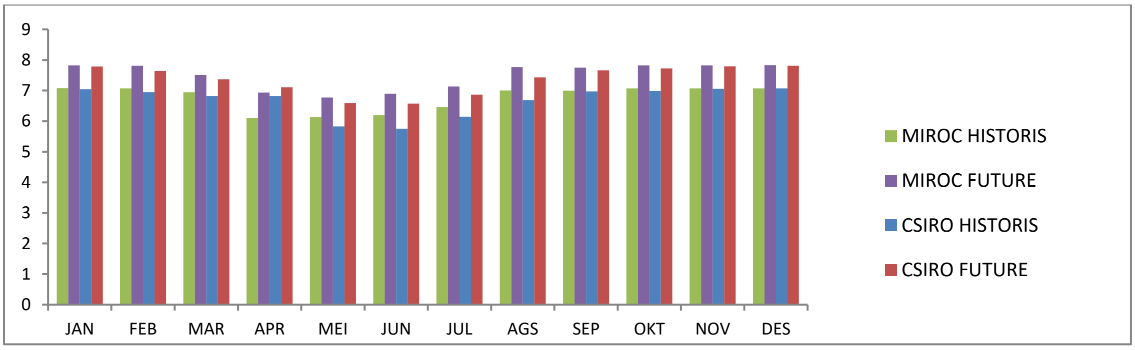
Figure 12 Average monthly rice productivity of baseline period (1986-2015) and future period (2021-2050) in cluster 4 during (a) Dasarian 1, (b) Dasarian 2, (c) Dasarian 3 in irrigated crop area

Figure 8 shows the average monthly rice productivity of baseline period (1986-2015) and future period (2021-2050) in cluster 4 during dasarian 1, 2, and 3 in irrigated crop area. The three dasarians productivity shows a relatively similar pattern with the highest productivity tend to be in September – February planting date and low productivity in April – June planting date. Based on the simulated results, the average monthly rice productivity in the the first dasarian varies between 5,7 - 7,1 tons/ha in the baseline period, wereas in the future period result shows higher productivity. The productivity in the future period varies between 6,5 – 7,8 tons/ha. In the second dasarian, the monthly average rice productivity varies between 5,7 – 7.1 tons/ha in the baseline period and 6,4 – 7,8 tons/ha in the future period. In the third dasarian, the monthly average rice productivity varies between 5,7 – 7.1 tons/ha in the baseline period and 6,4 – 7,8 tons/ha in the future period.



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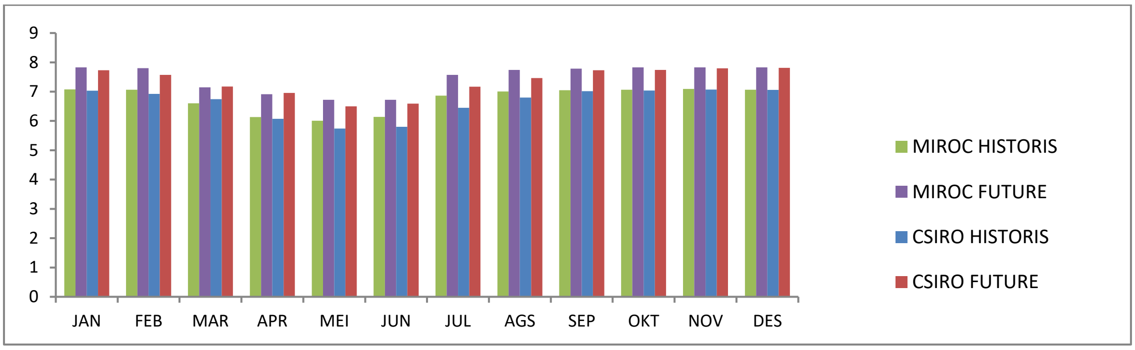

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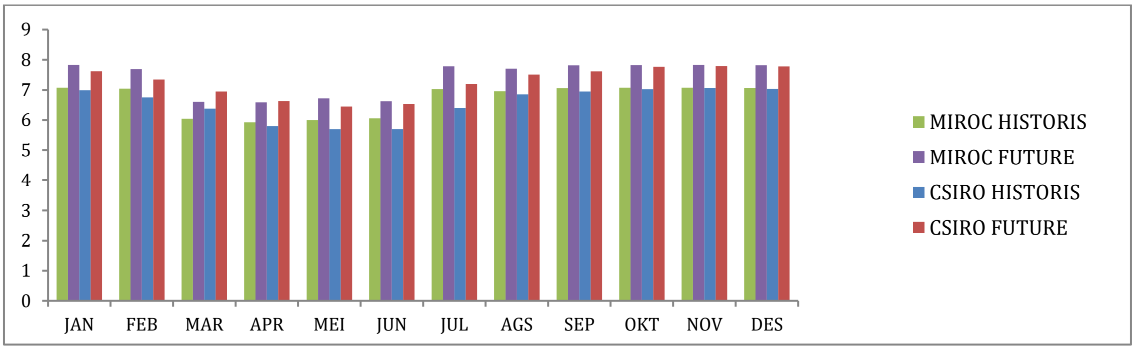
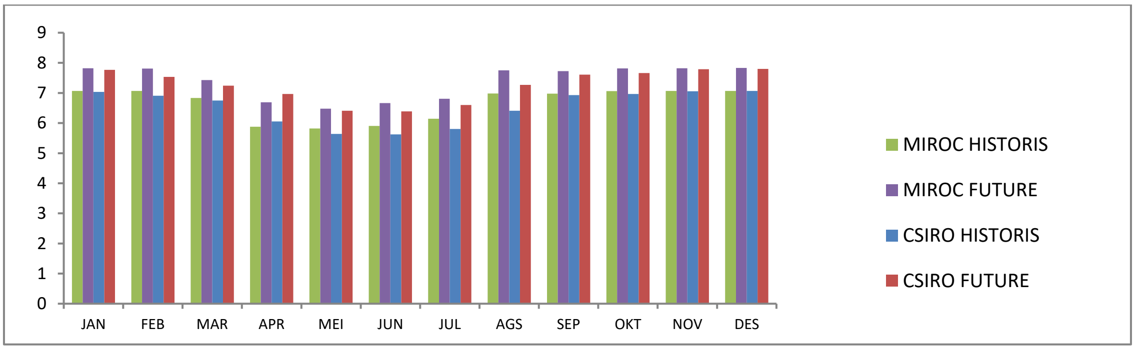


(c)

Figure 13 Average monthly rice productivity of baseline period (1986-2015) and future period (2021-2050) in cluster 5 during (a) Dasarian 1, (b) Dasarian 2, (c) Dasarian 3 in irrigated crop area

Figure 9 shows the average monthly rice productivity of baseline period (1986-2015) and future period (2021-2050) in cluster 5 during dasarian 1, 2, and 3 in irrigated crop area. The three dasarians productivity shows a relatively similar pattern with the highest productivity tend to be in September – February planting date and low productivity in April – June planting date. Based on the simulated results, the average monthly rice productivity in the the first dasarian varies between 5,8 - 7,1 tons/ha in the baseline period, wereas in the future period result shows higher productivity. The productivity in the future period varies between 6,6 – 7,8 tons/ha. In the second dasarian, the monthly average rice productivity varies between 5,7 – 7.1 tons/ha in the baseline period and 6,5 – 7,8 tons/ha in the future period. In the third dasarian, the monthly average rice productivity varies between 5,7 – 7.1 tons/ha in the baseline period and 6,5 – 7,8 tons/ha in the future period.



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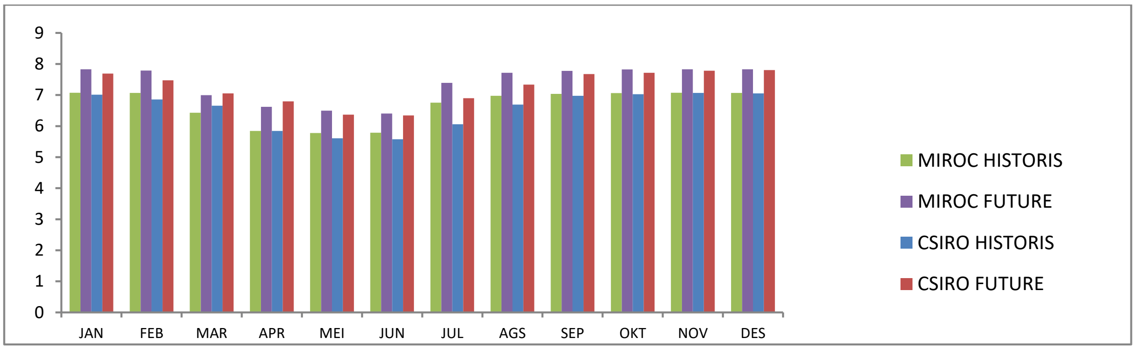

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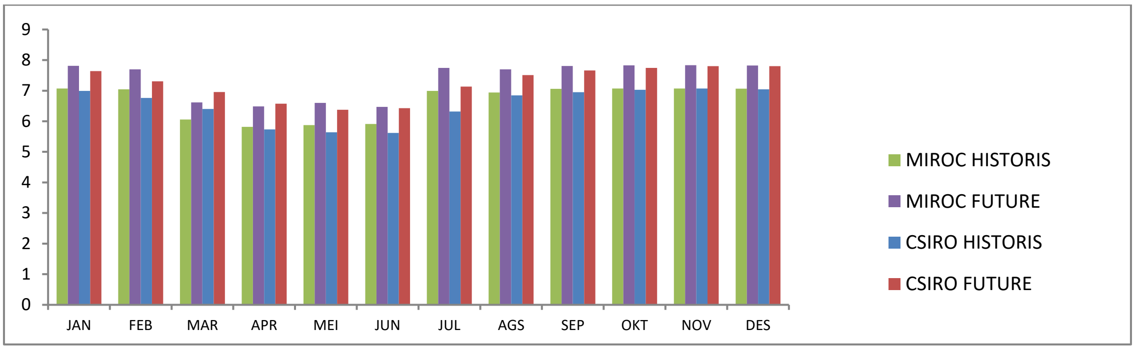
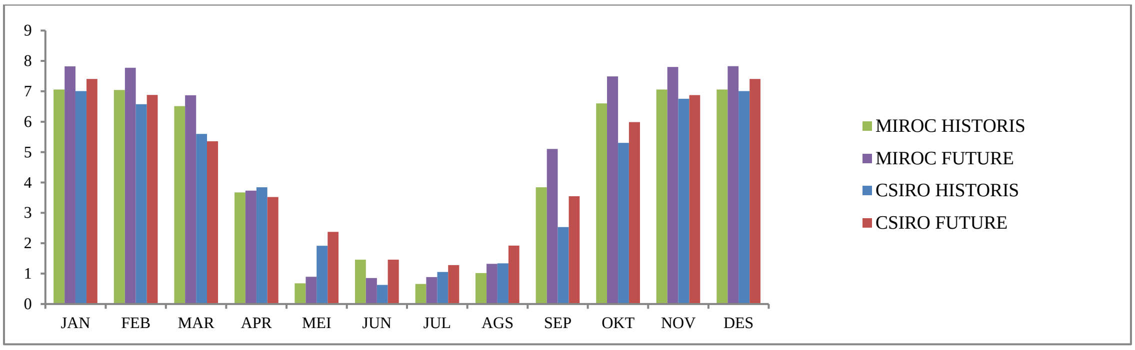


(c)

Figure 14 Average monthly rice productivity of baseline period (1986-2015) and future period (2021-2050) in cluster 7 during (a) Dasarian 1, (b) Dasarian 2, (c) Dasarian 3 in irrigated crop area

Figure 10 shows the average monthly rice productivity of baseline period (1986-2015) and future period (2021-2050) in cluster 7 during dasarian 1, 2, and 3 in irrigated crop area. The three dasarians productivity shows a relatively similar pattern with the highest productivity tend to be in September – February planting date and low productivity in April – June planting date. Based on the simulated results, the average monthly rice productivity in the the first dasarian varies between 5,6 - 7,1 tons/ha in the baseline period, wereas in the future period result shows higher productivity. The productivity in the future period varies between 6,4 – 7,8 tons/ha. In the second dasarian, the monthly average rice productivity varies between 5,6 – 7.1 tons/ha in the baseline period and 6,3 – 7,8 tons/ha in the future period. In the third dasarian, the monthly average rice productivity varies between 5,6 – 7.1 tons/ha in the baseline period and 6,4 – 7,8 tons/ha in the future period.



