JURNAL UPI

Jurnal Geografi Gea

Journal homepage: https://ejournal.upi.edu/index.php/gea

JURNAL GEOGRAFI Gea

Oldeman Agroclimatic Zone Mapping in Trenggalek Regency Using Geographic Information System

Bintang Harfian[1], Evi Fitriana[2]*

[1,2]Universitas Negeri Malang, Kota Malang, Indonesia

Correspondence: E-mail: *bintang.harfian.2107226@students.um.ac.id

ABSTRACT

Climate is one of the essential factors that influences plant productivity. One of many ways to identify climate in a region, especially those whose use focuses on agriculture, is to identify climatic zones based on Oldeman's climate classification. In this research, Oldeman agro-climatic zone mapping was carried out by interpolating rainfall data for 2011-2022 obtained from twelve rain stations spread across Trenggalek Regency using a geographic information system so that map of the Oldeman agroclimatic zone of Trenggalek Regency can be produced. The map explains that Trenggalek Regency has seven agro-climatic zones which include zones A1, B2, B3, C2, C3, D3, and E3 with the most dominant agro-climatic zone are C2 zone that covering 35% and B2 zone covering 29% of the entire Trenggalek Regency area. The majority of planting patterns that can be implemented in one year are one rice crop and two secondary crops, or two rice crops and one secondary crop. However, the planting pattern must still be adjusted to the conditions of water availability in each region.

ARTICLE INFO

Article History:
Submitted/Received 26 March 2024
First Revised 09 October 2024
Accepted 30 October 2024
First Available online 30 Oct 2024
Publication Date 31 Oct 2024

Keywords:
Agro-Climatic,
Oldeman,
Trenggalek Regency

DOI: https://doi.org/10.17509/gea.v24i2.68362
p- ISSN 1412-0313 e- ISSN 2549-7529

1. INTRODUCTION

The staple food commodities of Indonesian people come from cassava, rice, sorghum, sago, and several other plants, but rice is the most dominant food-crop commodity. Paddy fields produce rice, which is the staple food for most Indonesian people, especially on the island of Java. East Java became the largest rice-producing province in 2021, with a production of 9.90 million tons of dry-milled grain (GKP or Gabah Kering Panen). One of the areas that has the main rice commodities is Trenggalek Regency, which produces 169,374 tons of rice (BPS, 2021).

Trenggalek Regency is located in the southern part of East Java Province, which has an area of 1,248.40 km2. Trenggalek Regency has a diverse topography due to the limestone's dissolution process. Most of the topography of Trenggalek Regency (more than 66%) is hilly mountains, including steep slopes with more than 40%. Meanwhile, the remaining less than mountains, including steep slopes with more than 40%. Meanwhile, the remaining less than 34% is lowland with a slope of between 0-15%. (Rosadi & Hariyani, 2023).

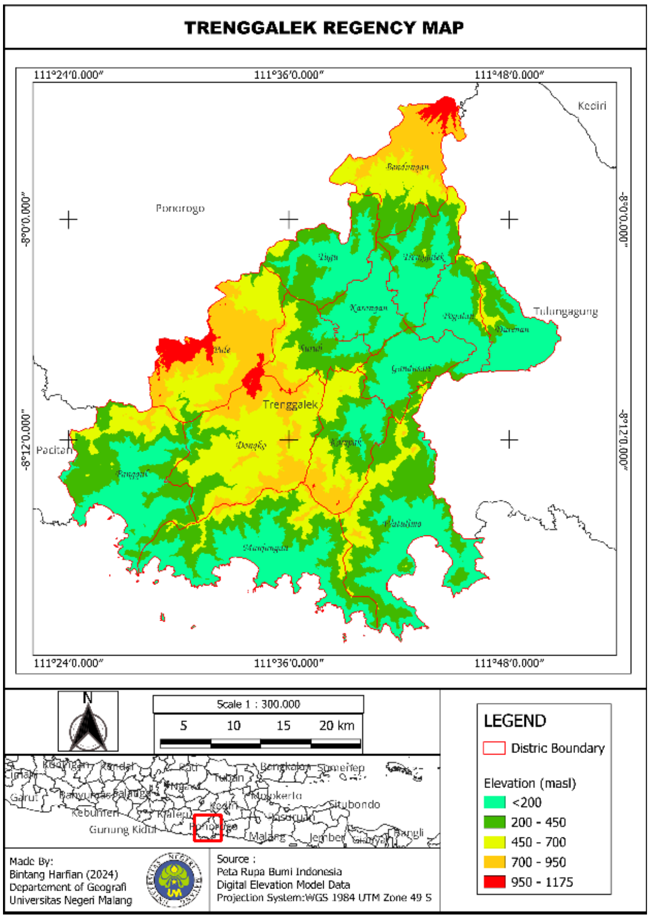

Figure 1. Map of Trenggalek Regency (Area Of Interest)

