Estimation of planting season for food crops based on water balance model at center of food crops, Parimo Regency, Central Sulawesi Province

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Abstract. Rice is an essential and strategic commodity because of its role as the staple food of Indonesian society. The purpose of this study is to facilitate farmers in planning system of planting patterns based on water balance model. It is useful to reduce the risk of crop failure in the centre for food crops. Therefore, it is necessary to make a good plan in regulating rice cropping system pattern based on water balance model. The method used is Thornthwaite and Mather. The data needed to conduct this research are rainfall, temperature data, evapotranspiration data and soil sample data of each sub-district in Parigi Moutong. The results showed that there were some sub-districts not suitable to be planted rice, i.e. Palasa, Siniu, Ampibabo, Suli and Torue. Therefore, other plant alternatives are needed to support food security of Parigi Moutong. The appropriate sub-districts as centres for paddy, i.e. Moutong, Sausu, Toribuli Tinombo Selatan, Dolago and Baliara. The results of this research make researchers easier to map the area after it is known which areas are suitable to be a centre for food crops especially paddy. Finally, it needs great support from the government to create strong food security in Parigi Moutong.

1. Introduction
In Indonesia as is the case with other tropical areas, water is one of the most important factors in increasing crop productivity. Different plants need water depending on the growth stage and type plant. Apart from water, temperature and humidity also has an important role in determine land suitability for each type of plant.

Rice is an important and strategic commodity because of its role as staple food for Indonesian people. The need for rice tends to increase every year as the population increases, on the other hand efforts to increase rice production increasingly difficult due to various problems, one of which is drought. Responding to this phenomenon, the President of the Republic of Indonesia. Mandated that Indonesia must be self-sufficient in food so that it does not depend on supplies from other countries.

In general, the definition of drought is the availability of water which is far below the water requirement for the needs of life, agriculture, economic activities and the environment (Sonjaya, 2007; Yusuf et al., 2020). Drought is very influential on the cultivation of agricultural crops and has an impact on the decline in food production, especially rice.
The spread of agro-climatic zones is an analysis that can provide an overview of how far the potential for the planting period for food crops. Oldeman (1975) has developed a system of climate classification associated with agriculture using climate elements. The analysis is done by counting the number of wet months in a row and the number of dry months in a row adjusted to a station or region. According to Oldeman (1975) what is meant by a wet month for lowland rice cultivation is a month with an average rainfall of > 200 mm/month, while a dry month is a month with an average rainfall of < 100 mm/month. Lowland rice requires an average of 145 mm/month of water in the rainy season, while secondary crops require 50 mm/month in the dry season. Furthermore, in determining the climate classification, Oldeman uses the terms of the length of the wet month and dry month periods, respectively.

Central Sulawesi Province has sufficient dry and wet land potential and is one of the centers development of food crops, land area dry and wet in Central Sulawesi province can support food security in this province.

Availability of water is one of the limiting factors that determine the type and distribution of plants and the period of planting. Each type of plant and farming system requires varying amounts of water, depending on genetic characteristics and environmental factors. The availability of groundwater will determine the water status of plants and is important in the process of CO₂ absorption (Chang, 1968; Jensen, 1991; Grant et al., 1993; Yusuf et al., 2020).

Climate forecasts are still far from perfect, so that the tactical approach can be done through simulation techniques and scenarios. The water balance approach makes it possible to quantitatively evaluate groundwater dynamics and water use by plants (Lascano, 1991; Brisson et al., 1992; Lascano, 2000). This can be done by monitoring crop water stress (Doraiswamy and Thompson, 1982) and evaluating the application of irrigated farming systems to specific climatic conditions (Binh et al., 1994).

The water balance simulation model compiled in this study can be used to estimate the dynamics of soil water content during plant growth, so that it can calculate the amount of plant water needs, especially during periods of water deficit, when the soil water content is very low or under normal conditions. In addition, the output of this model can be combined with Geographical Information System (GIS) techniques.

The aim of the study was to predict the growing season and develop patterns of food crops in dry and wet land based on the water balance model in the center of secondary crops in the province of Central Sulawesi.

