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The effect of temperature rise to rice crop yield in Indonesia uses Shierary Rice model with geographical information system (GIS) feature

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Abstract

The temperature rise is one of issues of climate change that has the effect of rice production in Indonesia, especially to the development and growing of plants. This research used the Model of Shierary Rice with Geographical Information System (GIS) to estimate the decreasing of rice production in every province in Indonesia based on some scenarios of temperature rise. The model used the Shierary Rice to estimate the rice production and Shierary Weather to forecast the weather on the certain location based on the condition of normal climate. The result of research showed that temperature rise would make the age of rice the shorter and decrease the rice yields. This research pointed out that irrigated farm having less impact from temperature rise compared with rainfed farm which had the decreasing of rice yield for 11.1%/OC and 14.4%/OC sequentially as well.

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Keywords: climate change; crop modeling; GIS modeling; rice; Shierary Rice; temperature rise

1. Introduction

Most of Indonesian people consume rice as their primary food. This fact makes Indonesia become the biggest consumer of rice in Asia. Hariadi [1] said that projection of rice consumption in 2010 was 49.3 million tons. The

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high consumption of rice was not balanced by production of their rice. Muttaqin and Martianto [2] said that it was almost every year. Indonesia had deficit of rice stock and this matter caused government import the rice to suffice the national rice need.

The change of Climate is a change of climate pattern that causes the phenomenon of weather fluctuating. Susandi [3] explained that the elements of main climate of climate change are rainfall and air temperature. IPCC [4] reported that the increasing of CO2 concentration in atmosphere in 1970 until 2005 had increased the air temperature for 1.8-2.90C in 2010.

The change of Climate has many impacts in an agriculture sector. One of them is the decreasing of yields. The result of research from Perdinan *et al.* [5] and Surmaini *et al.* [6] explained that the change of climate affected the yields by decreasing the productivity of plant and breadth of crop. The change of Climate affected the phase of growth and age of plant. Therefore, biomass and total yields would decrease [7]. The system of National rice production was valued to be a vulnerable sector with the change of climate. In several areas of Indonesia, Amien *et al.* [8] predicted the production of rice that it would decrease for around 20-30% in 2030.

2. Methodology

This research used mean of monthly rainfall and days of rain. The data was arranged from some climate stations in 1970-2004 by Risdiyanto (in http://banyudata.blogspot.com). The data sources were from various institutions such as Indonesian Agency for Meteorological, Climatological and Geophysics (BMKG), Indonesia Public Works Agency, Agriculture Agency and private sector. The other data are Map of paddy field type (irrigation and rain-fed) in 2003 from Spatial Information Agency (BIG), Map of farm location in 2007 from Forestry Planology Agency (BAPLAN), Digital Elevation Model Shuttle Radar Topography Mission (DEM-SRTM) as altitude data from Consultative Group for International Agricultural Research site, Map of Indonesia administration in 2003 from Statistic Center Bureau (BPS) of Indonesia.

This research used data of point (pixel) with 1x1 km^2 of spatial resolution. Each pixel was produced from spatial processing between map of paddy field, monthly rainfall and days of rain, altitude, and administration map. The attribute from pixel are paddy field location (latitude and longitude), type of paddy field, altitude, province, monthly rainfall and days of rain.

Shierary Rice Model is a model of rice simulation that was able to describe the relation of climate with rice growth and development processes and estimates the harvest as well. This model was developed by Handoko in 1994 [9]. The data of climate was estimated by using the Generator data of Shierary Weather. This model is able to estimate the data of daily weather (temperature, rainfall, sun radiation, relative humidity and speed of wind). Rice yield for each area was calculated from production in each pixel. The impact of temperature rise was calculated from differences between result of temperature rise (Scenario 0) and scenario after temperature rise. The temperature rise was from 0.5°C to 3.0°C with 0.5° increments.

Sub model of development described the rate of development by applying the concept of heat unit. The development of plant will work when temperature of daily average is higher than the crop base temperature. The occurrence of Phenology is calculated since seedling to harvest phase and given 0-1 scale. This occurrence of phenology is divided into five phases of plant development with each different scale as follows, emergence (s=0.00 - 0.25), vegetative (s=0.25 – 0.50), generative (s=0.50 – 0.75), and maturity (s=0.75 – 1.00). The development rate on each phase is calculated below:

I. Emergence

$$s_t = s_{t-1} + 0.25\left(\frac{T-Tb}{TU1}\right) \quad T>Tb \qquad (1)$$
$$s_t = s_{t-1} + 0 \quad T\leq Tb$$

II. Vegetative

$$s_t = s_{t-1} + 0.25\left(\frac{T-Tb}{TU2}\right) \quad T>Tb \qquad (2)$$
$$s_t = s_{t-1} + 0 \quad T\leq Tb$$