Climate is one of the essential factors that influences plant productivity. Climate is also a determining variable in choosing the use of plants that suit land conditions in a particular area (Tando, 2019). One of many ways to identify climate in a region, especially those whose use focuses on agriculture, is to identify climatic zones based on Oldeman's climate classification. This classification is based on the water requirements for agricultural plants, namely rice and secondary crops, to be able to grow by relying on rainfall as a very influential factor, so it is also called the "Agro-Climate classification system" (Oldeman, 1980; Anna, 2021). Oldeman's agro-climatic zone classification can help the agricultural sector in determining planting

DOI: https://doi.org/10.17509/gea.v24i2.68362
p- ISSN 1412-0313 e- ISSN 2549-7529

periods (Nasution & Nuh, 2018). Based on the classification of agro-climatic zones according to Oldeman, the determination of the planting period can be predicted using indicators of the number of consecutive wet months and dry months in an area so that the appropriate planting pattern to be implemented in a region can be identified. Climate information in the form of the Oldeman Agro-climatic Zone Map for Indonesia, including Java and Bali, was created using data in the 1975s. However, climate change has recently occurred due to global warming, so this information needs to be updated using the latest data available (Yiwananda, 2021).

A Geographic Information System (GIS) is a system used to collect, examine, and analyze information related to geosphere phenomena (Ridwana & Himayah, 2020; Wasil, 2020). The use of the word "geographical" implies a problem regarding the two or three-dimensional surface of the earth (Arrasyid et al, 2021). The term "geographical information" contains the meaning of information about places located on the earth's surface, knowledge about the position where an object is located on the earth's surface, and information about evidence (attributes) contained on the earth's surface whose position is given or known (Fujiati, 2023; Simanjuntak, 2022). With advances in technology, the regional climate identification process has been combined with geographic information systems (GIS) so that climate zone data can be analyzed and displayed in a spatial form in the form of regional climate-type zones (Sasminto & Tunggul, 2014).

The research aims to map the newest agro-climatic zones in Trenggalek Regency, East Java Province, based on the provisions of the Oldeman classification. With this agro-climatic zone map, current climate conditions can be known and compared with previous research, and the results of this research can be used as material for literature studies on planning related planting patterns that will be implemented by related governments at Trenggalek Regency.

2. METHODS

This research is quantitative research that uses the interpolation method to identify agro-climatic zones based on Oldeman's classification in Trenggalek Regency, East Java Province. Determination of agro-climatic zones occurring from the Oldeman classification system is based on rainfall data for twelve years (2011-2022) obtained from thirteen rain observation stations spread across Trenggalek Regency, which is between 111º 24' to 112º 11' east longitude and 7º 63' to 8º 34' south latitude.

Table 1. List of Rain Station at Trenggalek Regency

No	No. STA	Station Names	X (Degree Minute Second)	Y (Degree Minute Second)	Z (mdpl)
1	27 A	Bendungan	111°42’34”E	07°55’57”S	704
2	40	Bagong	111°42’26”E	08°02’24”S	121
3	40 A	Tugu	111°35’55”E	08°03’24”S	200
4	40 B	Prambon	111°40’07”E	08°01’15”S	146
5	41	Jabung	111°39’07”E	08°05’38”S	139
6	42	Widoro	111°43’08”E	08°07’22”S	124
7	43	Watulimo	111°42’17”E	08°14’22”S	343
8	50	Kampak	111°40’16”E	08°10’34”S	141

DOI: https://doi.org/10.17509/gea.v24i2.68362
p- ISSN 1412-0313 e- ISSN 2549-7529

