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Analysis of Distribution of Rain Stations Based on Physiomorphohydro Zoning

D. Rohmat* and I. Setiawan

Departement of Geography Education, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudhi 229 Bandung 40154, Indonesia

*dede_rohmat@upi.edu

Abstract. The placement of a rain station must precisely represent the area it is measuring, so it is necessary to examine the distribution of existing rain stations compared to the characteristics of the area measured. This study aims to assess the distribution of existing rain station in East Java compared with physiographic variables, altitude and rainfall characteristics. The method used is overlay map method using Geographic Information System application. The overlaid maps consist of physiographic maps, topographic maps and rain maps whose results are called physiomorphohydro maps. The results showed that the distribution of rain stations in East Java is relatively uneven compared to the physiomorphohydro condition. Based on the overlay results it is known that there are a number of zoning that have no rain stations and excessive rain stations. Other zones have the corresponding number of rain stations. The number of zoning physiomorphohydro which has no rain station as many as 23 zones and more as 33 zones and as many as 6 zones have been appropriate. Therefore, it is necessary to review the distribution of rain stations in East Java in accordance with the characteristics of the area measured.

1. Introduction

Rainfall data has been used by many parties for various purposes. The existence of these data is very important for planning in the fields of agriculture, irrigation, transportation, industry, tourism and so on. In Indonesia, rainfall data is provided by official institutions namely Meteorology and Geophysics Agency . Besides that, there is also rainfall data in a number of other agencies to fulfill their needs in a limited area, such as dam managers, universities, and others.

Of course the availability and accuracy of rainfall data is very important to be considered by data providers and data users. Data availability will be related to the distribution of stations or rain posts, as well as data accuracy. WMO (World Meteorological Association) states that in the tropics a network of rain stations is required to have a minimum density of 100-250 km^2. WMO also provides more detailed guidance for small mountainous regions with irregular rainfall of 25 km^2 per station and 10-20 km^2 per station in urban areas. If the area is difficult with a heavy terrain the density of the rain station is recommended at 250-1000 km^2 [1].

A number of other experts, using a different approach, proposed a method of rain network which had the final result in the form of the number of rain stations, distance between stations, and distribution patterns in the form of equilateral triangles [2]. Meanwhile, determined the method of placing a rain station by linking network density and rainfall data statistics [3]. Awadalllah, uses the Krigging and Entrropy method to determine the optimum location of the rain station [4].

These various methods each have their strengths and weaknesses. The aim of this research is to develop alternative methods to determine the distribution of rain stations that represent physiographic conditions, altitude and isohyet patterns. It is hoped that the method can be considered by various parties in placing the rain station.

2. Method

Analysis of the distribution of rain stations is done by comparing the distribution of existing rain stations with the distribution of physiomorphohydro units. Therefore, a physiomorphohydro map must be made beforehand and then overlay with rain distribution.

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Physiomorphohydro map is the result of overlaying/ stacking several maps, consisting of topographic maps, physiographic maps and isohyet maps that have been made before. For this purpose, the Geographic Information System (GIS) application is used. The results of overlaying maps are composite / composite maps, which each land unit in it is a combination of physiographic conditions, altitude and rainfall. For convenience, each land unit is coded. Example:

Da 2 a

The first two letter symbol indicates physiographic conditions
The second symbol indicates the rainfall condition
The third symbol shows topography
The classification of physiography, altitude, and rainfall are:

Physiographic Classification

1. Volcanic Quarter (Vk)
2. Dome and Ridge of Middle Depression Zone (Dm)
3. Rembang-Madura Anticlinorium (Ar)
4. Kendeng Anticlinorium (Ak)
5. Randublatung Zone (Zr)
6. Alluvial Plain of North Java (Da)
7. Southern Mountain (Ps)

Rain Classification (mm/year)

1. 500 – 1000 (1)
2. 1000 – 1500 (2)
3. 1500 - 2000 (3)
4. 2000 – 2500 (4)
5. 2500 – 3000 (5)
6. 3000 – 3500 (6)
7. 3500 – 4000 (7)
8. 4000 – 4500 (8)

Altitude Classification (meter)

1. < 600 (a)
2. 600 – 1000 (b)
3. 1000 – 1500 (c)
4. > 1500 (d)

For more details, the procedure for determining physiomorphohydro zoning can be seen in the picture below:

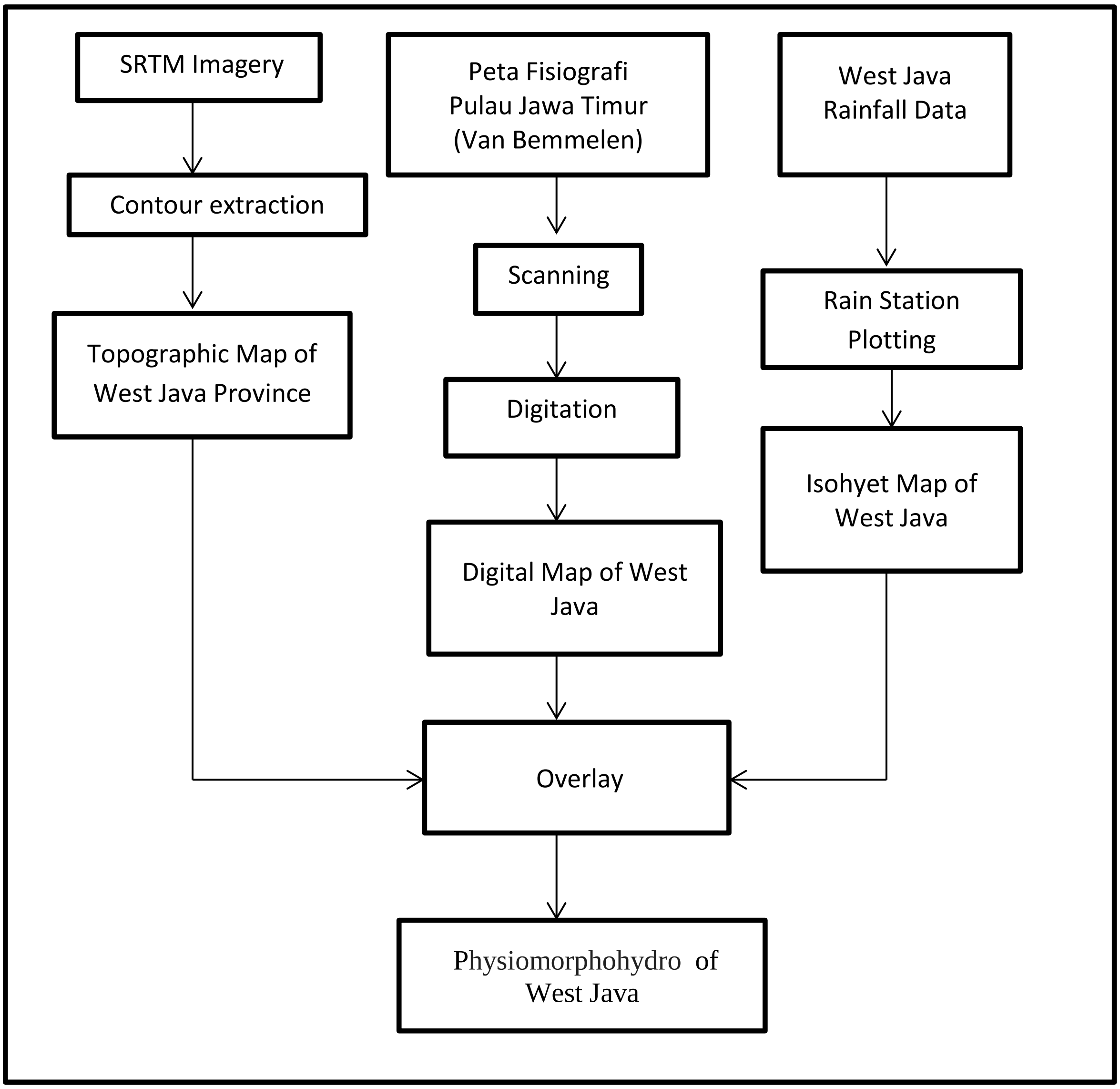

Figure 1. Chart of Research Flow

3. Result and Discussion

The results of this study consisted of physiomorphohydro zoning in East Java and analysis of the distribution of rain stations based on physiomorphohydro zoning.