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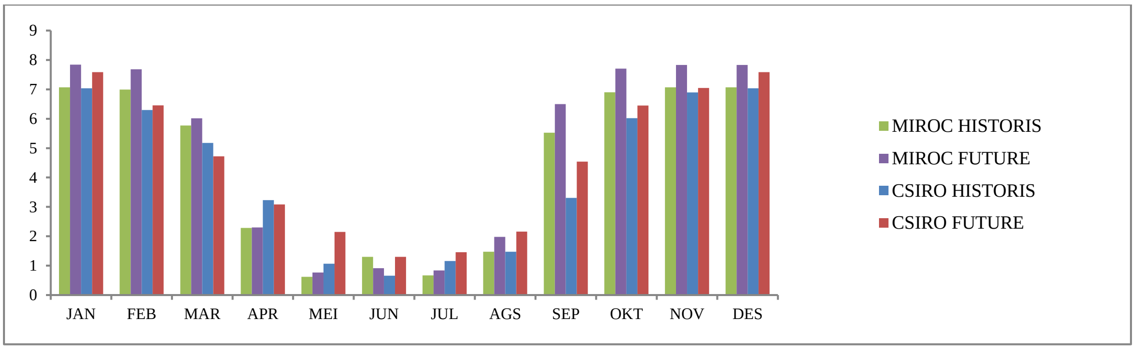

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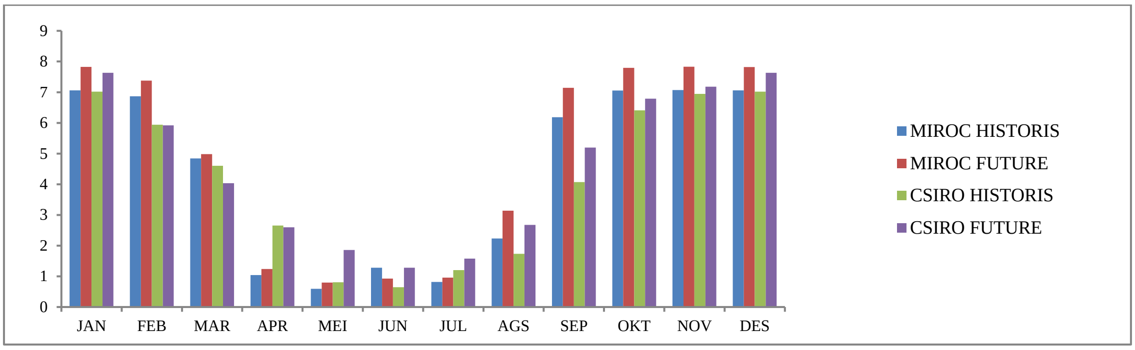
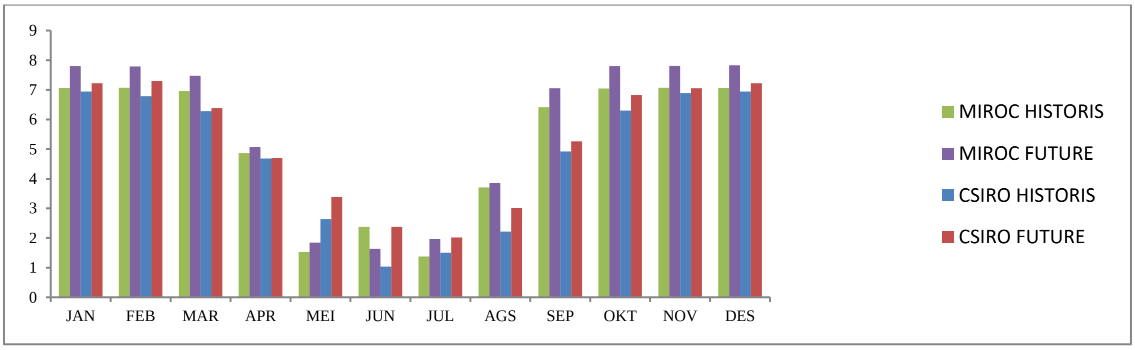


(c)

Figure 15 Average monthly rice productivity of baseline period (1986-2015) and future period (2021-2050) in cluster 1 during (a) Dasarian 1, (b) Dasarian 2, (c) Dasarian 3 in rainfed crop area

Figure 11 shows the average monthly rice productivity of baseline period (1986-2015) and future period (2021-2050) in cluster 1 during dasarian 1, 2, and 3 in rainfed crop area. The three dasarians productivity has a similarity with the monthly rainfall pattern in Subang. Based on Figure 6, the highest average monthly rice productivity in rainfed crop area tend to be in Oktober – January planting date, following the heavy rainfall season and low productivity in April – July planting date. Based on the simulated results, the average monthly rice productivity in the the first dasarian varies between 0,6 - 7,1 tons/ha in the baseline period, wereas in the future period result shows higher productivity. The productivity in the future period varies between 1,3 – 7,8 tons/ha. In the second dasarian, the monthly average rice productivity varies between 0,6 – 7.1 tons/ha in the baseline period and 0,8 – 7,8 tons/ha in the future period. In the third dasarian, the monthly average rice productivity varies between 0,6 – 7.1 tons/ha in the baseline period and 0,8 – 7,8 tons/ha in the future period.



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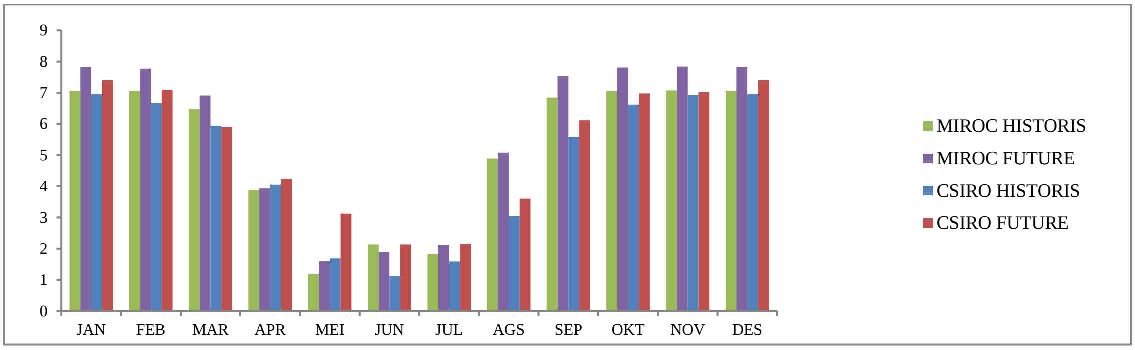

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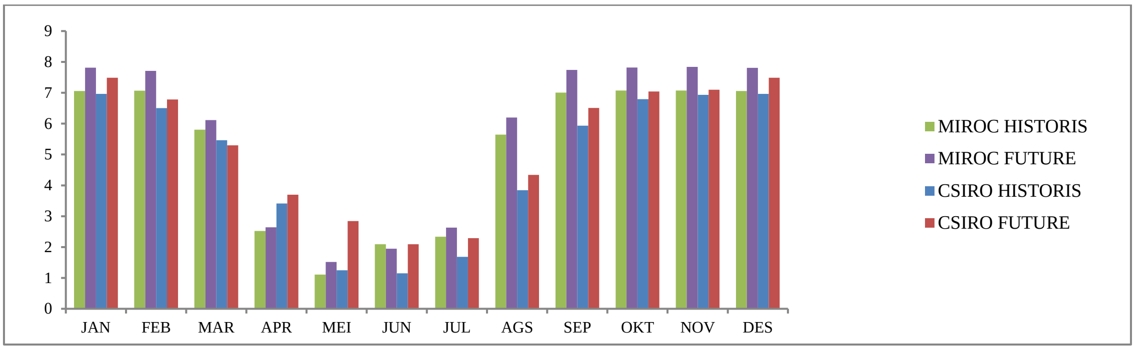
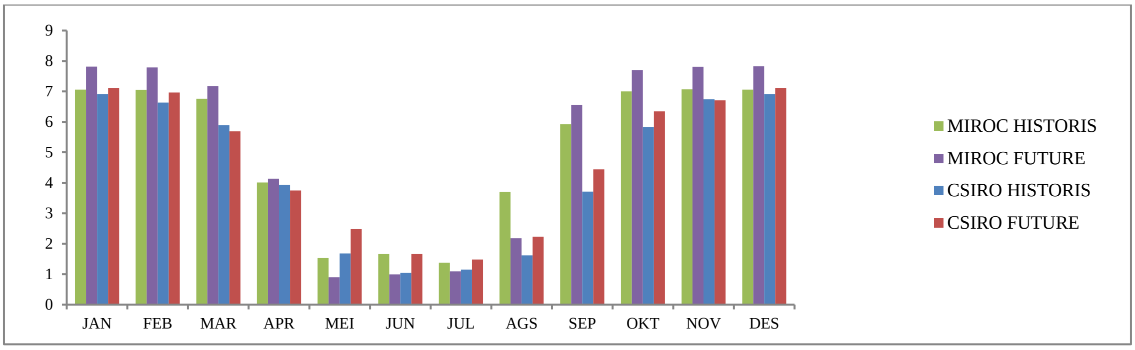


(c)

Figure 16 Average monthly rice productivity of baseline period (1986-2015) and future period (2021-2050) in cluster 3 during (a) Dasarian 1, (b) Dasarian 2, (c) Dasarian 3 in rainfed crop area

Figure 12 shows the average monthly rice productivity of baseline period (1986-2015) and future period (2021-2050) in cluster 3 during dasarian 1, 2, and 3 in rainfed crop area. Based on Figure 7, the highest average monthly rice productivity in rainfed crop area tend to be in September – February planting date, following the heavy rainfall season and low productivity in May – July planting date. Based on the simulated results, the average monthly rice productivity in the the first dasarian varies between 1 - 7,1 tons/ha in the baseline period, wereas in the future period result shows higher productivity. The productivity in the future period varies between 1,6 – 7,8 tons/ha. In the second dasarian, the monthly average rice productivity varies between 1,2 – 7.1 tons/ha in the baseline period and 1,6 – 7,8 tons/ha in the future period. In the third dasarian, the monthly average rice productivity varies between 1,2 – 7.1 tons/ha in the baseline period and 1,5 – 7,8 tons/ha in the future period.