9	51	Pule	111°56’29”E	08°11’31”S	717
10	51 B	Dongko	111°34’30”E	08°11’22”S	526
11	52 B	Munjungan	111°35’56”E	08°18’38”S	34
12	52	Panggul	111°27’18”E	08°14’58”S	37
13	27 A	Gembleb	111°45’25”E	08°04’18”S	128

The rainfall data that has been obtained is then calculated on a monthly average using Microsoft Excel software using the following formula:

$$CHrt = \sum_{i=1}^{n} \quad CHi/n$$

CHrt: Average monthly rainfall (mm)

Chi: Rainfall of the-X month at the-Y rain observation station

n : Number of years of observation

From the calculation of the average monthly rainfall, it will be categorized as a wet month in accordance with the Oldeman classification provisions in Table. 2 and Table. The three are based on water needs for plants, especially rice and secondary crops. Where months with rainfall >200mm are categorized as Wet Months, months with rainfall between 200-100mm are categorized as Humid Months-, and months with rainfall <200mm are categorized as Dry Months.

Table 2. Climate Classification According to Oldeman

Zone	**Wet Month (CH >200mm)**	**Sub-Zone**	**Dry Month (CH <100 mm)**
A	> 9 Months	1	<2 Months
B	7-9 Months	2	2-3 Months
C	5-6 Months	3	4-6 Months
D	3-4 Months	4	7-9 Months
E	<3 Months	5	>9 Months

Source: Oldeman et al. (1980)

Table 3. Interpretation of the Oldeman Climate Classification

Climate Zone	Cropping Patterns
A1;A2	Suitable for continuous rice but production is not optimal because the solar radiation flux density is generally low throughout the year
B1	Suitable for continuous rice planting with good planning for the start of the planting season, high production when harvested in the dry season
B2; B3	Suitable for planting rice twice a year with short-lived varieties and a short dry season is sufficient for secondary crops
C1	Suitable for planting rice once and secondary crops twice a year

DOI: https://doi.org/10.17509/gea.v24i2.68362
p- ISSN 1412-0313 e- ISSN 2549-7529

C2; C3; C4	Suitable for planting rice once and secondary crops twice a year. The second planting season of crop should not be planted in the dry season
D1	Suitable for planting short-lived rice once with high production due to high radiation flux density and once secondary crops
D2; D3; D4	Suitable for planting once rice crop or once secondary crop, depending on water supply from rain or irrigation
E1; E2; E3; E4	Suitable for one crop planting, depending on water supply

Source: Utomo (2018)

The rain observation station data is then further processed into point format (Shapefile) so that the distribution of rain stations in Trenggalek Regency can be determined spatially by inputting it into ArcMap software. Processing and analysis of SHP rain observing stations in ArcMap software is carried out by interpolating values for wet months and dry months. Interpolation in mapping is the process of estimating values in an area that does not have samples or data (Albeta, 2021). The interpolation method used is the inverse distance weighting (IDW) method. This method performs a simple determination by considering the influence of nearby points or sources. IDW is used because it has good accuracy and is able to provide values that are close to the data sample (Arif, 2019).

