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Changes in government policies for regulating irrigation water in order to maintain food productivity

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Abstract. Global Warming has had an impact on climate change, which has caused disturbance to the availability of surface water and the change in the allocation of irrigation water for agriculture. The agricultural sector is a sector that is vulnerable to climate change. Therefore, the provision of irrigation water must be adapted to climate change so that the supply of irrigation water for agricultural land is well maintained to increase food production. The method used in completing this research is the descriptive method, involving observations during the rainy season, first dry season, and second dry season, soil tests at the research site, and disseminating improvements to the provision of irrigation water, so that irrigation water is more efficient in usage and distributed at the right time at the start of the rainy season, first dry season, and second dry season. In distributing questionnaires and providing understanding of the occurrences of climate change, almost all stakeholders have understood that the provision of irrigation water must be refined and adapted to climate change. Dissemination has been carried out to all stakeholders including the government and relevant agencies. The government promises to change the irrigation water regulation policy in order to maintain food productivity.

Keywords: climate change, irrigation, adaptation, government policies

1. Introduction

Global warming has resulted in climate change, and climate change has caused a shift in the rainy and dry seasons. The durations of the rainy and dry seasons are not fixed; sometimes the rainy season lasts less than six months or sometimes more, and so does the dry season [1]. The annual pattern of precipitation (rain) and temperature will change substantially during this century [2]. This condition causes the availability of surface water to become erratic, and if the surface water is affected, the water discharge conditions are also affected; adjustment by adapting surface water to climate change becomes necessary [3]. Climate change is projected to have a significant impact on the conditions affecting agriculture [4].

The agricultural sector must be adapted to climate change [5]. Therefore, irrigation water supply must also be adapted to climate change so that the supply of irrigation water for agricultural land is well maintained and, in the end, food production can be increased. Food production can be increased through the management of appropriate and efficient irrigation water allocation [6]. Up to now, irrigation water has been supplied by the regency government. Planning for irrigation water supply and planning of the pattern of tertiary plot planting in each irrigation area are outlined in the Global Planting Plan (RTTG).

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This Global Planting Plan arrangement was carried out one year before the implementation of the cropping pattern. The cropping pattern in one year consists of three growing seasons: (1) rainy season/MH; (2) first dry season/MK1; and (3) second dry season/MK2. Considering that the use of irrigation water must be managed efficiently in order to produce environmentally-friendly cropping patterns and to be adapted to climate change, the Global Planting Plan preparation also needs to be adapted to climate change so that the Global Planting Plan implementation can increase rice productivity and avoid crop failures. Because the Global Planting Plan arrangement is one of the policies of the district government, after all stakeholders understand and can accept ways to utilize irrigation water efficiently and create an improved Global Planting Plan that is more appropriate to climate change, it is then expected that there will be improvements in policies from related agencies.

2. Materials and Methods

Greater numbers of studies show that the world is warming and will continue to warm up when greenhouse gas concentrations increase in the future [7]. This has resulted in climate change. Climate change can affect ecosystems, the environment, and water sources. One of the most important impacts of climate change is the change in available water at the regional and local levels [8].

The conclusion from these results is that it is important to know how climate change impacts water resources in the river area and to formulate policies that are appropriate for the utilization and management of appropriate resources [9]. Policies must be determined based on societal conditions in relation to water resources management [10]. The availability of water resources and agricultural land has the potential to become increasingly scarce and limited, while water needs for a variety of interests are increasing, causing more competition for water demands [11].

Agriculture is an economic activity that is very dependent on climatic conditions. Climate change has threatened the productivity of the agricultural sector, making it vulnerable, both economically and physically, to imbalances and climate change. Productivity is influenced by a number of climate change variables including rainfall patterns, rising temperatures, changes in sowing and harvesting, water availability, and land suitability [12].

The Global Planting Plan, also called the Regional Planting Plan (RTTD), is a set of guidelines that includes plans for planting area, planned cropping patterns, planned planting time, and planned allocation of irrigation water provision in an Irrigation Area (DI), while an Irrigation Area is made up of land areas or rice fields that receive irrigation water from an Irrigation Network (JI). With the occurrence of climate change, the planned irrigation water allocation is not the same throughout the year, but must consider the pattern of effective rainfall times that fell one year before the implementation of the Global Planting Plan for the following year. This continues for later years; dynamically, planning of the pattern of effective rainfall times should always be carried out first as a reference to determine alternative planting schedules before planning the Global Planting Plan.