3.1. East Java Physiomorphohydro Zoning

Physiomorphohydro zoning is done by overlaying three maps, namely physiographic maps and isohyet maps that have been made before. Therefore, each physiomorphohidro unit describes its physiographic, topographic and rainfall characteristics. East Java has different characteristics seen from the three parameters, so the number of physiomorphohydro units is also quite large. The description of the distribution of the physiomorphohydro unit can be seen in the following map.

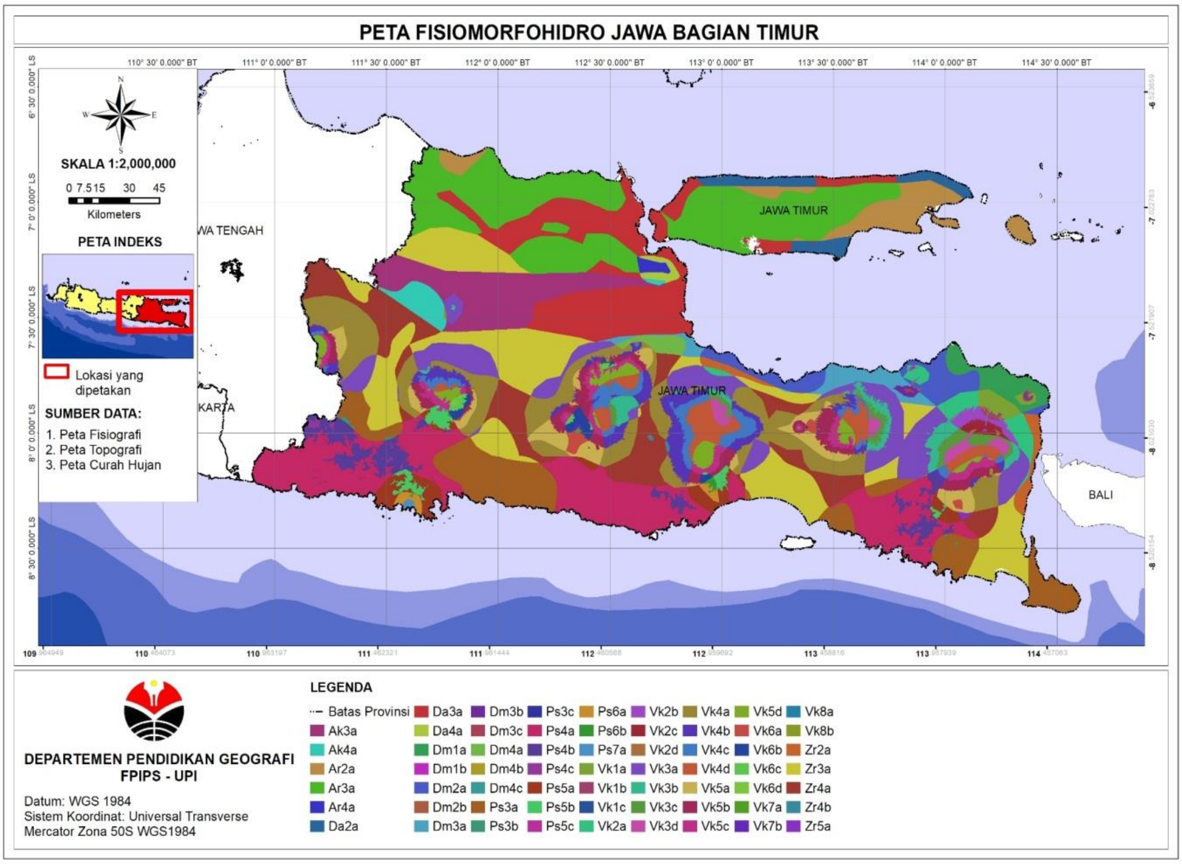

Figure 2. Zoning Map of the Physiomorphohydro Region of East Java Province.

Based on the physical and geographic zoning, it appears that Eastern Java has 62 physiomorphohydro units. This means there are physiographic, topographic and rainfall variations in East Java. Each unit has its own characteristics that are different from one another. Therefore, each physiomorphohidro unit should have a representative rain station to measure the rainfall that occurs in the area.

3.2. Distribution of Rain Stations and East Java Physiomorphohydro Zoning

Based on rainfall station data obtained from the West Java Province Water Resources Management (PSDA) Office, there are at least 998 (nine hundred ninety eight) rain stations in East Java which are summarized in several river areas. The author believes that there are still many other rain stations that have not been inventoried. Of the 998 rain stations known, only 788 (seven hundred eighty eight) mapped rain stations were reduced by 88 (eighty eight) rain stations that did not have rainfall data. So precisely only 780 (Seven hundred eighty) rain stations can be mapped and have rainfall data.