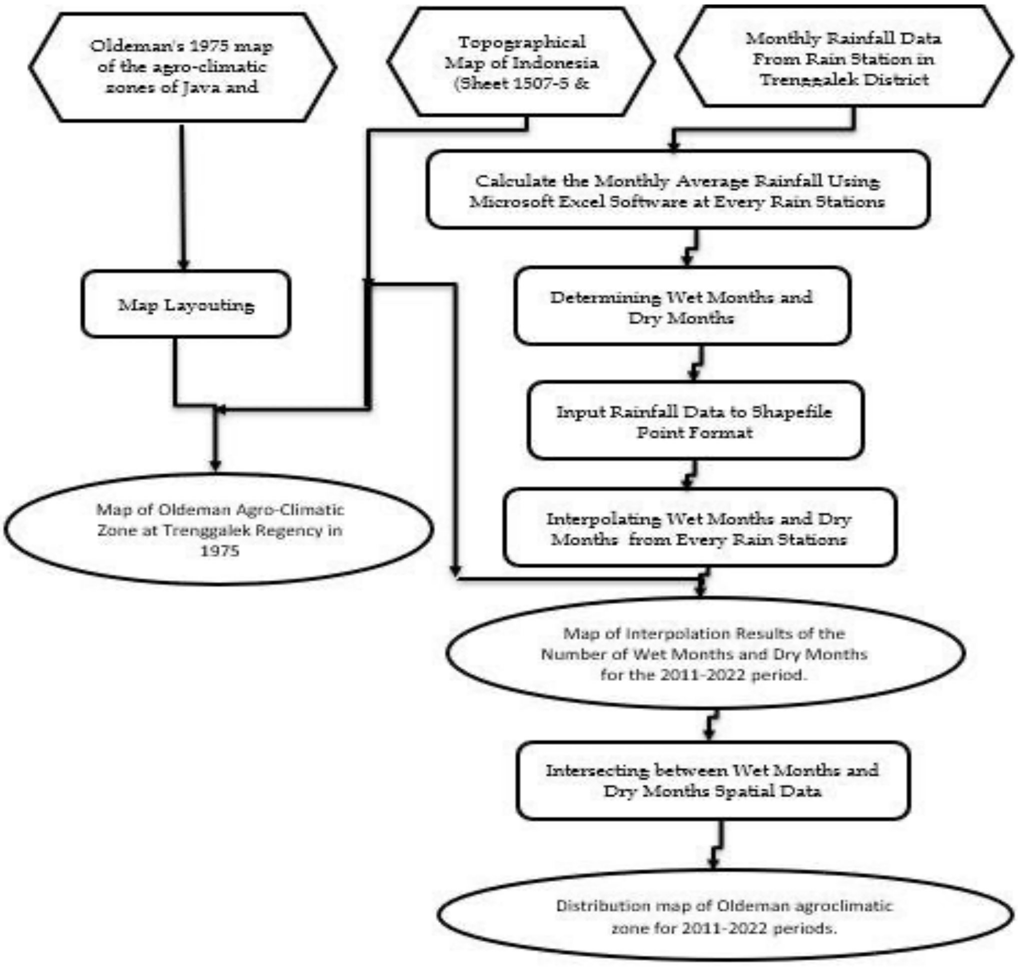

Figure 2. Research flow diagram

DOI: https://doi.org/10.17509/gea.v24i2.68362
p- ISSN 1412-0313 e- ISSN 2549-7529

3. RESULTS AND DISCUSSION

3.1. Rainfall Conditions at Trenggalek Regency

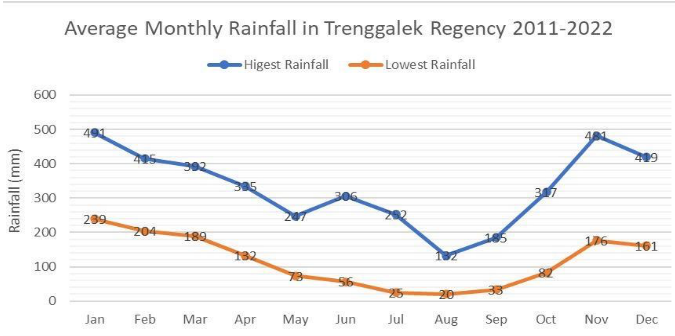

Figure 3. Graph of Average Monthly Rainfall of Trenggalek Regency 2011-2022

Trenggalek Regency has a rainfall distribution of monsoon pattern where the rainfall pattern tends to form a U shape as in Figure 3, which is a graph of the distribution of the highest and lowest rainfall for each month in the 2011-2022 period. The graph shows that the highest average rainfall value occurred in January, with a total of 491 mm, which then decreased slowly until August, with the lowest average rainfall value of 20 mm. After August, the rainfall increased again.

The monsoon rainfall pattern shows a peak in the rainy season around November-February and a peak in the dry season around July- September. It is important to pay attention to determining the timing of planting in areas that have rainfall patterns like this because there are conditions where water cannot meet the threshold needs of plants, especially during the dry months (Patty, 2017; Aditya, 2021).