2. Material and methods

2.1. Study Area

The research was carried out in the food crop center in Central Sulawesi, especially Parimo Regency, and the materials used in the research are:
1. Identify farm locations
2. Contour map
3. GPS
4. District administrative boundary map, to determine location coordinates.
5. Soil sampling equipment (ring, shovel, hammer, plastic, marker)

2.2. Soil sampling. Soil sampling technique

1. Clean the soil surface of grass or litter.
2. Dig the soil to a certain depth (5-10 cm) around the copper tube candidate is placed, then level the soil with a knife.
3. Place the tube on the ground surface perpendicular to the ground surface, then using a small block placed on the surface of the tube, the tube is pressed until three-quarters of the way into the soil.
4. Place another tube on top of the first tube, and press it until 1 cm into the soil.
5. Separate the upper tube from the lower tube.
6. Dig the tube using a shovel. In digging, the tip of the shovel must be deeper than the end of the tube so that the soil under the tube is lifted.
7. Slice off the excess topsoil carefully first so that the soil surface is the same as the surface of the tube, then cover the tube using the plastic cap that has been provided. After that, slice and cut off the excess bottom soil in the same way and close the tube.
8. Put a label on the top of the soil sample tube cap containing information on the depth, date, and location of the soil sample taking

![Figure 1. Soil sample ring (left) and Steps of soil sampling technique (right).](image)

2.3. Soil Analysis

Field capacity water content
- Weigh the whole soil sample to determine wet soil weight
- Oven the whole soil sample ±2x24 hours
- After being baked, re-weigh the whole soil sample to determine the dry soil weight
- Clean the ring, then weigh the ring
- Calculate Dry Soil Weight
- By knowing wet dry weight and dry soil weight.

2.4. Air dry soil moisture content
- Take 10 g of sifted soil and put it in a cup (weigh the cup first).
- Weigh the soil along with the cup
- Oven the soil for ± 1 x 24 hours and then weighed again to find dry soil weight
- Ring volume = Soil volume

\[ V = \pi r^2 \cdot t \]

Field capacity Moisture Content = weight of wet soil – weight of dry soil x 100% Weight of dry soil

2.5. Climate Data Collection
1. Rainfall data (secondary data from BMKG Palu) for at least 5 years.
2. Evaporation Data
3. Temperature data (using estimation or lapse rate method)

2.6. Data Analysis
By doing calculations using the monthly water balance table to analyze the data.

2.7. Running water balance model
From the results of calculations and analysis, a model graph is made to facilitate the reading/description of the calculation results. Mapping of water availability in Parimo Regency area. After running the water balance model, a monthly water balance map is made for each plant coefficient.
2.8 Data collection

The data used is secondary data owned by the Mutiara Palu BMKG Station for climate data, because the post that observes rainfall data for each point has different post ages so that the availability of data is different for each post, the data needed is based on the availability of existing data. For data on soil characteristics, it is done by direct sampling at the research location.

2.9 Data analysis

Land water balance analysis for each unit of analysis in the research area was carried out using the Thornthwite and Mether method (1957), the results of the land water balance analysis with a geographic information system were mapped based on the potential water surplus period (planting period) and water deficit and those experiencing a water surplus period.

2.10 Region Modeling

The zoning of the availability of plant water content is carried out by running a model that has been prepared by incorporating weather elements and soil parameters so that it is easier to describe the contents of the map and can be used as an early warning to anticipate problems in determining the types of plants to be planted and drought problems in the future to minimize losses due to incorrect cropping patterns.

3. Result and discussion
VALUE IN AMPIBABO

VALUE IN MOTONG

VALUE IN DOLAGO

VALUE IN TORUE
Figure 2. The graph of the value of groundwater availability in the Sub District of Sausu, Suli, Palasa, Tinombo Selatan, Ampibabo, Moutong, Dolago, Torue, Baliara, Toribulu, and Siniu respectively.

The results of calculations in the graph of Sub District Sausu shows for the availability of water is very sufficient on the land, so that the area is suitable to be used as agricultural land for rice plants, the period is May - August, and if the value of the rice coefficient is entered in the calculation, it shows that there is a suitability for the water needs of the land for rice plants. In one year, rice planting can be done once.