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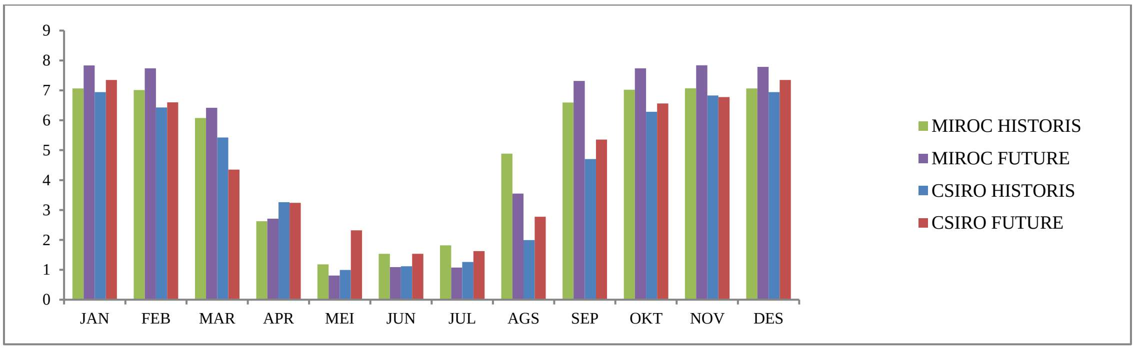

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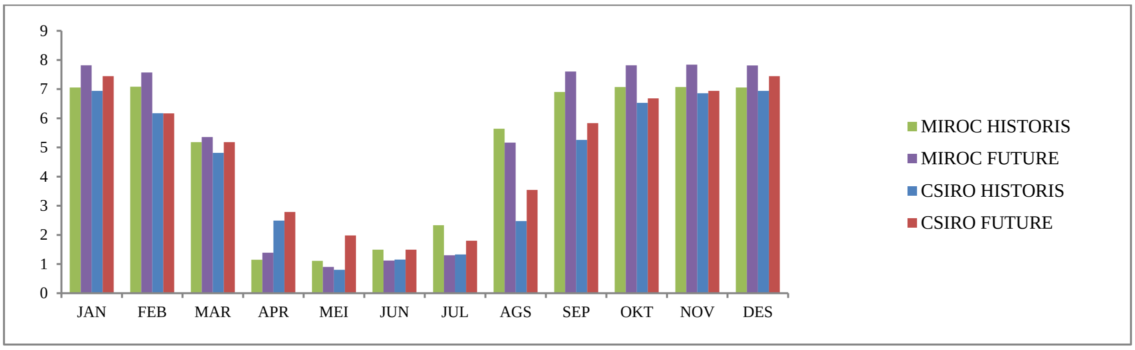

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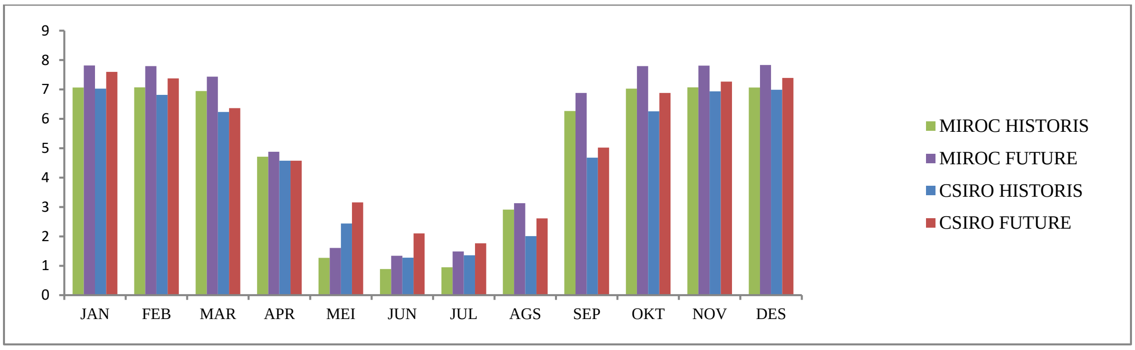
Figure 17 Average monthly rice productivity of baseline period (1986-2015) and future period (2021-2050) in cluster 4 during (a) Dasarian 1, (b) Dasarian 2, (c) Dasarian 3 in rainfed crop area

Figure 13 shows the average monthly rice productivity of baseline period (1986-2015) and future period (2021-2050) in cluster 4 during dasarian 1, 2, and 3 in rainfed crop area. Based on Figure 8, the highest average monthly rice productivity in rainfed crop area tend to be in Oktober – February planting date, following the heavy rainfall season, whereas the low productivity in May – July planting date. Based on the simulated results, the average monthly rice productivity in the the first dasarian varies between 1 - 7,1 tons/ha in the baseline period, wereas in the future period result shows higher productivity. The productivity in the future period varies between 0,9 – 7,8 tons/ha. In the second dasarian, the monthly average rice productivity varies between 1 – 7.1 tons/ha in the baseline period and 0,8 – 7,8 tons/ha in the future period. In the third dasarian, the monthly average rice productivity varies between 0,8 – 7.1 tons/ha in the baseline period and 0,9 – 7,8 tons/ha in the future period.



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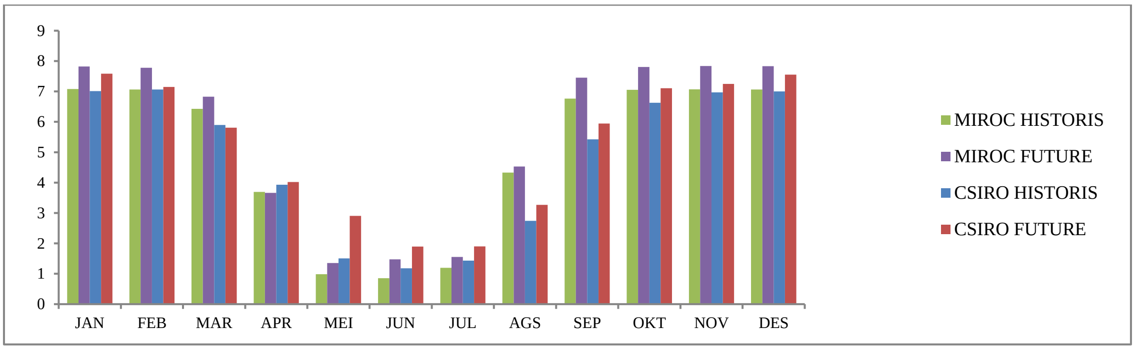

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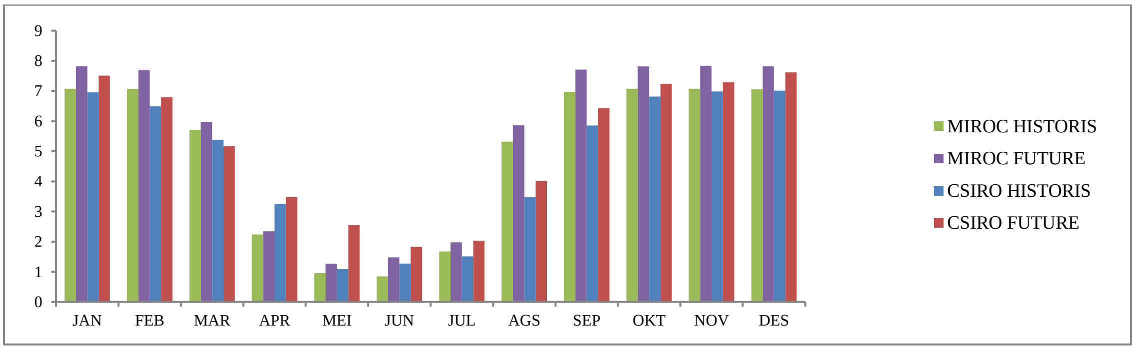
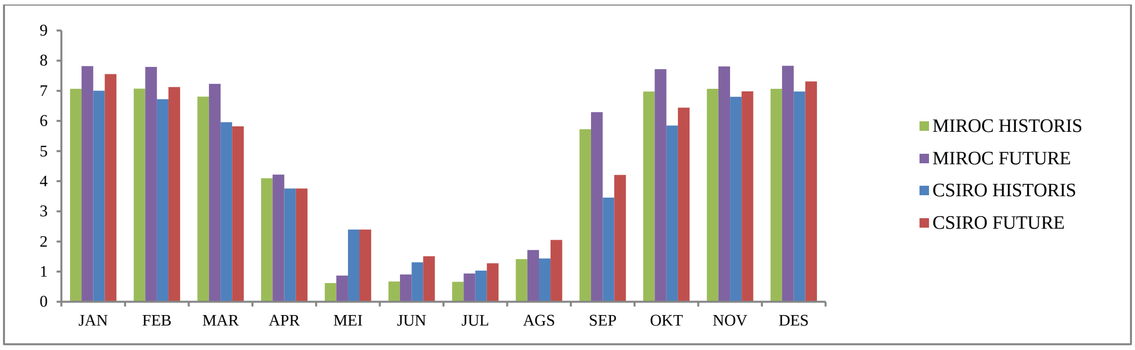


(c)

Figure 18 Average monthly rice productivity of baseline period (1986-2015) and future period (2021-2050) in cluster 5 during (a) Dasarian 1, (b) Dasarian 2, (c) Dasarian 3 in rainfed crop area

Figure 14 shows the average monthly rice productivity of baseline period (1986-2015) and future period (2021-2050) in cluster 5 during dasarian 1, 2, and 3 in rainfed crop area. Based on Figure 9, the highest average monthly rice productivity in rainfed crop area tend to be in October – February planting date, following the heavy rainfall season, whereas the low productivity in May – July planting date. Based on the simulated results, the average monthly rice productivity in the the first dasarian varies between 0,9 - 7,1 tons/ha in the baseline period, wereas in the future period result shows higher productivity. The productivity in the future period varies between 1,3 – 7,8 tons/ha. In the second dasarian, the monthly average rice productivity varies between 0,9 – 7.1 tons/ha in the baseline period and 1,4 – 7,8 tons/ha in the future period. In the third dasarian, the monthly average rice productivity varies between 0,8 – 7.1 tons/ha in the baseline period and 1,3 – 7,8 tons/ha in the future period.



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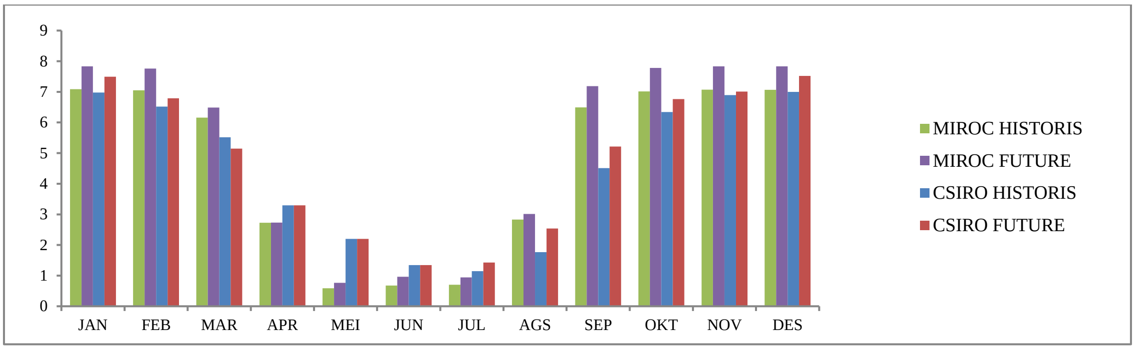

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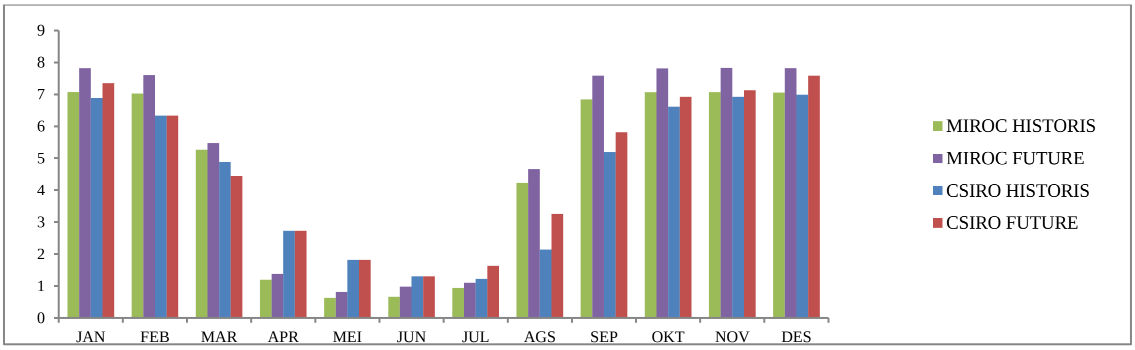


(c)