3.2. Distribution of Agro-climatic Zones in Trenggalek Regency

Based on the results of calculating rainfall data recorded at rain observation stations for twelve years (2011-2022) with Microsoft Excel software, we can find periods of wet months (CH > 200 mm) and dry months (CH < 100 mm), respectively. Following the provisions of the Oldeman climate classification at rain observation stations, which are presented in **Table 4**

Station Names	No. STA	Wet Months	Dry Months
Bendungan	27 A	8	3
Bagong	40	6	4
Tugu	40 A	6	3
Prambon	40 B	6	6
Jabung	41	5	6
Widoro	42	2	0
Watulimo	43	7	0
Kampak	50	6	3
Pule	51	6	3
Dongko	51 B	6	2
Munjungan	52 B	10	0
Panggul	52	6	2
Gembleb	27 A	5	5

DOI: https://doi.org/10.17509/gea.v24i2.68362
p- ISSN 1412-0313 e- ISSN 2549-7529

From the information presented in Table 4, it can be seen that Trenggalek Regency has an average number of wet months of around 5-6 months, and the number of wet months is greater than the number of dry months. The results of the data calculations in Table 4 are then interpolated so that they can be analyzed spatially using the help of ArcGIS software. The processing results in ArcGIS software can be seen in Figure 4.

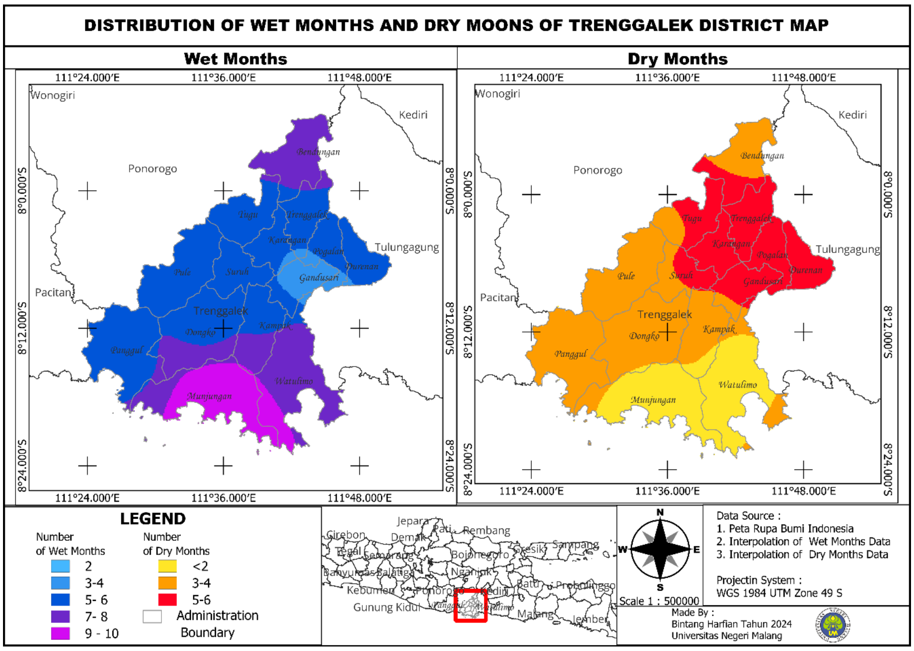

Figure 4. Map of Interpolation Results of the Number of Wet Months and Dry Months

The Map in Figure 4 is the result of interpolation and overlay of rainfall data recorded by rain observation stations during the 2011-2022 period in Trenggalek Regency which was then intersected to obtain a map of the agro-climate distribution as in Figure 5.

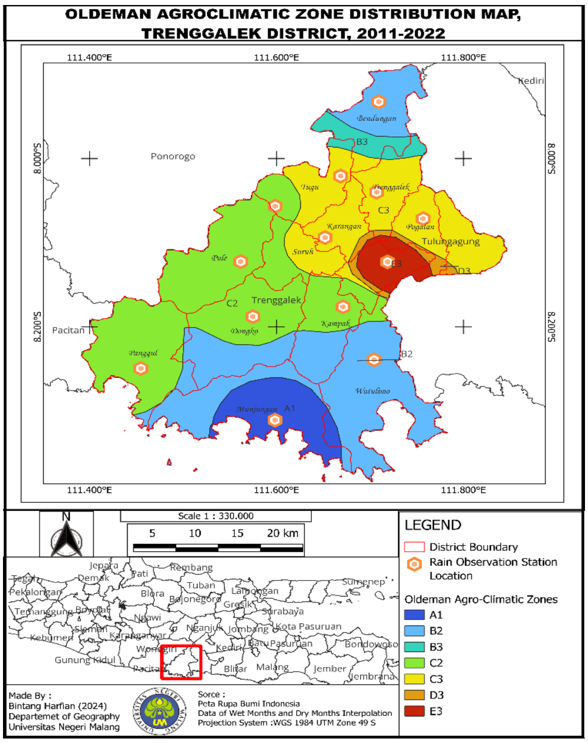

Figure 5. Distribution map of Oldeman agroclimatic zone for 2011-2022 periods

DOI: https://doi.org/10.17509/gea.v24i2.68362
p- ISSN 1412-0313 e- ISSN 2549-7529