From the preliminary research, a new Global Planting Plan has been created that is more accommodating to the shifting seasons. The new Global Planting Plan considers the shift in the rainy season and factors of rainfall amount and percolation in paddy fields [1]. Based on the preliminary research, it is necessary to conduct research to improve the use of irrigation water in order to be more efficient, as well as to produce environmentally friendly and sustainable cropping patterns and to adapt to climate change.

Previously, the implementation of planting patterns for the rainy season, dry season 1, and dry season 2 were observed from December 2018 to August 2019. Many paddy fields did not deliver expected results and productivity was disrupted. This was due to the fact that many farming communities did not comply with the planting patterns set by the government and water either leaked or were stolen by local people from the irrigation channels, resulting in the allocation of irrigation water being not in accordance with what has been set. To find out how far the people understood about this condition as well as the impact of climate change, distribution of approximately 300 copies of a questionnaire was carried out; these contain questions related to the distribution of irrigation water allocation and the implementation of cropping patterns and rice crop productivity.

The questionnaire was distributed to all stakeholders in the research location as well as people in government positions who are responsible for the distribution of irrigation water allocation. The population of this study is all stakeholders involved in planning and implementing the allocation of irrigation water in the Molek Irrigation Area in Malang Regency. The number of samples were determined based on the Slovin formula, as detailed below [13]:

$$n = N / (1 + N.E^2)$$

Where:
n: Sample size
N: Population size
E: Percent of allowance = 0.05

Furthermore, the questionnaire results were analysed based on Research Variables and Instrument Feasibility Testing (Validity Test, Reliability Test, Data Processing and Analysis). Data obtained from the results of the survey (questionnaire) were processed to obtain information in the form of tables. Data processing was carried out with the aid of Microsoft Excel for Windows.

3. Results and Discussion

3.1. Data Analysis

Data analysis was performed to find out the relationship between cropping patterns in three conditions (rainy season, first dry season, and second dry season) with the availability of irrigation water discharge according to its management. The regression analysis utilized the Microsoft Excel 2007 software and the data collected from questionnaires, which are divided into two data components, being the influencing or independent variables and the affected or dependent variables. Correlation analysis is a kind of analysis to determine the degree of closeness of the relationship between two variables, specifically the relationship between the independent variable(s) (X) and the dependent variable(s) (Y), which can be in the form of first-degree (linear) polynomials of second-degree (quadratic) polynomials. The level of relationship can be categorized as having a positive relationship, having a negative relationship, or not having a relationship.

The variables used in this analysis are independent variables (X) and dependent variables (Y); the independent variables (X) consist of the following four components:

X_1 = Consideration of water availability for cropping patterns
X_2 = Setting the planting pattern by the RTTG
X_3 = Success of the planting pattern by the RTTG
X_4 = Failure of the planting pattern by the RTTG

The dependent variables (Y) consist of the following three components:

Y_1 = Availability of water in the Rainy Season
Y_2 = Availability of water in the First Dry Season
Y_3 = Availability of water in the Second Dry Season

The results of multiple linear regression analysis using Microsoft Excel are described in Table 1, Table 2, and Table 3 below.

Table 1. Summary Output of Water in the Rainy Season

Regression Statistics	
Multiple R	0.569945
R Square	0.324837
Adjusted R Square	-0.06097
Standard Error	6.326094
Observations	12

Table 1 shows that the correlation value between the rainy season planting pattern and the availability of water discharge is 0.569. The coefficient of determination (R^2) is 0.324, which means that the contribution by the availability of water discharge to the magnitude of the influence on the rainy season planting pattern is 0.324 (32.4%), while the rest is influenced by other factors.

Table 2. Summary Output of Water in the First Dry Season

Regression Statistics	
Multiple R	0.423268
R Square	0.179156
Adjusted R Square	-0.2899
Standard Error	7.073358
Observations	12

Table 2 shows that the correlation value between the first dry season planting pattern and the availability of water discharge is 0.423. The coefficient of determination (R^2) is 0.179, which means that the contribution by the availability of water discharge to the magnitude of the influence on the first dry season planting pattern is 0.179 (17.9%), while the rest is influenced by other factors.