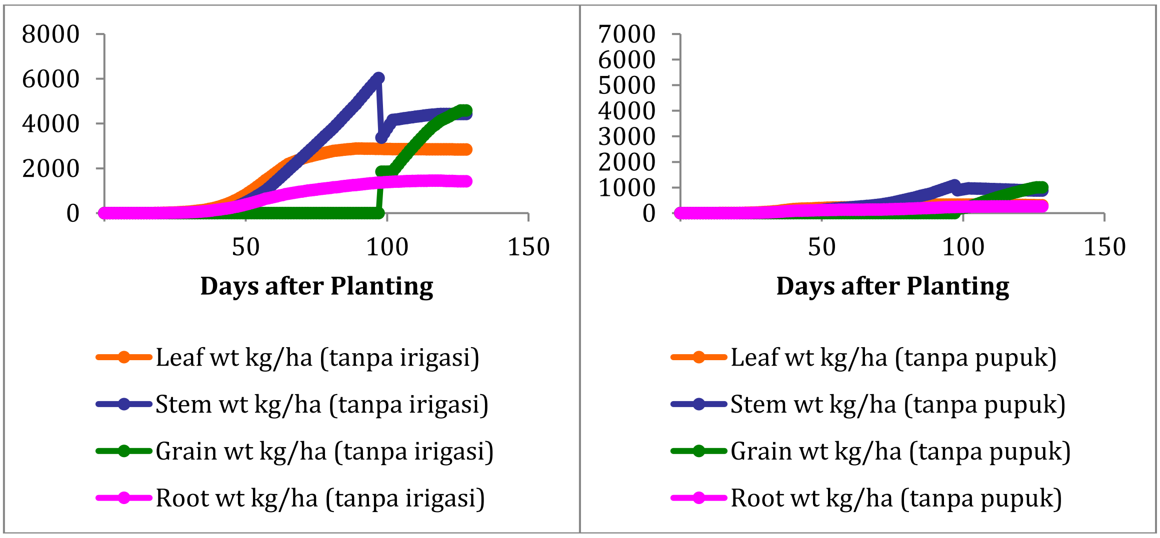
Figure 19 Average monthly rice productivity of baseline period (1986-2015) and future period (2021-2050) in cluster 7 during (a) Dasarian 1, (b) Dasarian 2, (c) Dasarian 3 in rainfed crop area

Figure 15 shows the average monthly rice productivity of baseline period (1986-2015) and future period (2021-2050) in cluster 7 during dasarian 1, 2, and 3 in rainfed crop area. Based on Figure 9, the highest average monthly rice productivity in rainfed crop area tend to be in October – February planting date, following the heavy rainfall season, whereas the low productivity in May – August planting date. Based on the simulated results, the average monthly rice productivity in the the first dasarian varies between 0,6 - 7,1 tons/ha in the baseline period, wereas in the future period result shows higher productivity. The productivity in the future period varies between 0,9 – 7,8 tons/ha. In the second dasarian, the monthly average rice productivity varies between 0,6 – 7.1 tons/ha in the baseline period and 0,8 – 7,8 tons/ha in the future period. In the third dasarian, the monthly average rice productivity varies between 0,6 – 7.1 tons/ha in the baseline period and 0,8 – 7,8 tons/ha in the future period.

Table 13 Rice productivity and biomasses of Cijambe in various conditions

Variable	**With irrigation and fertilizer (kg/ha)**	**Without irrigation and fertilizer (kg/ha)**	**With fertilizer and without irrigation (kg/ha)**	**With irrigation without fertilizer (kg/ha)**
Leaf biomass	2785	332	2845	305
Stem biomass	4375	876	4426	881
Root biomass	1400	274	1419	262
Grain biomass	4526	1040	4582	1008
Productivity	4526	1040	4582	1008

Table 13 shows the rice productivity and biomasses in Cijambe for 1 cultivating season. Rice productivity based on observation in Cijambe is around 4 tons/ha, whereas the closer simulated result of rice productivity is 4,5 tons/ha in the area where irrigation and fertilizer are provided for the crop. Based on the simulated results, the highest rice productivity and biomasses in Cijambe are in the area where irrigation isn't provided for the crop. Cijambe is located in the highest elevation area compared to the other four sub-districts (Pamanukan, Pagaden, Binong, and Purwadadi) and the irrigation relatively is not needed considering the high precipitation in the first cultivating season (Oktober – Maret) and the area's location near the water springs. The lowest rice productivity and biomasses based on the simulated results are in the area where fertilizer isn't provided for the crop. Based on the simulated results, fertilizer have the bigger impacts on rice productivity and biomasses compared to irrigation in Cijambe.



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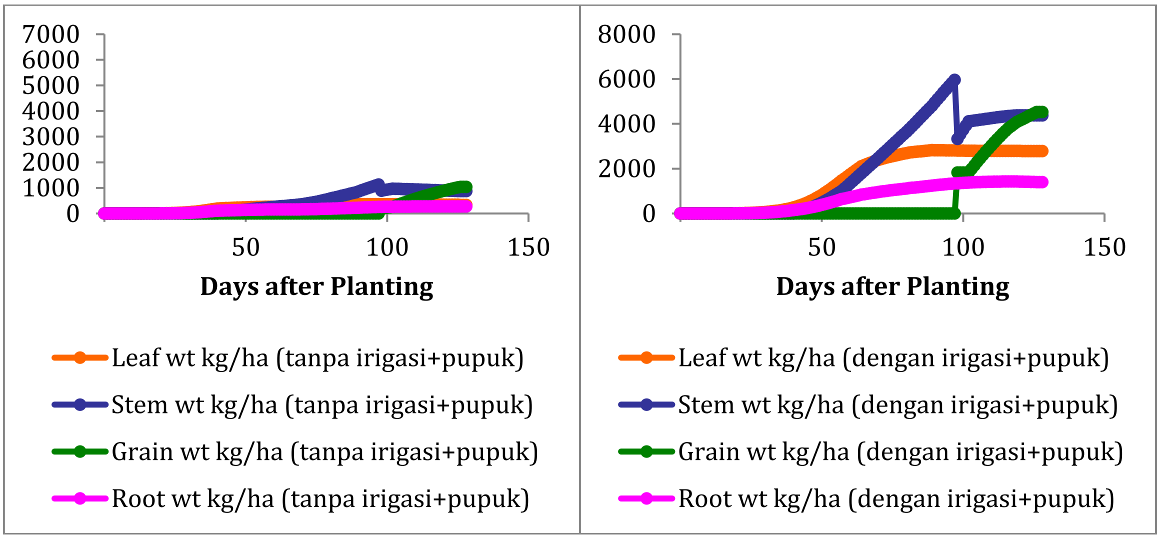


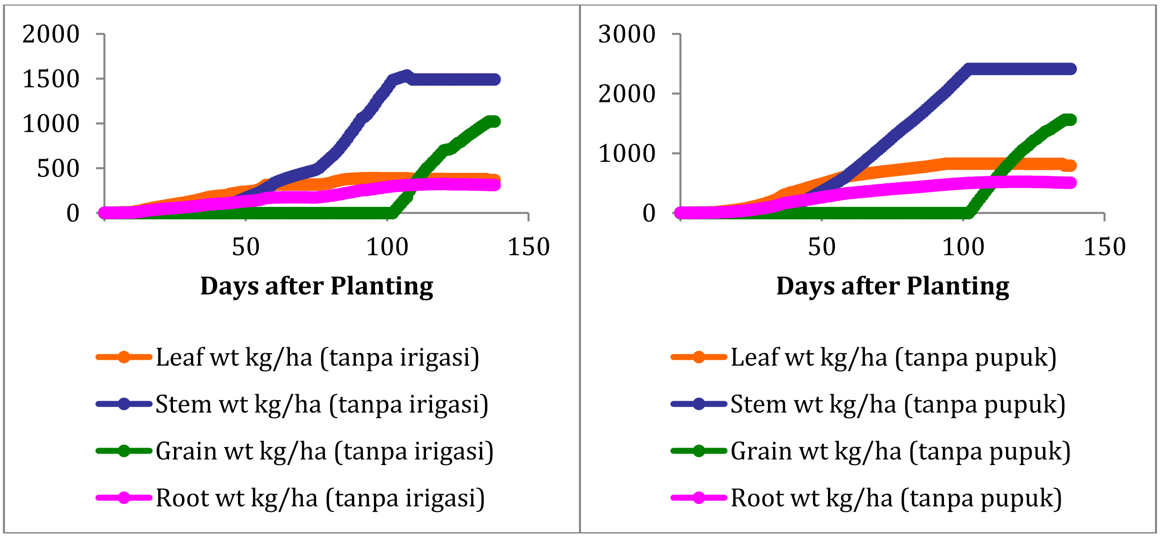
(c) **(d)**

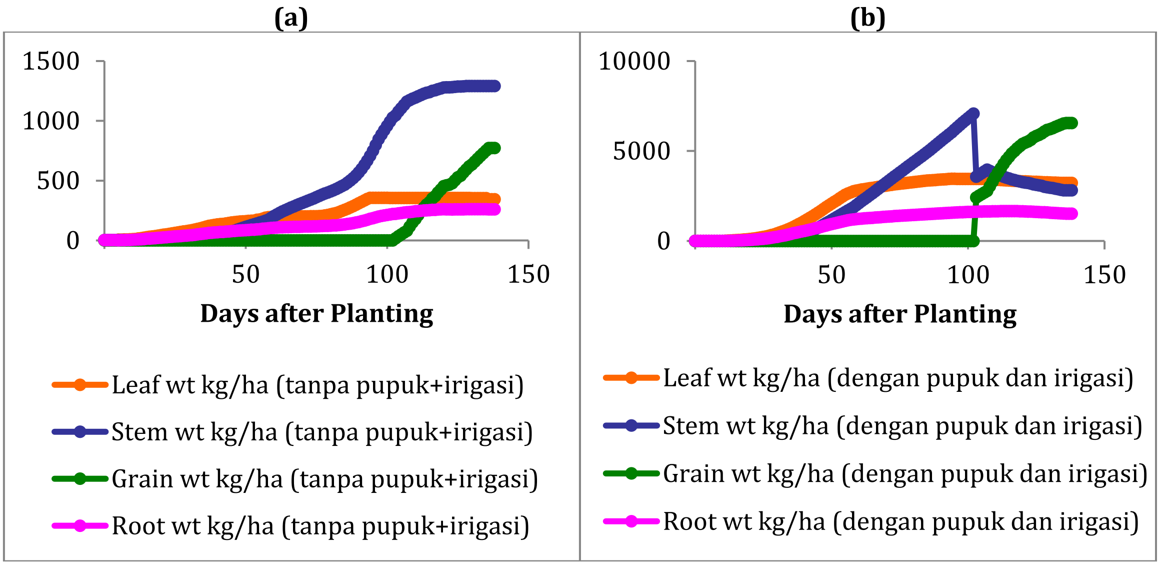
Figure 20 The biomasses growth simulation for demonstration plot in Cijambe (a) without irrigaton with fertilizer, (b) without fertilizer with irrigation, (c) without irrigation and fertilizer, (d) with irrigation and fertilizer

Table 14 Rice productivity and biomasses of Pamanukan in various conditions

Variable	With irrigation and fertilizer (kg/ha)	Without irrigation and fertilizer (kg/ha)	With fertilizer and without irrigation (kg/ha)	With irrigation without fertilizer (kg/ha)
Leaf biomass	3224	345	369	795
Stem biomass	2816	1291	1491	2414
Root biomass	1518	261	314	508
Grain biomass	6561	773	1023	1564
Productivity	6561	773	1023	1564

Table 2 shows the rice productivity and biomasses in Pamanukan for 1 cultivating season. Rice productivity based on observation in Pamanukan is around 6 tons/ha, whereas the closer simulated result of rice productivity is 6,6 tons/ha in the area where irrigation and fertilizer are provided for the crop. Based on the simulated results, the highest rice productivity and biomasses in Pamanukan are in the area where irrigation and fertilizer are provided for the crop. Pamanukan is located in the lowest elevation area compared to the other four sub-districts (Cijambe, Pagaden, Binong, and Purwadadi) and the irrigation and fertilizer are really needed for the growth and development of the crop. The lowest rice productivity and biomasses based on the simulated results are in the area where fertilizer and irrigation aren't provided for the crop. Based on the simulated results, irrigation have the bigger impacts on rice productivity and biomasses compared to fertilizer in Pamanukan.