The information on the map shows the distribution of Oldeman climate zones in Trenggalek Regency consisting of eight agro-climatic zones, namely Zones A1, B1, B2, B3, C2, C3, D3, and E3, with zone C2 occupying 35% of the total area of Trenggalek Regency and Zone B2 occupies 29% of the total area of Trenggalek Regency. The distribution of agro-climatic zones in each sub-district can also be seen in the graph in Figure 6.

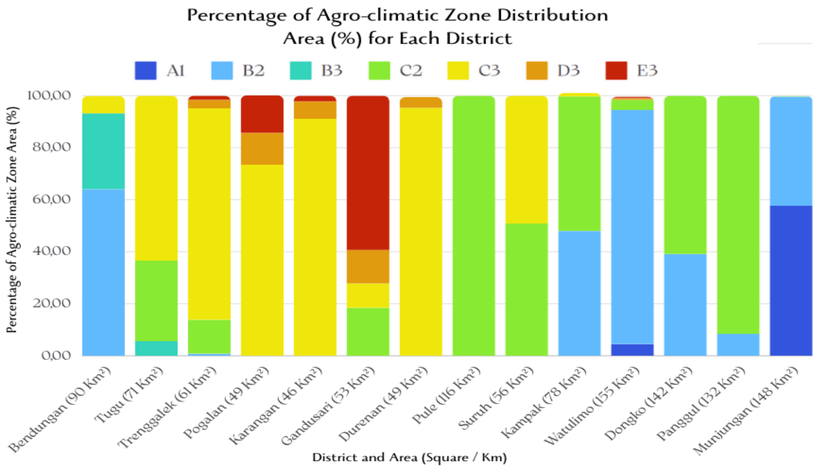

Figure 6. Graph of Percentage Distribution of Agro-climatic Zones (%) Per District

The A1 agroclimatic zone is in the southern part of Trenggalek Regency, and the majority (57.62%) of Munjungan District and 4.53% of the southern part of Watulimo District are in it. This agro-climatic zone has 10 consecutive wet months and is also the agro-climatic zone with the most wet months. This zone is suitable for rice plants throughout the year, but what needs to be considered is that the solar radiation flux density can be sufficient for optimal production results.

The distribution of the B2 agro-climatic zone is located in the northern and southern parts of Tenggalek Regency. The northern part of the B2 climate zone is located in Bendungan District (64%) and a small part of Trenggalek District (0.81%). Meanwhile, the B2 zone, which is located in the southern part, is located in almost the entire Watulimo District (89.96%), 48% of the Kampak District area, 39.16% of the Dongko District area, 42% of the Munjungan District area and a small part of Panggul District (8.39%). According to Oldeman, the suitable planting pattern implemented in this climate zone is two short-term paddy fields where, between the two rice planting periods, the paddy fields can be planted once with secondary crops.

The B3 agro-climatic zone occupies 29.21% of the southern part of Bendungan District and the northern part of Trenggalek District with a percentage of 5.63% of the total area of the district. The planting pattern in this agro-climatic zone is suitable for implementing a planting pattern in the form of two short-term paddy fields where between the two rice planting periods the paddy fields can be planted once with secondary crops.

The distribution of the C2 zone is located in the central and western parts of Trenggalek Regency which covers 30% of the area of Tugu District, 13% of the area of Trenggalek District, all of Pule District (100%), part of Suruh District (50.87%) and Kampak (51.65%), a small portion from the northern part of Watulimo District (3.88%), 60.83% of Dongko District, 91.6% from Panggul District and 0.33% from Munjungan District. Areas belonging to the C2 agro-climatic zone are very suitable for cultivating rice and several types of secondary crops, with a planting pattern of once for rice and twice for secondary crops. It is necessary to ensure that the second planting season of secondary crop planting does not fall during a dry month.