Table 3. Summary Output of Water in the Second Dry Season

Regression Statistics	
Multiple R	0.924359
R Square	0.854439
Adjusted R Square	0.771261
Standard Error	2.484799
Observations	12

Table 3 shows that the correlation value between the second dry season planting pattern and availability of water discharge is 0.924. The coefficient of determination (R2) is 0.854, which means that the contribution by the availability of water discharge to the magnitude of the influence on the second dry season planting pattern is 0.854 (85.4%), while the rest is influenced by other factors.

All stakeholders involved in the planning and implementation of the allocation of irrigation water understand climate change situations and conditions that are very influential on surface water and irrigation water; thus, they argue that the RTTG arrangement must be adapted to climate change conditions to avoid the possibility of crop failures.

3.2. Cropping Analysis

In this research, an analysis was performed of the method that has been used, in comparison with the Water Balance/PU method and the Cropwat 8.0 Method, in order to produce a method in accordance with the utilized method. Furthermore, the calculation of irrigation water needs using the most appropriate method to approach the utilized method involved the addition of parameters that have never been added, which are the amount of rainfall and the physical soil condition. The two stages were carried out as the basis for the preparation of a new Global Planting Plan that is based on more complete, more applicable, and dynamic parameters, and follows the development of rainy conditions. The Global Planting Plan results of this research are expected to be carried out in accordance with the plan to anticipate the effects of climate change. Based on the aforementioned, in this study, the best alternative for Regional Planting in the Molek Irrigation Area is carried out in order to improve the needs and availability of irrigation services. Determination of alternative planting patterns in the Molek Irrigation Area based on effective rain patterns in the area is shown in Figure 1.

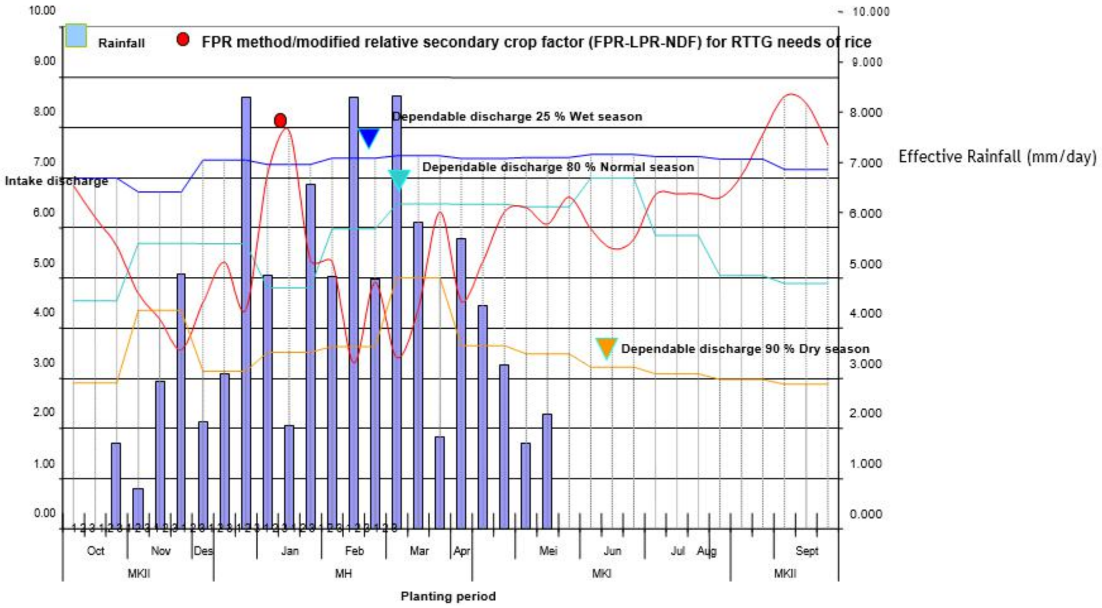

Figure 1. Rain Patterns and Water Needs of Irrigation Intake, Molek Irrigation Area
The New Relative Secondary Crop Factor Method - Relative Secondary Crop Area

The effective rain pattern above is used as a reference to determine alternative planting schedules. Considering that the implementation of planting in one year is divided into three seasons – rainy season, first dry season, and second dry season – based on the effective rain patterns presented in Figure 1, the rainy months are November to April, and thus the good months to start the planting schedule are November to February. The following are alternative analyses of the planting schedule for the Molek Irrigation Area.