Rain stations in East Java that have rainfall data and are mapped all use manual rain gauges. The results of recording rain gauges are usually recorded as daily rainfall data, so it is very difficult if you need rainfall data with minutes and times duration. This is an obstacle for some researchers who need rainfall data with minutes or hours duration. Some of the stations identified above can be a reference for several people/ agencies that require rainfall data with minutes and hours.

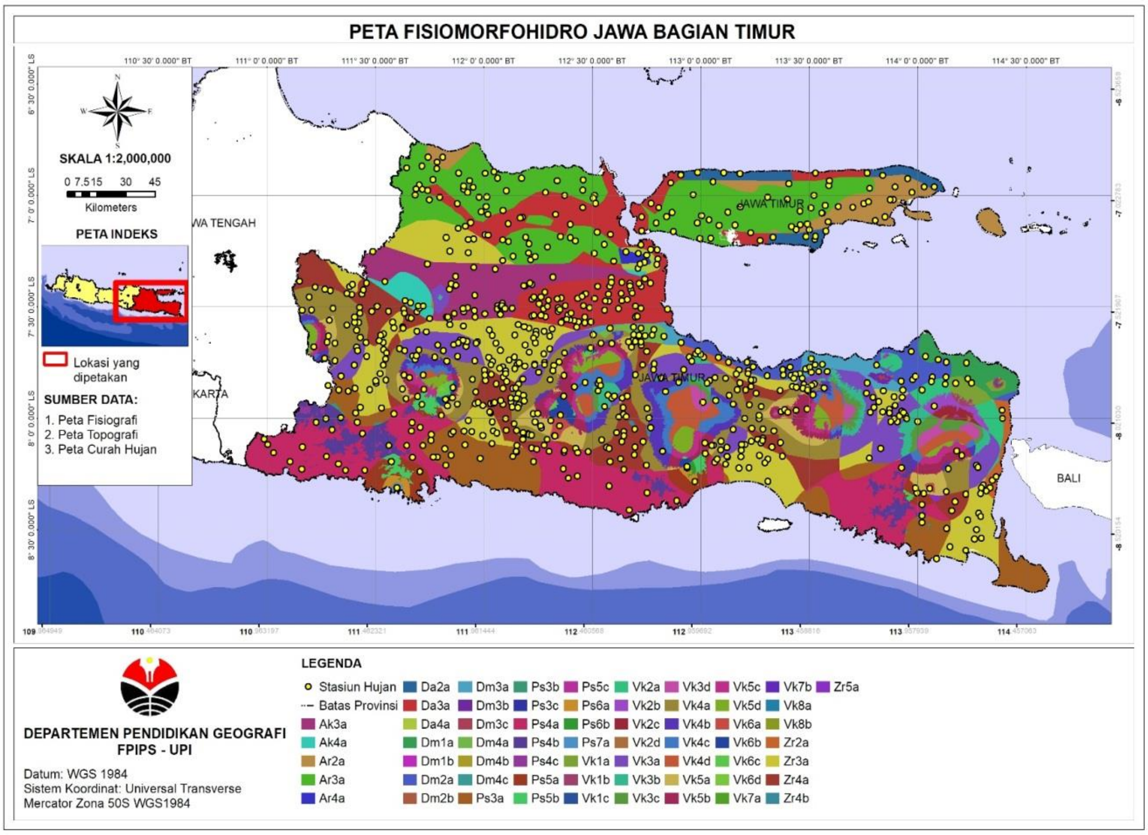

Figure 3. Map of Distribution of Rain Post in East Java Province Based on Physiomorphohydro Zoning.

3.3. Analysis of the Distribution of Rain Stations Based on Physiomorphohydro Zoning

Based on the results of overlaying the zoning zoning of the physiomorphohydro region and a map of the distribution of rain stations in East Java, it is known that there are many advantages and disadvantages of the rain station stations in each zoning. The ideal determination criteria for the zoning of the physiomorphohydro region is 10 - 1000 km^2, this is because the zoning area is more specific than the three physiographic, topographic, and isohyet aspects. The distribution of rain stations is more widespread in central, northern and western East Java while the southern and eastern parts of East Java, the distribution of rain stations is still lacking.

