SPATIAL MODEL OF KOPPEN CLIMATE CLASSIFICATION USING THIESSEN POLYGON OPTIMIZATION ALGORITHM

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[ABSTRACT]

Global climate change significantly affects global and regional climate conditons. This research aims to predict climate distribution by using thiessen polygon algorithm optimization. Thiessen polygon weighs rainfall and measured surrounding areas to predict locations affected by surrounding climate condition. Our study produces spatial model of climate classification and thematic maps of spatial climate in the forms of types of spatial climates based on Koppen climate classification. The Central Java Province itself has three climate types, namely (af) wet tropical, (am) monsoon tropical, and dry wet tropical or savana tropical (aw). It is expected that our study could be used for reference of disaster impact mitigation, determining agricultural cropping patterns, transport navigation and disaster management.

[KEYWORDS] *Climate, Koppen, Thiessen Polygon, Spatial Model, Optimization, Algorithm.*

1. INTRODUCTION

Climate is a weather condition during a long period that could statistically indicate different statistical values for different conditions [1]. Climate differences between different areas on earth is significantly affected by those areas' positions toward the sun. As a consequence, there are several climate classifications that are based on earth's geographical location. In general, climate can be differentiated into tropical climate, subtropical climate, temperate climate, and polar climate [2].

Indonesia has not yet fully utilized climate in numerous sectors. There has been continuing general misconception that perceives that climate is a natural phenomenon that causes disasters and obstructs various activities. This common misconception has to be challenged. The paradigm has to shift from perceiving climate as a cause of disaster to climate utilization to maximize the potentials of natural resources [3]. However, the limited availability of accurate, timely, and easily understandable climate information has been a major obstacle of this effort.

During last years, global climate change has been an increasingly important set of information. This has occurred and will continuously happen in line with increasing human activity [4]. Global climate change affects climate conditions in Indonesia, especially in the Central Java Province. Changing rainfall and temperature are the most obvious indicators of climate change, especially in the Central Java Province.

Our study aims to classify climates in the Central Java Province from 2007 to 2017 into the appropriate climate groups based on rainfall, temperature, and surface area using the Koppen spatial climate classification model. This method is one of the best method to classify and allocate a particular climate into a certain area. We use Thiessen polygon optimization algorithm to determine climate distribution in the areas based on the surface area and rainfall of these areas.

2. USABILITY EVALUATION

The first study investigates spatial model to produce Voronoi diagrams focusing on points and not on linear or polygon ones. This study integrates the Voronoi diagram model and spatial model using raster-based approach. In developing such approach, this study implements ArcGIS with the Arc Objects extension. It focuses on methodology, and implementation based on point, line, and polygon features. This research also discusses the advantages and limitations of the extensions. Extensions exhibit the following features: (1) feasible for points, lines, and polygons; (2) capable to produce multiplicative Voronoi diagram in vector format; (3) capable to provide non-spatial input attributes to Voronoi cells through spatial combination, and (4) capable to produce a set of long-distance Euclidean rasters for spatial modelling [5].

The second study uses the determination of the rainfall distribution in a particular area to calculate and predict rainfall in other areas that do not have rainfall data in particular periods using Thiessen polygon method. More specifically, this method estimates the rainfall of neighboring areas that do not have rainfall data by calculating the weighted average of each rain station of the impacted areas based on polygons that describe the axis lines of connecting lines between two neighboring rain station. This method can predict the average rainfall of designated neighboring areas of the rainfall measurement stations [6].

The third study uses Thiessen polygon method to search zones that affect rainfall measurement stations. In this study, Thiessen polygon determines all rainfall measurement stations in the Anantapuram district to estimate all areas affected by these stations [7].

The fourth study compares three empirical methods of rainfall estimation using the ten years rainfall data of Ogun river, Southwestern Nigeria. This study also evaluates the optimal network density to predict rainfall area and reliability to determine water sources. This research analyzes the 10-years average data (2001-2010) using ANOVA. The results exhibit little deviation of rainfall areal visualization between Thiessen polygon and Isohyetal methods. However, comparison between arithmetic mean of these two methods. This study therefore uses both methods to estimate rainfall of Ogun river topography. Further, this study also discusses the reliability of each method in measuring and extrapolating rainfall data [8].

The fifth study related to the rainfall forecasting are needed in order to support the development in different fields including agricultural areas. There is no one model or system integrating climatic classifications and the weather forecasting aiming at determination of the ideal cultivating season. This rainfall forecasting was developed by processing the previous rainfall data using the combination of Z-Score model, transformation function, and the Winters Triple Exponential Smoothing. The data resulted from the forecasting was used to determine the spatialbased climatic classification in Boyolali, Central Java, Indonesia using Oldeman method. The proposed model is able to predict the weather using climatic classification. The rainfall data resulted from the proposed forecasting model can be used for climatic classification using Oldeman method in the research area [9].