DOI: https://doi.org/10.17509/gea.v24i2.68362
p- ISSN 1412-0313 e- ISSN 2549-7529

The C3 agro-climatic zone is spread across the central to eastern parts of Trenggalek Regency, covering most of the Tugu District area (63.38%). 6.74% from the Bendungan District area. This zone also covers 81.3 of the Trenggalek District area, 73.46% of the Pogalan District area, most of the Karangan District (91.11%), and Durenan District (95.3%). 49, 12% from the Suruh subdistrict area, 9.25% from the Gandusari subdistrict area, and a small part of the northern part of the Kampak subdistrict (1.44%). The planting pattern that is suitable to be implemented in this zone resembles the planting pattern in zone C2, namely once for rice and twice for secondary crops.

D3 agro-climatic zone is in the central part of Trenggalek Regency and is spread across several districts, such as the southern part of Pogalan District (12.24%) and Gandusari District (12.96%). Apart from that, this zone is found in 3.25% of the Trenggalek District area, 6.66% of the Karangan District area, 4.16% of the Durenan District area, and 0.64%. According to Oldman, the planting pattern that can be applied in this agro-climatic zone is one planting of rice or one crop of secondary crops.

The distribution of the E3 agro-climatic zone is mostly in the Gandusari District area (59.25%). Apart from that, this agro-climatic zone is found in 1.62% of Trenggalek District, 14.46% of Pogalan District, 2.22% of Karangan District, and 0.64% of Watulimo District. This zone is only suitable for secondary crop planting, even then depends on water availability.

It needs to be emphasized that the classification of agro-climatic zones, according to Oldeman, is only one of the supporting factors that can be used to determine plant types or planting patterns because this classification only uses rainfall as the main variable. Meanwhile, in terms of selecting plant types or planting patterns according to land suitability, additional variables are needed, such as intensity of sunlight, degree of slope, land use, landform, and physical and chemical conditions of the soil (Tentua, 2017; Pasya, 2016).

3.3. Changes in the Oldeman Agroclimatic Zone at Trenggalek Regency

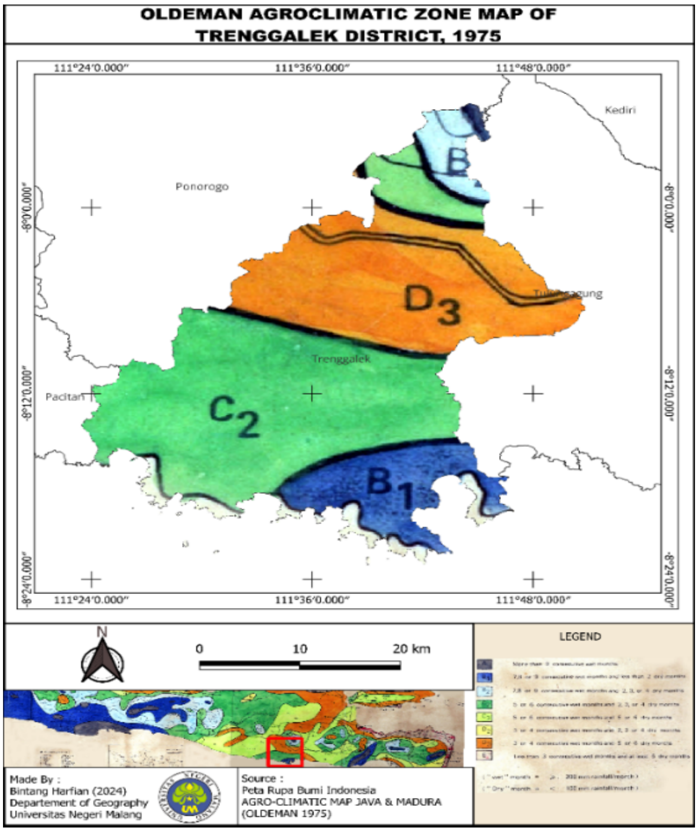

Figure 7. Map of Oldeman Agro-Climatic Zone at Trenggalek Regency in 1975

DOI: https://doi.org/10.17509/gea.v24i2.68362
p- ISSN 1412-0313 e- ISSN 2549-7529

Oldeman himself had carried out the mapping of agro-climatic zones for the islands of Java and Madura (Agro-Climatic Map of Java & Madura) in 1975 (see Fig 7). In this map, agro-climatic zones of Trenggalek Regency consist of zones A1 & B2 in the northern part, zone B1 in the southern part, and zones C2 & D3 in the centre part.