1. Schedule for early planting in November, period I
2. Schedule for early planting in November, period II
3. Schedule for early planting in November, period II
4. Schedule for early planting in December, period I
5. Schedule for early planting in December, period II
6. Schedule for early planting in December, period III
7. Schedule for early planting in January, period I
8. Schedule for early planting in January, period II
9. Schedule for early planting in January, period III
10. Schedule for early planting in February, period I
11. Schedule for early planting in February, period II
12. Schedule for early planting in February, period III

Based on the results of calculations and analysis that have been performed, the following conclusions can be drawn:

1. The comparison between the Relative Secondary Crop Factor - Relative Secondary Crop Area method used with the Water Balance/PU method and the Cropwat 8.0 Method leads to the following results. a) The Cropwat 8.0 method has a pattern that is almost the same as the Water Balance/PU method, and is very different from the Relative Secondary Crop Factor - Relative Secondary Crop Area method; the average shows smaller results than both methods. b) The Relative Secondary Crop Factor - Relative Secondary Crop Area method has almost the same pattern as the Water Balance/PU method and the average shows the same results.
2. Calculation of irrigation water needs using the most appropriate method and to approach the

Relative Secondary Crop Factor - Relative Secondary Crop Area method that has been used up to now, with the addition of rainfall parameters and soil physical conditions, shows results that are closer to the availability of discharge.

3. The new Global Planting Plan consists of three Global Planting Plans, as the Global Planting Plan for the wet (rainy) season, the Global Planting Plan for the normal (first dry) season, and the Global Planting Plan for the (second) dry season. The new Global Planting Plan shows that there is a shift in planting time during the rainy season, first dry season, and second dry season. This shift in planting time resulted from simulations of rice planting and secondary crops, which produced the most optimal planting area.

Development of a Global Planting Plan for the wet season, normal (first dry) season, and (second) dry season to anticipate the effects of climate change is composed of the following stages:

1. Analysis of rain data consistency
2. Analysis of regional average rainfall
3. Dependable rainfall analysis
4. Analysis of effective rainfall
5. Analysis of soil physical condition
6. Determination of the initial planting schedule based on reliable rain patterns
7. Determination of Planting Schedule Areas
8. Determination of the Relative Secondary Crop Factor (FPR) value
9. Analysis of the calculation of the New Relative Secondary Crop Factor - New Relative Secondary Crop Area
10. Analysis of the availability of reliable discharge at the intake
11. Analysis of the value of irrigation efficiency
12. Water balance analysis between demand and availability of discharge
13. Determination of planting schedules that produce the most optimal production by several simulations
14. Compilation of the Global Planting Plan
15. At the time of implementation of the Global Planting Plan to be used, if there is a shift in the rainy period and it is confirmed by the appropriate agency for recording rainfall and climatological data that there would be such a change, then cropping patterns would be immediately changed in the next period after harvest.

In the next stage, all research results were disseminated, starting from the results of the questionnaire data processing to the analysis of irrigation water demand and how to determine the Global Planting Plan, which must be adapted to climate change. The participants of the dissemination consist of the officials from agencies responsible for the allocation of irrigation water, heads of sub-districts, and people in society. Farmers who are gathered in the Association of Water Users have understood the importance of changes in government regulations on the planning of cropping patterns, because a plan that is not useless will continue to move itself without any regulatory umbrella from the government.

4. Conclusion

1. All stakeholders involved in the planning and implementation of the allocation of irrigation water understand climate change situations and conditions that are very influential on surface water and irrigation water; thus, they argue that the RTTG arrangement must be adapted to climate change conditions to avoid the possibility of crop failures.
2. All stakeholders already understand how to determine a Global Planting Plan that is more accommodating to climate change. The new Global Planting Plan consists of three types: the Global Planting Plan for the wet season, the Global Planting Plan for the normal (first dry) season, and the Global Planting Plan for the (second) dry season.

3. Considering that the authority to regulate the distribution of irrigation water rests with the regional and central governments, in order for the people to not move independently, this should immediately be followed by changes in regulations governing the preparation of the Global Planting Plan at both the regional and national levels.
4. The appropriate authority for observing climate and weather and rainfall should continuously observe weather changes to ascertain whether the ongoing year is entering the wet season, the normal (first dry) season, or the (second) dry season. This should also be followed by communication and information to agencies that have the authority to regulate the provision of irrigation water for changes in cropping patterns in the next planting period.
5. Dissemination has been carried out to all stakeholders, including the government and relevant agencies. The government promises to change irrigation water regulation policy in order to maintain food productivity.

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