The sixth study mapping of agro-ecological zone, which is integrated with the suitability of land evaluation, will determine the ideal farming system. The ideal farming system including sustainable land management will support the food security scenario of a region. In this chapter, the implementation of fuzzy logic for mapping the agro-ecological zone is discussed. The agroecological zone in Boyolali is used as case study in which the mapping considers its physiographic characteristics and climate. Two physiographic characteristics are involved: slope of the land and elevation. Rainfall is used as representative of climate. The experiment results reveal that simple membership function with the Mamdani inferences system could help decision makers to classify the agricultural land in Boyolali [10].

Previous studies classify climates using Oldeman classification, Schmidt-Fergusson, and standard Thiessen polygon methods The SchmidtFerguson comparison based on the comparison of wet and dry months. These three methods' main weakness is that they ony use rainfall data and only emphasize water intensity. Meanwhile, climate differences are also affected by the hemisphere's location relative to sun. Further, various temperature in different hemispheres produce different humidity for each area. Consequently, these three methods are less accurate in estimating climate of certain areas. In response to that, we propose the Thiessen polygon optimization method to improve the climate classification accuracy.

3. PROPOSED METHOD

The climate components that exhibit notable diversity is the basis of climate classification with rainfall data is the commonly used climate element. Climate classification is generally very specific in use such as for agriculture, plantation, aviation, and marine. Specific climate classifications also use climate element data as their basis, but only select related climate element data that directly affect activities or objects in these fields [7].

Agriculture is one of human activities that is heavily affected by climate. Climate conditions of particular areas significantly affect agricultural activities and climate continuously change according to area and time scales. In time scale, climate change will produce certain patterns or cycles, such as daily, seasonally, annually, or cycles covering several years.

Global climate change has been increasingly important information in recent years. This will likely continue in the future in response of increasing human activity. Added with increasing number of rainfall measurement posts, global climate change likely changes climate types based on Koppen classification. Meanwhile, agricultural decision making highly requires climate information of particular areas. Technological advances enable ones to integrate climate identification process of certain areas with information technology to exhibit zonal climate data in spatial figures in the forms of zones of spatial climate types. This visual figures arguably simplifies the reading and interpretation of the data [8].

This method take the proportion of rain stations' affected areas into account to accommodate distance differences. Affected areas are formed by describing axis line on connecting lines of nearest rain stations. This method assumes that rainfall variation among rain stations are similar and rain station can represent neighboring areas. This method is appropriate when rain stations are not evenly spread and limitedly distributed relative to areas covered. This method calculates the weighting factors or Thiessen coefficients by including the area effect factors that represent rain station. Selection of rain station must consider the related river basins. Formula [13] calculates the Thiessen coefficient.

This method creates polygons that are perpendicular to the middle of the connecting line of two rain stations. Consequently, each rain measurement station Rn will be located on a closed polygon area of An. By calculating the ratio of polygon area for each station = An/A where A = basin area or reserving area and multiplying this ratio rainfall Rnt produces Rnt x (An+ A) indicating weighted rainfall. Average rainfall is generated by adding all weighted rainfall data for each area within reserving areas. If there are n stations in reserving areas and m in neighboring areas that affect reserving areas, then the average rainfall (Rave) in equations 1, 2, and 3 will be.

A thematic map (statistical map or specificobjectives map) exhibits spatial usage pattern of a particular area according to a specific theme. Its main objective is to specifically communicate concepts and data. The following are the examples of thematic maps that are commonly used in planning: kadastral map (ownership borders), zonal map (map of legal plan of land use), land use map, population density map, slope map, geology map, rainfall map, climate map, and agricultural productivity map. The objective of thematic map and terrain conditions determine data collected. Different from a referential map that exhibits geographical specialization (forests, roads, administrative borders, and climate), a thematic map tend to focus on the variation of spatial use instead of the amount of geographical distribution. This distribution refers to physical phenomena such as population density or health problems [14].

4. CONCLUSION

Based on the system development, it can be concluded that Koppen climate classification can be used to classify climate in Indonesia, especially in the Central Java Province. We use BPS data, namely rainfall, temperature, and surface area to determine each polygon of each regency in the province. From 35 regencies in the Central Java Province, 20 regencies exhibit Am climate, 13 regencies have Aw climate and 2 regencies with Af climate. We also find that the application of Thiessen Polygon method on Koppen climate classification generates different results from the Koppen climate classification itself. More specifically, 18 regencies have Aw climate, 13 regencies with Am climate, and 4 regencies with Af climate.

Our study can be used for informational reference for provincial or municipal agencies dealing with agricultural, transportation, and other fields that are related to the use of Koppen climate classification. It is expected that the availability of visual information will enable visual climate information searching process better and more accurately and optimize the natural resource potentials.

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