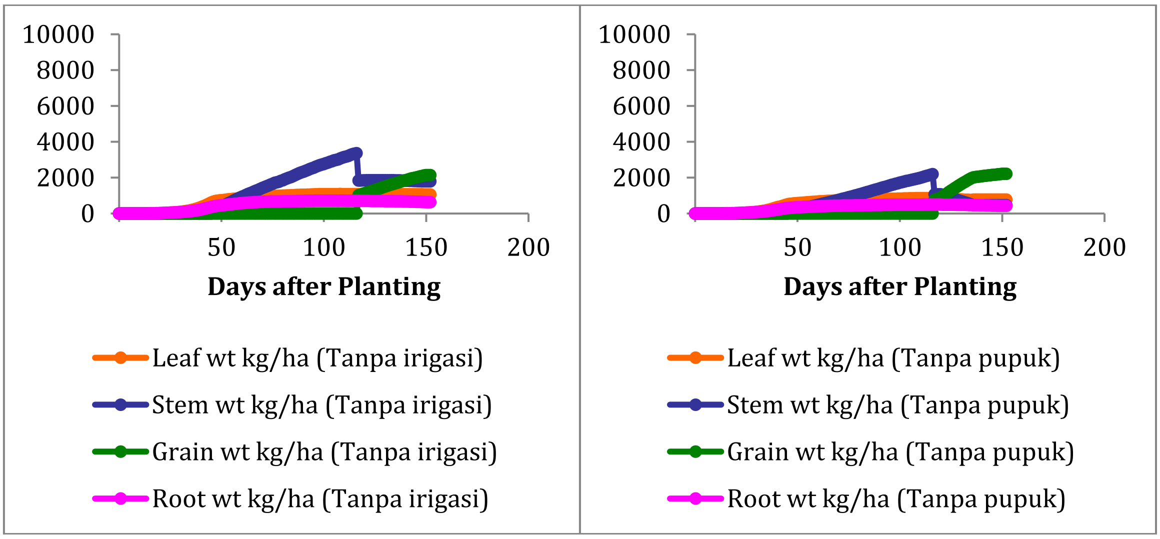
(c) (d)

Figure 21 The biomasses growth simulation for demonstration plot in Pamanukan (a) without irrigaton with fertilizer, (b) without fertilizer with irrigation, (c) without irrigation and fertilizer, (d) with irrigation and fertilizer

Table 15 Rice productivity and biomasses of Purwadadi in various conditions

Variable	With irrigation and fertilizer (kg/ha)	Without irrigation and fertilizer (kg/ha)	With fertilizer and without irrigation (kg/ha)	With irrigation without fertilizer (kg/ha)
Leaf biomass	5503	530	1065	773
Stem biomass	4918	931	1790	463
Root biomass	1977	206	638	427
Grain biomass	6153	238	2144	2210
Productivity	6153	238	2144	2210

Table 15 shows the rice productivity and biomasses in Purwadadi for 1 cultivating season. Rice productivity based on observation in Purwadadi is around 7,2 tons/ha, whereas the closer simulated result of rice productivity is 6,2 tons/ha in the area where irrigation and fertilizer are provided for the crop. Based on the simulated results, the highest rice productivity and biomasses in Purwadadi are in the area where irrigation and fertilizer are provided for the crop. Purwadadi is located in the low elevation area and therefore the irrigation and fertilizer are important for the growth and development of the crop. The absence of irrigation and fertilizer caused the decreasing of rice productivity and biomasses compared to the area where at least irrigation or fertilizer is provided for the crop. Based on the simulated results, irrigation have the bigger impacts on rice productivity and biomasses compared to fertilizer in Purwadadi.



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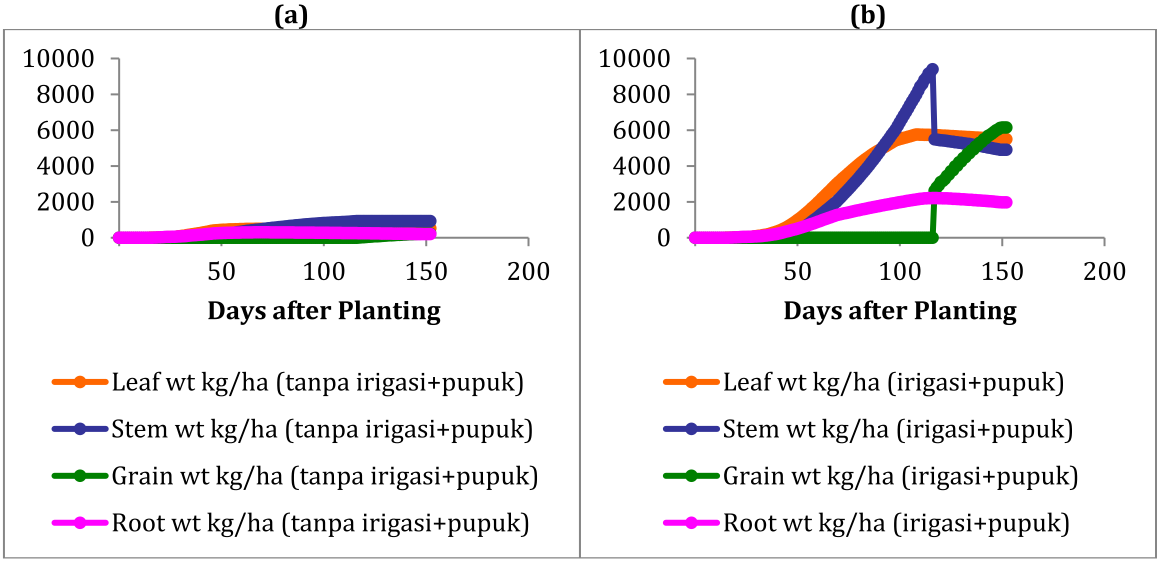


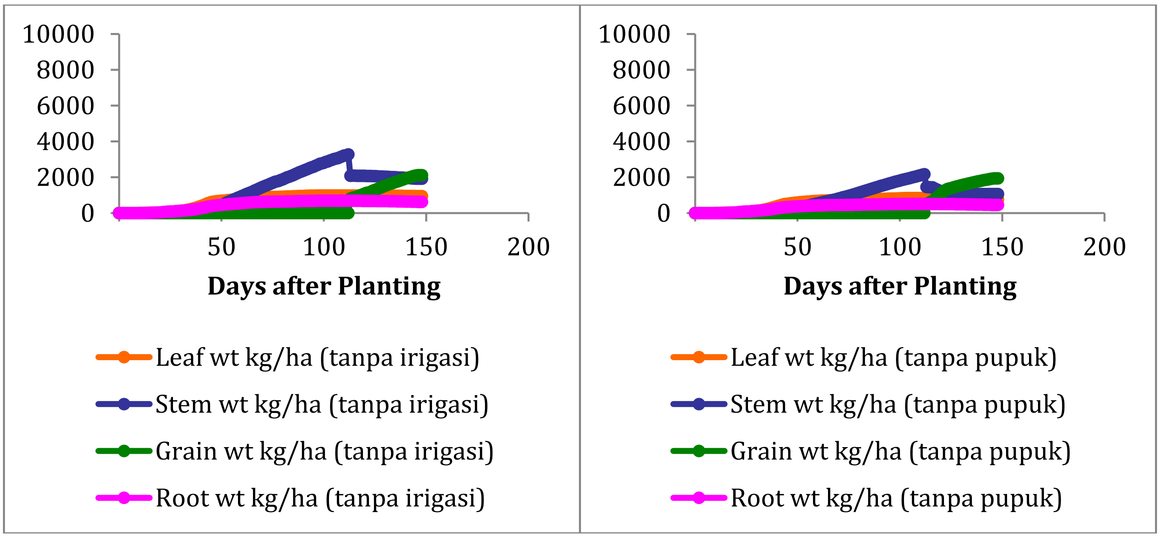
(c) (d)

Figure 22 The biomasses growth simulation for demonstration plot in Purwadadi (a) without irrigaton with fertilizer, (b) without fertilizer with irrigation, (c) without irrigation and fertilizer, (d) with irrigation and fertilizer

Table 16 Rice productivity and biomass of Pagaden in various conditions

Variable	With irrigation and fertilizer (kg/ha)	Without irrigation and fertilizer (kg/ha)	With fertilizer and without irrigation (kg/ha)	With irrigation without fertilizer (kg/ha)
Leaf biomass	4954	528	950	767
Stem biomass	5466	940	1922	1058
Root biomass	1898	219	627	456
Grain biomass	5412	273	2117	1937
Productivity	5412	273	2117	1937

Table 16 shows the rice productivity and biomasses in Pagaden for 1 cultivating season. Rice productivity based on observation in Pagaden is around 7 tons/ha, whereas the closer simulated result of rice productivity is 5,4 tons/ha in the area where irrigation and fertilizer are provided for the crop. Based on the simulated results, the highest rice productivity and biomasses in Pagaden are in the area where irrigation and fertilizer are provided for the crop. Pagaden is located in the low elevation area and therefore the irrigation and fertilizer are important for the growth and development of the crop. The absence of irrigation and fertilizer made the rice productivity and biomasses are really small compared to the area where at least irrigation or fertilizer is provided for the crop. Based on the simulated results, fertilizer have the bigger impacts on rice productivity and biomasses compared to irrigation in Pagaden.



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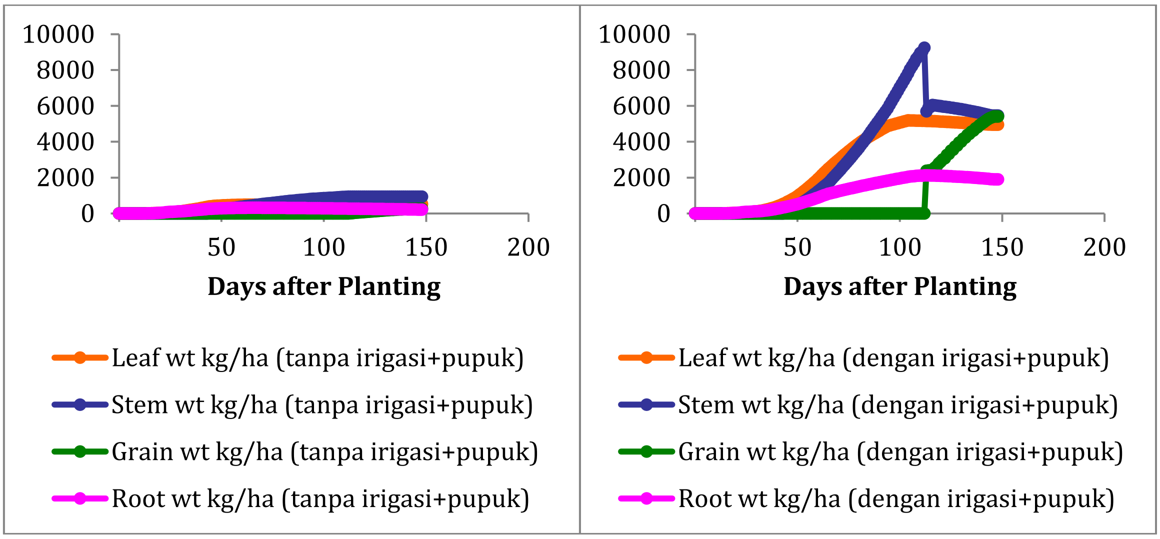