Suli Sub district show that basically the availability of ground water on the land is very lacking, so that rice plants are not recommended but other alternatives crops can be planted such as sweet potato, corn, chili and tomato plants, with water conditions very little land is not possible to plant rice, it is necessary to supply water either from irrigation or from rivers that are flowed using pumps or waterwheels if this area is included in the watershed area. Rice plants are not recommended to be planted in this area.

Palasa sub district, the characteristics are clayey soil, from the results of calculations and poured in a weighting graph, it shows that this area can actually be planted with rice considering that the availability of groundwater in this area only occurs in June - August, but if it is forced to plant rice, it is a concern that not sufficient for water needs, the results of calculations using the rice coefficient in July and August show that there is less water availability, so it is not recommended. for rice, but other alternative crops that are suitable for this area, namely tubers crops such as potatoes, cassava and sweet potatoes.

For the South Tinimbo Sub District with the characteristics of dusty clay soil texture, the results of the analysis of the calculated data show that the pattern of groundwater availability on the land shows that it is very sufficient if the land is used for rice farming, seen from May-August shows the pattern of water availability on the land is very sufficient, and if the calculation is carried out by entering the coefficient value of rice plants, then it is suitable if planted in this area because the availability of ground water is very sufficient. In one period of planting rice only once a year in May-August.

For Ampibabo Sub District with clay texture characteristics, basically the availability of ground water on the land shows very less, so it is not recommended for rice, but other alternatives can be planted for sweet potato, corn, chili and tomato plants, but still need a good water supply from
irrigation or from rivers that are flowed using pumps or waterwheels if this area is included in the watershed area.

For the Sub District of Moutong with the characteristics of sandy loam soil, when viewed from the analysis of the results of the calculation of the value of land water availability, it shows that from January to June, the availability of water on the land is very sufficient if this area is used as rice farming land. If the rice coefficient is entered, the water availability value occurs in January-April. In one year, rice planting can be done once only, the period is January-April.

For the Dolago Sub District with sandy loam texture characteristics, the results of calculations and analysis show that this area has very adequate water availability on the land, as can be seen from the graph showing that from April to September the criteria are very sufficient availability of water on the land, this shows that this area is suitable if developed for rice plants, if the coefficient of rice planting is included, it turns out to be very suitable if it is used as a center for rice plants. In one year, rice cultivation can be done twice. April-September period.

For the Torue Sub District with sandy clay texture characteristics, the results of calculations and data analysis show that this area has very less groundwater availability, so that if rice cultivation is carried out it is not suitable because rice requires a lot of water, for that it is not recommended to plant rice in this area. However, if this area is included in the watershed area, additional supply from the nearest river or irrigation is needed if planting rice, or alternatively with plants that do not require a lot of water.

For the Baliara Sub District with dusty clay texture characteristics, the results of calculations and analysis show that for this area the availability of land water is very sufficient if this area is used for rice cultivation, it can be seen from the results of calculations in April - July that the availability of water is very sufficient if used for rice plants. And if you enter the value of the coefficient of rice planting, the availability of water is very sufficient. In one year, rice planting can be done once. April – July period.

For the Toribulu Sub-District with dusty clay texture characteristics, it can be seen from the results of the calculation analysis that the availability of groundwater on the land is very sufficient from January to November, although in the middle of the month there are several graphic patterns that show less but are still fulfilled by the previous month, after adding the coefficient value rice plants show there is a match if the plants are planted in this area, in one rice planting only once a year.

For Siniu Sub District with sandy loam soil characteristics, this area if the calculation of the state of land water is seen from the availability of water on the land is very sufficient available from January-August, if you add the value of the rice coefficient it shows the availability of water is very sufficient in May-August, so this area is suitable for rice farming, and rice planting can be done once a year.

4. Conclusion
For areas that do not have sufficient water availability on planting rice, it may be necessary to look for other alternatives, such as corn, chili, tomatoes and potatoes. However, if the area is in a watershed, then if this area is used for growing of rice plant, then it is necessary to make irrigation or increase water supply by using a waterwheel or water pump. Base on the calculation there are some area have less supply of land water availability, such as Sub District Torue, Palasa, Ampibabo and Suli.

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