Some zoning regions that do not have rain representative stations include the Ps3c, Vk8a, Dm1b, Dm4c, Vk1c, Dm4b, Dm2b, Dm3c, Vk7b, Vk2d, Ps5c, Vk6d, Zr4b, Zr5a and many more. The number of physiomorphohidro zones that have no rain station stations is 23 zones, which corresponds to 6 zoning and more as many as 33 zoning. The overall number of shortages of rain station based on physiomorphohydro zoning is 23 rain stations, while the excess rain station stations are 714.

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Table 1. Amount and Density of Rain Stations in East Java Based on Physiomorphohydro Zoning.

Physiomorphohydro	Area (km^2)	Actual Station	Ideal 1 per 10-1000 km^2	Information
Ps3c	0,01	0	1	Less 1
Vk8a	0,09	0	1	Less 1
Dm1b	0,48	0	1	Less 1
Dm4c	0,90	0	1	Less 1
Vk1c	3,27	0	1	Less 1
Dm4b	3,84	0	1	Less 1
Dm2b	3,89	0	1	Less 1
Vk7a	5,71	1	1	Suitable
Dm3c	6,73	0	1	Less 1
Vk7b	7,65	0	1	Less 1
Vk8b	7,82	2	1	Less 1
Vk2d	7,96	0	1	Less 1
Ps5c	10,05	0	1	Less 1
Vk6d	12,58	0	1	Less 1
Zr4b	13,89	0	1	Less 1
Zr5a	16,88	0	1	Less 1
Ps7a	20,18	1	1	Suitable
Ps3b	23,57	0	1	Less 1
Ps6b	27,20	1	1	Suitable
Dm3b	39,05	0	1	Less 1
Vk1b	46,88	0	1	Less 1
Ps4c	52,19	0	1	Less 1
Vk6c	65,42	0	1	Less 1
Ar4a	83,81	4	1	More 3
Vk2c	103,83	0	1	Less 1
Ps6a	113,75	2	1	More 1
Da4a	117,30	3	1	More 2
Vk6a	123,77	6	1	More 5
Vk2b	163,29	1	1	Suitable
Vk6b	167,12	3	1	More 2
Dm4a	189,66	10	1	More 9
Vk1a	200,31	1	1	Suitable
Ps5b	253,41	2	1	More 1
Vk3d	257,91	1	1	Suitable
Zr2a	313,80	11	1	More 10
Vk3c	338,18	0	1	Less 1
Ak4a	384,58	8	1	More 7
Vk2a	455,24	5	1	More 4
Vk5d	457,50	0	1	Less 1
Vk3b	522,01	9	1	More 8
Vk5c	535,73	3	1	More 2
Dm1a	540,61	5	1	More 4
Dm3a	541,83	12	1	More 11
Ps5a	622,17	9	1	More 8
Da2a	636,88	10	1	More 9

Physiomorphohydro	Area (km^2)	Actual Station	Ideal 1 per 10-1000 km^2	Information
Vk4c	694,12	5	1	More 4
Vk4d	780,99	0	1	Less 1
Dm2a	813,36	20	1	More 19
Vk5b	830,35	11	1	More 10
Ps4b	893,29	3	1	More 2
Vk5a	909,96	20	1	More 19
Vk4b	934,67	10	1	More 9
Ar2a	1277,07	19	1	More 18
Ak3a	2049,08	36	2	More 34
Vk3a	2522,53	52	3	More 49
Ps3a	2637,67	25	3	More 22
Zr4a	2791,17	75	3	More 72
Vk4a	3290,41	75	3	More 72
Da3a	3740,91	93	4	More 89
Ps4a	4724,00	37	5	More 32
Zr3a	5069,57	112	5	More 107
Ar3a	5605,62	77	6	More 69

4. Conclusion
Comparisons between physiomorphohydro zones and the distribution of existing rain stations indicate inequality. There is a physiomorphohidro unit with the number of rain stations exceeding the ideal number, and conversely there is a physiomorphohydro unit that has a rain station. However, there are also those that match the number. It is best to consider considering placing a rain station in a physiomorphohydro unit that is lacking or reduces the number of rain stations which are too many in number or meetings.

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