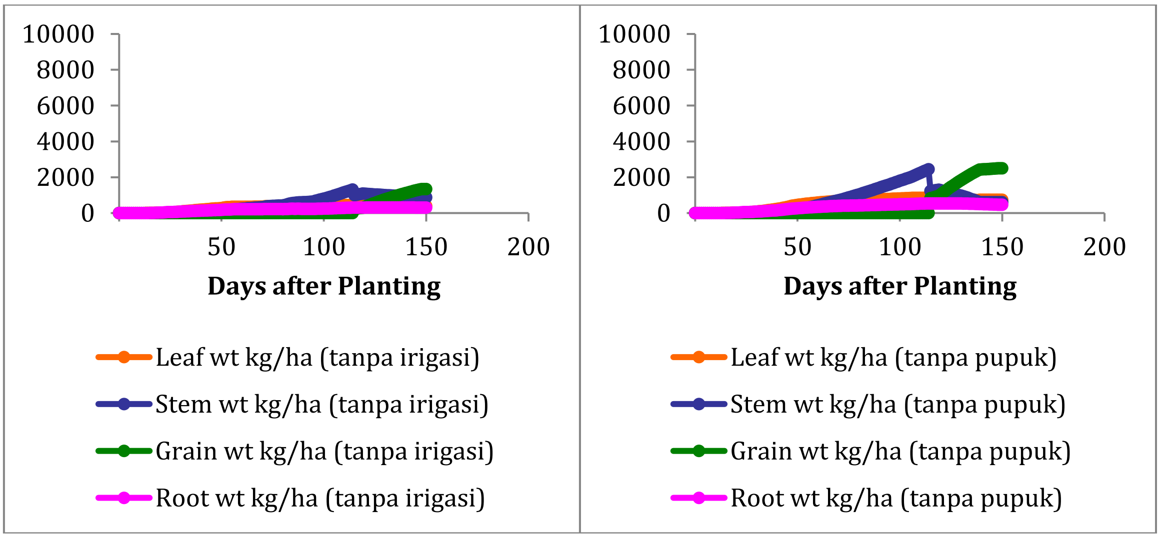
(c) **(d)**

Figure 23 The biomasses growth simulation for demonstration plot in Pagaden (a) without irrigaton with fertilizer, (b) without fertilizer with irrigation, (c) without irrigation and fertilizer, (d) with irrigation and fertilizer

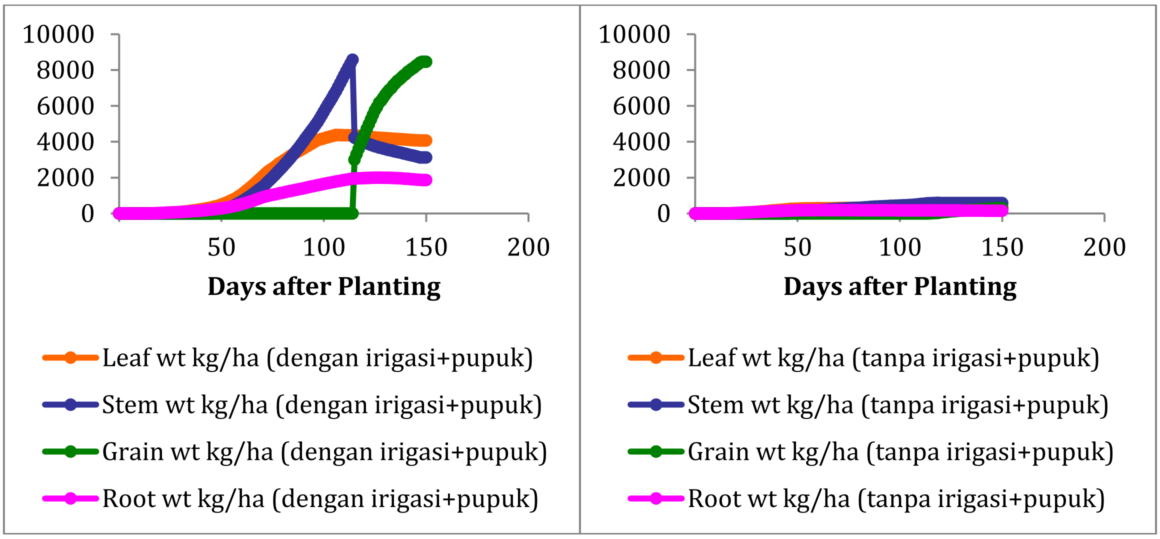
Table 17 Rice productivity and biomass of Binong in various conditions

Variable	With irrigation and fertilizer (kg/ha)	Without irrigation and fertilizer (kg/ha)	With fertilizer and without irrigation (kg/ha)	With irrigation without fertilizer (kg/ha)
Leaf biomass	4067	337	879	746
Stem biomass	3121	579	1342	608
Root biomass	1869	152	1457	469
Grain biomass	8467	290	306	1503
Productivity	8467	290	306	1503

Table 17 shows the rice productivity and biomasses in Binong for 1 cultivating season. Rice productivity based on observation in Binong is around 9 tons/ha, whereas the closer simulated result of rice productivity is 8,5 tons/ha in the area where irrigation and fertilizer are provided for the crop. Based on the simulated results, the highest rice productivity and biomasses in Pagaden are in the area where irrigation and fertilizer are provided for the crop. Pagaden is located in the low elevation area and therefore the irrigation and fertilizer are important for the growth and development of the crop. The absence of irrigation and fertilizer made the rice productivity and biomasses are the smallest compared to the area where at least irrigation or fertilizer is provided for the crop. Based on the simulated results, irrigation have the bigger impact on rice productivity and biomasses compared to fertilizer in Binong.



(a) **(b)**



(c) **(d)**

Figure 24 The biomasses growth simulation for demonstration plot in Binong (a) without irrigaton with fertilizer, (b) without fertilizer with irrigation, (c) without irrigation and fertilizer, (d) with irrigation and fertilizer

Table 18 Comparisons of each locations'rice productivities and biomasses

Variables	**Irrigation and Fertilizer**					**Without irrigation and fertilizer**				
	Pamanukan	**Cijambe**	**Binong**	**Pagaden**	**Purwadadi**	**Pamanukan**	**Cijambe**	**Binong**	**Pagaden**	**Purwadadi**
Leaf biomass (kg/ha)	3224	2785	4067	4954	5503	345	332	337	528	530
Stem biomass (kg/ha)	2816	4375	3121	5466	4918	1291	876	579	940	931
Root biomass (kg/ha)	1518	1400	1869	1898	1977	261	274	152	219	206
Grain biomass (kg/ha)	6561	4526	8467	5412	6153	773	1040	290	273	238
Productivity (kg/ha)	6561	4526	8467	5412	6153	773	1040	290	273	238
Variables	**Without irrigation and with fertilizer**					**Without fertilizer and with irrigation**				
	Pamanukan	**Cijambe**	**Binong**	**Pagaden**	**Purwadadi**	**Pamanukan**	**Cijambe**	**Binong**	**Pagaden**	**Purwadadi**
Leaf biomass (kg/ha)	369	2845	879	950	1065	795	305	746	767	773
Stem biomass (kg/ha)	1491	4426	1342	1922	1790	2414	881	608	1058	463
Root biomass (kg/ha)	314	1419	1457	627	638	508	262	469	456	427
Grain biomass (kg/ha)	1023	4582	306	2117	2144	1564	1008	1503	1937	2210
Productivity (kg/ha)	1023	4582	306	2117	2144	1564	1008	1503	1937	2210

Demonstration plots	**DSSAT**	**Field observation**
Pamanukan	6,6 tons/ha	6 tons/ha
Cijambe	4,5 tons/ha	4 tons/ha
Pagaden	5,4 tons/ha	7 tons/ha
Purwadadi	6,2 tons/ha	7,2 tons/ha
Binong	8,5 tons/ha	9 tons/ha

Table 6 shows the comparison of rice productivities and biomasses on 5 locations with 4 different treatments for 1 cultivating season based on the output of DSSAT. Based on the table above, the crop area where irrigation and fertilizer are provided for the development and growth of the crop, the highest rice productivity falls on Binong by 8,5 tons/ha. The result matched with the field observation in which Binong also has the highest rice productivity by 9 tons/ha. In the area where irrigation and fertilizer are not provided for the crop, Cijambe has the highest rice productivity by 1 ton/ha. In the area where only irrigation which isn't provided for the crop, Cijambe also has the highest rice productivity by 4,6 tons/ha. The simulated result are closed with the field observation result. Cijambe is located in the highest elevation area compared to the other four sub-districts (Pamanukan, Pagaden, Binong, and Purwadadi) and the irrigation is considered not needed considering the high precipitation in the first cultivating season (Oktober – Maret) and the area's location near the water springs. In the area where only fertilizer that isn't provided for the crop, Purwadadi have the highest rice productivity compared to the other 4 areas.

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Combining simulation model and field observation in understanding crop productivity to climate variation

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Abstract. Changes in climate characteristics affect the growth and development of paddy and therefore affect rice productivity. Simulation model can be used to study the effect of climate change on rice productivity. In this study, combination of crop simulation model and field observation are used to comprehend the effect of climate change on rice productivity. The study uses field observation data. Climate, soil, and crop management input variable are similar to observation conditions. The rice productivity in Pamanukan, Binong, Pagaden, Purwadadi, and Cijambe are about 6, 9, 7, 7, and 4 ton/ha. The output of the crop simulation model shows that rice productivity estimation based on the model have similar amount to rice productivity based on the field observation. Productivity estimation of simulation models based on climate change scenarios can be used to prepare mitigation and adaptation actions.

Keywords:climate change, rice productivity, simulation model

1. Introduction

Rice (Oryza sativa L.) is the main food crop cultivated in Indonesia. The need for rice increases every year in line with the rate of population growth [1]. This causes an increase in rice crop productivity to be the main focus of Indonesian agriculture. Rice farming provides employment for 21 million agricultural households in Indonesia [2]

Increasing the productivity of rice plants has various challenges. Challenges such as increasing the productivity of rice plants and the conversion of land degradation, agricultural infrastructure, availability of production facilities, the adoption of appropriate technology, extensive land ownership, agricultural institutions, farmers' access to capital, guarantee crop prices, and global climate change [3](Puslitbangtan 2008).In addition to agricultural management, challenges to climate change in the form of shifting rain patterns, changes in temperature and humidity directly affect the productivity of rice plants [4][5][6][7]. Climate change increases the vulnerability of pests to plant diseases, increases water stress, and decreases rice productivity[8][9]

Planning and management of rice is done as a form of adaptation to the challenges of rice plants. Planning and management of rice plants is carried out with the irrigation planning cropping system, fertilizer, pest control systems and plant season planning [10]. Post harvest management is also carried out to stabilize food prices, especially rice

A food crop simulation model as an alternative solution for food crop planning [9][10]. Food crop simulation models are used to assess the impacts of climate change and analyze adaptation strategies [9]. In this study, the Aquacrop model is used to simulate land water balance and the DSSAT (Decision Support System for Agrotechnology Transfer) model is used to estimate the productivity of rice crop yield components in one planting season.

A combination of a food plant simulation model with field observations was conducted to validate the results of a food crop simulation model, evaluate various agricultural management, and predict rice productivity based on climate change. This study provides the view that the food crop simulation model

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can be used to develop agricultural planning and management strategies, the food crop simulation model can be used as a basis for adaptation and mitigation actions related to food security, and be an option for estimating crop productivity and in areas with limited access.

2. Materials and Methods

This research was conducted with a general approach to the method as shown in Figure 1.

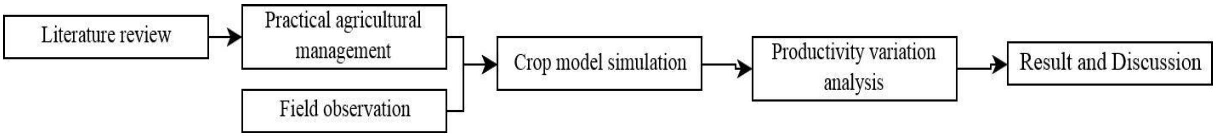

Figure. 1 Research general approach diagram

2.1 Literature Review

Literature review is conducted from January 1, 2019 to January 15, 2019 using the Google Scholar search engine (scholar.google.com). The keywords used are agricultural management, crop model simulation, paddy phenology field observation, rice productivity on climate change scenario

2.2 Practical Agricultural Management

Practical agricultural management in the form of determination of planting time, land processing technology, selection of cultivars, the time and amount of irrigation, the time and amount of fertilizer application, and the time of pest control of rice plants. Practical agricultural management refers to the Integrated KATAM of the Ministry of Agriculture and is verified by field observations.

2.3 Crop Model Simulation

2.3.1 DSSAT 4.7. The DSSAT 4.7 simulation model was carried out in the demoplot of Pamanukan and Cijambe Districts with the location of the area in Figure 2. The method uses the default simulation option DSSAT 4.7. The data used the DSSAT 4.7 simulation model in Table 1.

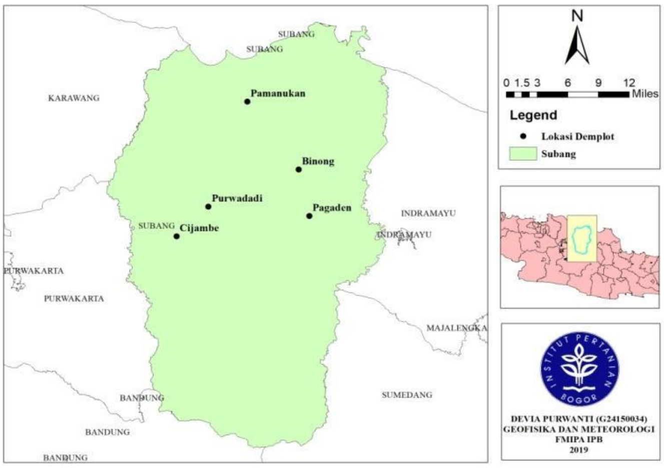

Figure. 2 Demoplot location

Table 1. Data input simulation model DSSAT 4.7

Data	Parameter	Description
Climate	Daily rainfall, maximum air temperature, minimum air temperature	Pamanukan Demoplot of 1 January 2018 - 6 June 2019 Cijambe Demoplot of 1 January 2018 - 24 May 2019
Soil	Physical/chemical properties	Soil Laboratory test of Pamanukan and Cijambe demoplot
Farming management parameters for the CERES-rice model		

Parameter	Pamanukan	Cijambe
Planting date	December 31, 2018	January 9, 2019
Planting method	*Dry seed*[a]	*Dry seed*
Planting distribution	*Rows*[b]	*Rows*
Plant population at seeding/m^2	250	100
Row spacing	20 cm	30 cm
Planting depth	5 cm	10 cm
Row direction, Degree from North	0	0
Irrigation	200 mm at 2,9,15, and 20 DAP; 150 mm at 25 DAP; 100 mm at 30 DAP; 70 mm at 41,51,62,65,68,74 and 77 DAP	90 mm at 9 and 17 DAP; 150 mm at 27 DAP
Urea	220 kg / ha at 10 DAP	310kg/ha at 17 DAP
		95 kg/ha at 41 DAP
		95 kg/ha at 47 DAP

Genetic coefficients for IR42 (Pamanukan) and IR64 Cijambe varieties				
coefficient	Unit	Definition	IR42 Value	IR64 Value
P1	^{0}C day	*Thermal unit* for vegetative base phase	651	500
P2R	^{0}C day	Day length sensitivity coefficient	120	160
P5	^{0}C day	*Thermal units* are needed from the initial filling of grains (3-4 days after initial flowering) rice to physiological maturity	580	450
P2O	Hour	The length of the critical day when developments are at their maximum rate	10.5	12
G1	(/gram)	Potential grain coefficient as an estimate of the number of grains per gra at flowering	65	60
G2	Gram	Unit grain weight under ideal development conditions (light, water, and nutrients are met, while pests and diseases are absent)	0.028	0.025
G3		Koefisien anakan	1	1
G4		Temperature coefficient of tolerance (usually a value of 1 for varieties that grow in a normal environment)	1	1

Note: DAP= Days after planting

2.3.2 Aquacrop. Aquacrop simulation models carried out in 2 out of 5 clusters of Subang Regency [11]. Data used in the DSSAT 4.7 simulation model in Table 5

Table 2. Aquacrop simulation model input data

No.	Data	Parameter	Description
1	Iklim	Daily rainfall, daily maximum air temperature, daily minimum air temperature	Field observation data for Binong, Pagaden and Purwadadi areas
2	Soil Profile	Physical properties of soil	Test results of the Environmental Biotechnology Laboratory at the Indonesian Center for Biodiversity and Biotechnology
3	Irrigation Management	High irrigation	The water level is 20 mm to 5 DAP and 50 mm / 10 days to 70 DAP
4	Rice plants	Plant Characteristics	Results of Aquacrop simulation model calibration

2.4 Field Observation. Data and methods for collecting field observations are shown in Table 6. Field observations were carried out in the demonstration plots of Pamanukan, Binong, Pagaden, Purwadadi and Cijambe Districts.

Tabel 3. Data and field observation data collection methods

No	Data	Parameter	Observation Method
1	Climate	Rainfall Air temperature air humidity evapotranspiration	1. Rainfall data is taken with a simple rain gauge measured 2 days 2. Measured using a thermometer every day 3. Measured with a wet ball and dry ball thermometer then a calculation is made 4. Plant samples are taken on paint cans and weighed 2 days
2	Phenology	Plant height and tillers	Measured using tape measurement and counters once a week in the vegetative phase and 4 days in the generative phase
3	Irrigation	Soil water level	Measured by tape measurement following phenological measurements

3. Result and Discussion

3.1. Field Observation Result

The characteristics of the study locations are shown in Table 7. Variations in climatic characteristics can be seen from the high rainfall [11]. Variations in the phenological characteristics of plants can be seen from differences in rice varieties [12]. Climate characteristics and characteristics of rice varieties determine the needs of rice water plants and rice productivity in each region [12]. Cijambe demoplots have the lowest productivity because the growth and development of plant phenology is not optimum at low temperatures.

Tabel 4. Research location characteristics observation results

Demoplot (Varietas)	Variabel						Producti-vity (ton/ha)
	T Average (°C)	Rainfall (mm / plant season)	RH (%)	Tillers (stem)	Plant Height (cm)	Water Requirement (mm/ plant season)	
Binong (Ketan)	29	600	86	38	123.88	1134	9
Purwadadi (Inpari 32)	28	536	88	29	112.84	897	7
Pamanukan (IR42)	29	1033	87	49	140.20	1242	6

Pagaden (Tarabas)	31	542	84	24	134.84	1216.	7
Cijambe (IR64 Jumbo)	25	2471	85	30	104.63	690	4

3.2. Crop Model Simulation

3.2.1 Crop Water Requirement. A comparison of the water needs of the Aquacrop simulation model results with the observations is shown in Figure 3. The daily water requirement trend of the simulation model with field observation results is negatively related but simulation model result have a fluctuation pattern following field observation results. Field observation results have a value of 10-12 higher than crop simulation model results. High water requirement influenced by differences in the phase of rice plants [13]. This is caused by Aquacrop not taking into account agricultural management.

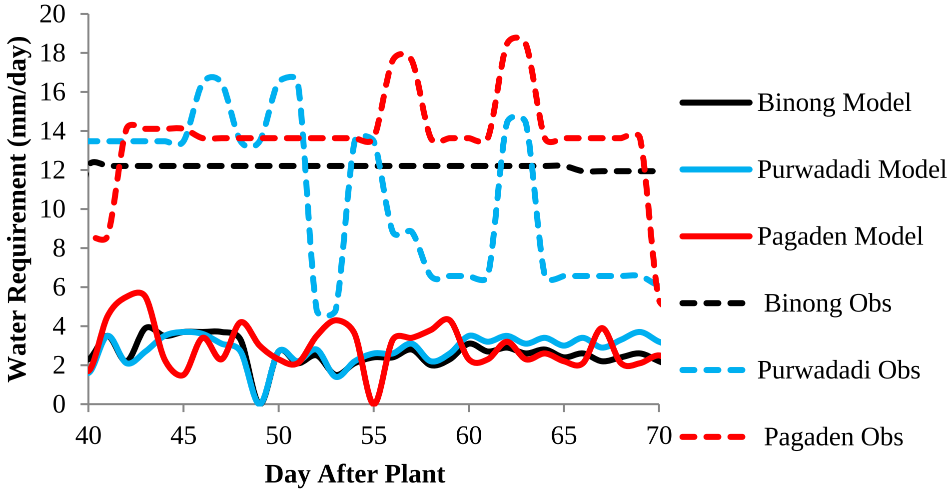

Figure 3. Comparison of crop water requierement model simulation and field observation

3.2.2 Biomass productivity. Growth conditions of rice plants can be seen from the growth of leaf biomass, stems, roots and grains of rice. The biomass of leaves, stems, and roots of rice tends to increase and reach a maximum point at 100 HST. Stem and leaf biomass growth is a reference for rice plant growth conditions in the vegetative phase and initial indicator of rice crop productivity estimation. Rice biomass growth can be the basis for estimating rice productivity. The biomass growth of leaves, stems, roots and ears can be seen in Figure 4. The pattern of height and number of observed tillers was positively related to the growth of biomass from the simulation model. Plant height and number of tillers observed in Figure 5. illustrates the growth of rice plant biomass in the field.

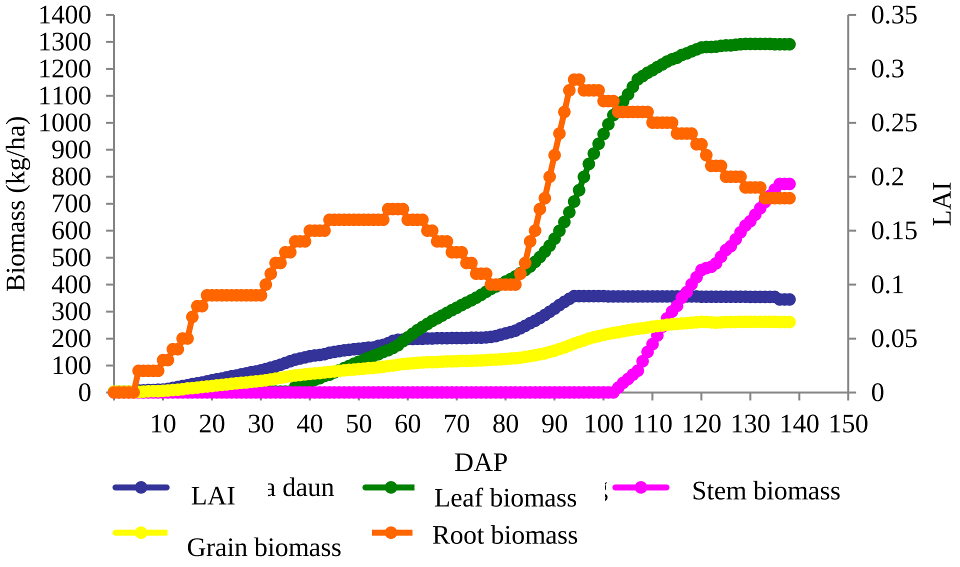

Figure 4. The model simulation result of rice growth components in the Pamanukan demoplot

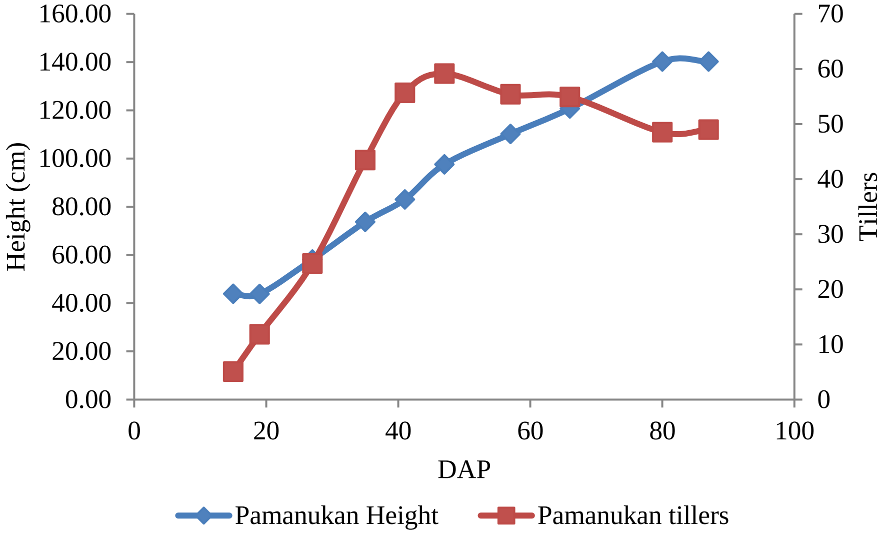

Figure 5. Pamanukan demoplot rice plant phenology observations

3.2.3 Rice Productivity. Rice productivity comparison from DSSAT simulation results with field observations is shown in Table 8. DSSAT simulation results with irrigation and fertilizer inputs based on field conditions show values that are comparable to the results of field observations. DSSAT simulation results without irrigation and fertilizer show productivity results that are only influenced by regional climatic conditions. DSSAT simulation results without irrigation and fertilizer have a very low productivity value compared to the results of field observations. The application of fertilizer and irrigation is an act of adaptation and mitigation of agricultural management for climate change [9]

Table 5. Productivity estimation comparison using the DSSAT model and field observation productivity

Demoplot	DSSAT (with irrigation + fertilizer)	DSSAT (without irrigation + fertilizer)	Field Observation
Cijambe	4,5 ton/ha	1 ton/ha	4 ton/ha
Pamanukan	6,5 ton/ha	0,8 ton/ha	6 ton/ha

4. Conclusion

Archiving observation data for plant growth and development has not well recorded in Indonesia. The statistical data are usually reported only crop production and/or productivity. On the other hand, devising tactical management strategy for farming in anticipating climate variation or extremes requires understanding on contributing factors to crop growth and development such as climate, soils and applied farming practices. This study shows a plant simulation model as an alternative solution for planning and management of food crops. We utilized agricultural simulation models, i.e., Aquacrop and DSSAT, in combination with field observations to study plant growth and development as well as the effects farming practices to paddy production at the study sites.

The results of the simulation of crop models have a value not far different from the results of field observations. Plant simulation models can be an evaluation instrument for agricultural management. Crop biomass productivity simulation model have a similiar trend to field observation phenology. Water requirement result between model simulation and field observation have a similiar fluctuation pattern. Simulation models can be used as an alternative to study crop growth and development. The models also offer an opportunity to predict crop response to different environment (ie., climate, soils,) and farming practices (i.e., cultivar, irrigation, fertilizers).

5. Acknowledgement

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Water requirement based on climate characteristic (case study: Subang Regency)

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Abstract. Regional climate conditions, especially rainfall, air humidity and air temperature are among the factors that affect the water needs of rice paddy. Research on water requirements based on climate characteristics needs to be done to support water management towards efficient use of water and early climate-based drought detection. This study aims to compare the estimation of rice crop water requirements, analyze the adequacy of rainfall to the water needs of rice paddy plants for each climate characteristic, analyze the response of water needs of rice paddy plants to climate characteristics and analyze the actions of farmers in response to meeting the water needs of rice plants. The need for rice water is determined by calculating the evapotranspiration value minus evaporation to get transpiration values. The total rice water requirements are compared with the total rainfall in each climate region. The response of rice water needs is influenced by the phase of growth and development of rice which follows the distribution pattern of air temperature of each demoplot. Water requirement estimation for demoplot Binong, Purwadadi, Pamanukan, Pagaden and Cijambe are 1134mm/season, 897mm/season, 1242mm/season, 1216mm/season, dan 690mm/season. Water requirements are significantly influenced by the average air temperature and relative humidity (climate variable) and crop height and number of tillers (rice varieties). Effective total rainfall does not meet the rice water needs of each demoplot. The provision of irrigation water is carried out to meet the rainfall deficit in each region. The tendency to provide irrigation water based on the number of rainy days and weekly rainfall causes a high inaccuracy of soil water content that rice can use in certain growth phases.

Keywords: evapotranspiration, climate characteristic, rainfall, water balance, water requirement

4.12 APPENDIX C. Modules

4.12.1 APPENDIX C.1. Training Module of Tim Iklim for Agricultural Extension Workers

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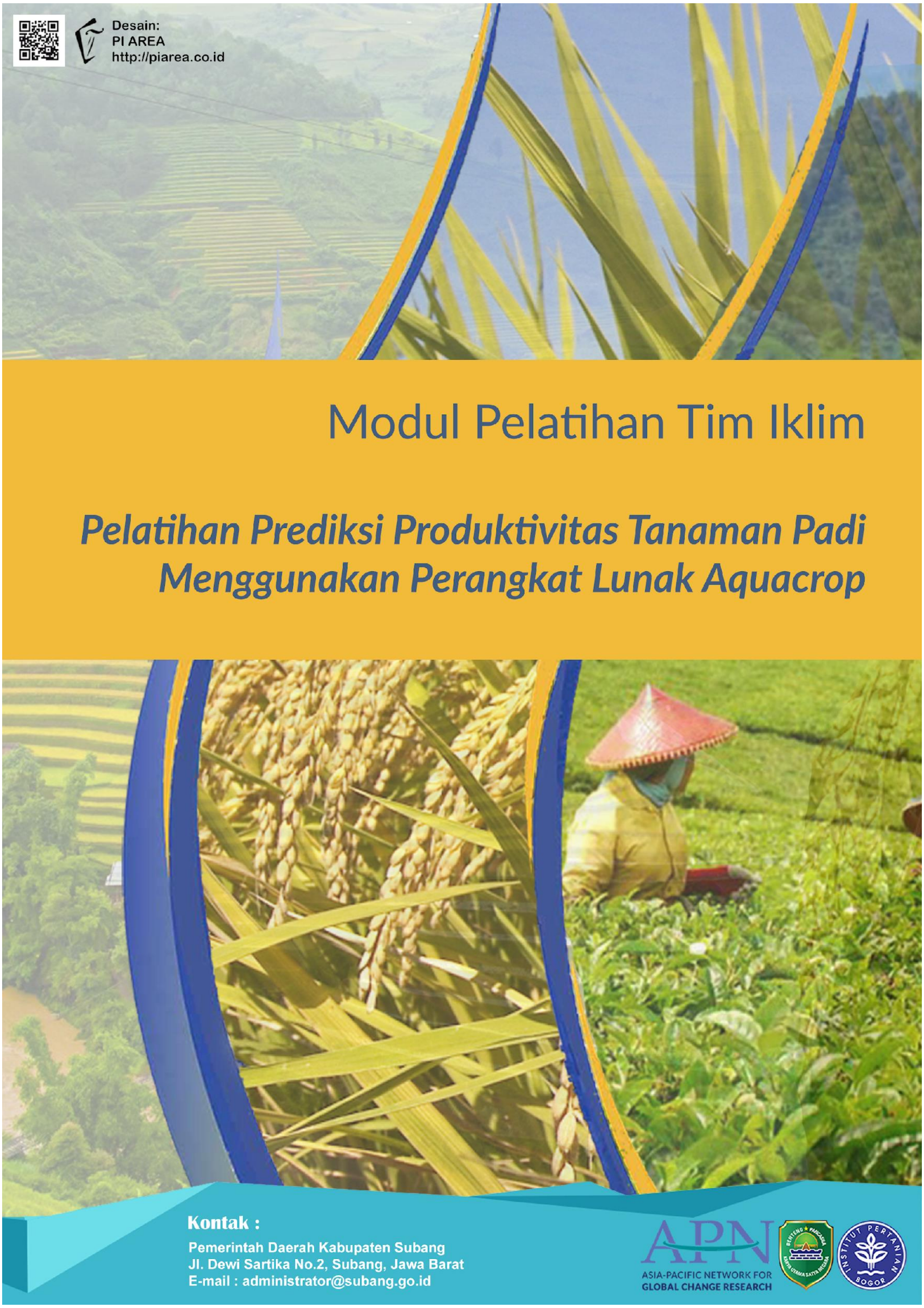
4.12.3 APPENDIX C.3. Training Module for Predicting Rice Productivity using Aquacrop Model



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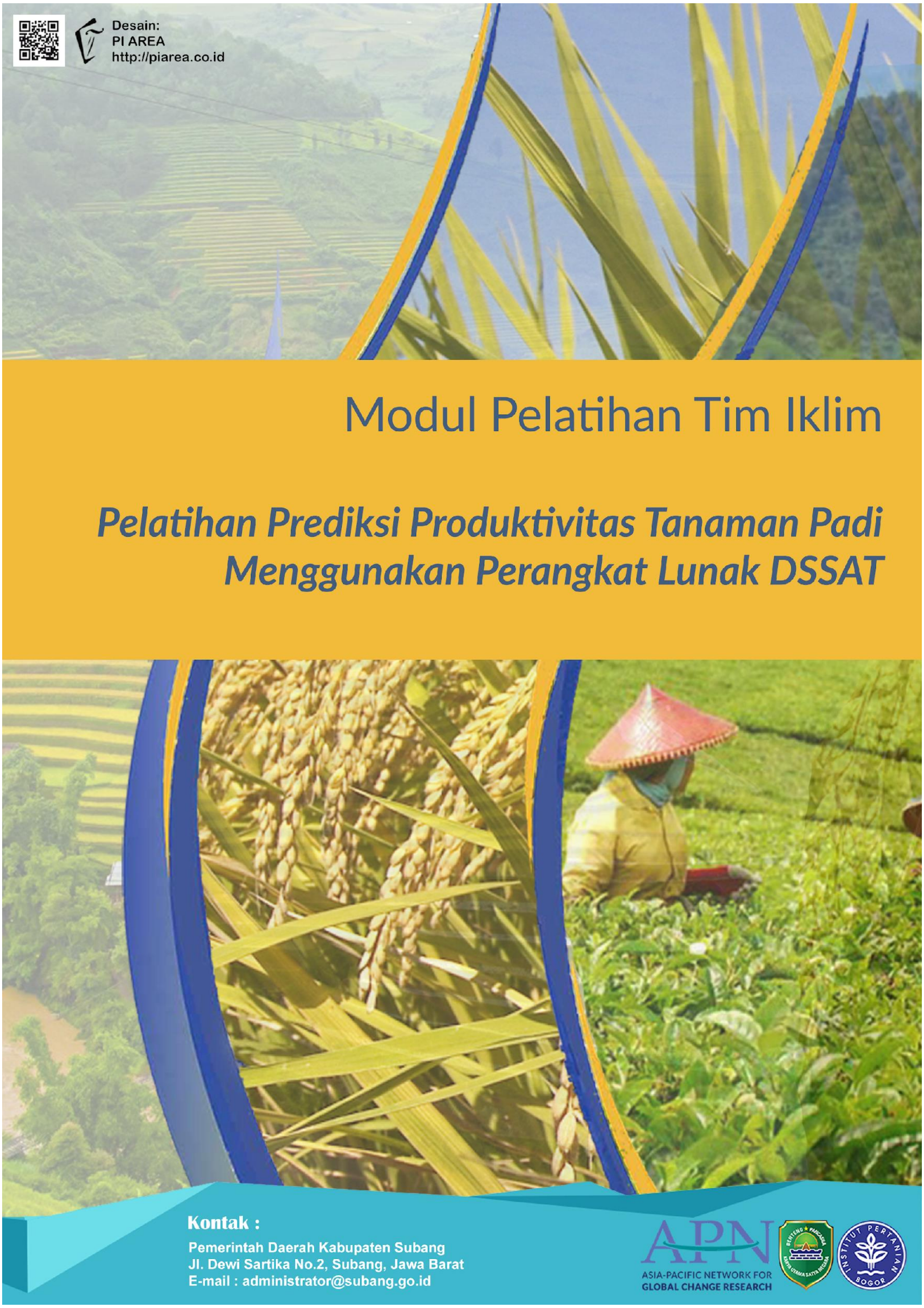

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4.12.5 APPENDIX C.5. Observation Module of Paddy's Phenology, Climate Variable (rainfall, air temperature, air humidity, and evapotranspiration), and Plant Pests

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4.12.6 APPENDIX C.6. Module of Website and Web-Tools Tim Iklim

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