The agro-climatic zone in Trenggalek Regency resulting from this research process is different from the Agro-Climatic Map of Java & Madura map made by Oldeman in 1975. The difference is there are some changes from zone B1 to A1, as in the Munjungan sub-district area. Another change also occurred in the central part of Trenggalek Regency, where the D3 zone became C3. Changes in agro-climatic zones can occur due to several things, such as differences in the number of rain measuring stations used, and the results of similar research also explain that there are trends of climate change, such as changes in temperature in the high and lowlands, changes in rainfall, as well as extreme weather events and seasonal shifts causing this climate change to occur (Madani, 2022; Barung & Suwandi, 2017; Fadholi, 2018).

However, there are also similarities between the two maps, where the C2 agro-climatic zone in the central and western parts of Trenggalek Regency is the most dominant agro-climatic zone. The next aspect that does not change can be seen in agro-climatic zones that have lots of wet months, such as zones A1, B1, B2, and B3 spread across the northern and southern parts of Trenggalek Regency where these areas have elevations that tend to be higher if compared to the surrounding area (see Fig. 1). This can be caused by the mountainous topographic conditions which indicate that the area is influenced by orographic rain. Orographic rain can occur due to the presence of wet or humid air masses originating from the evaporation of water bodies that are lifted by the presence of mountains.

4. CONCLUSION

The Oldeman agroclimatic zones that have been successfully mapped in the Trenggalek Regency are zones A1, B2, B3, C2, C3, D3, and E3. Among these zones, C2 and B2 are the most dominant, covering 35% and 29% of the area, respectively. Each zone has its own suitable planting pattern, with zones A1 and B2 being ideal for planting rice continuously throughout the year in the north and south regions. The similarities between this research and the research conducted by Oldeman in 1975 are that the C2 agro-climatic zone is the most dominant in Trenggalek Regency, this agro-climatic zone has high rainfall most in the southern and northern parts of Trenggalek Regency. The higher altitude of the area is also a factor that increases the influence of orographic rain in the northern and southern parts of Trenggalek Regency. However, changes and shifts in agro-climatic zones have occurred in several regions due to differences in the number of rain measuring stations used and global climate change trends. Apart from identifying agro-climatic zones, additional analysis is needed regarding other factors that influence the land suitability for agriculture.

5. RECOMMENDATIONS

Based on the results of this research, the following suggestions can be put forward. Each agro-climatic zone that has been mapped has a suitable planting pattern to be implemented. Therefore, it is important for stakeholders in the agricultural sector to follow the appropriate planting pattern. Apart from climate factors, there are still several supporting factors in terms of land suitability and planting patterns, such as soil type, intensity of sunlight, and so on, that also need to be considered.

DOI: https://doi.org/10.17509/gea.v24i2.68362
p- ISSN 1412-0313 e- ISSN 2549-7529

6. REFERENCES

Aditya, F., Gusmayanti, E., & Sudrajat, J. (2021). Pengaruh perubahan curah hujan terhadap produktivitas padi sawah di Kalimantan Barat. *Jurnal Ilmu Lingkungan*, *19*(2), 237-246.

Albeta, R. (2021). *Studi Sebaran Curah Hujan Menggunakan Metode Interpolasi Inverse Distance Weighting (IDW).* Skripsi Sarjana, Universitas Sriwijaya. https://repository.unsri.ac.id/54060/2/RAMA_45201_08021381722090_0003017201_0013096402_01_front_ref.pdf

Anna, K. (2021). *Buku Praktikum Dasar-Dasar Klimatologi*. repository.polteklpp.ac.id.

Arif, N. (2019). Studi Komparasi Kriging dan IDW untuk Estimasi Spasial Bahan Organik Tanah. *Geomedia: Majalah Ilmiah Dan Informasi Kegeografian*, 17(2), 83–87. DOI: https://doi.org/10.21831/gm.v17i2.28866

Arrasyid, R., Ruhimat, M., Logayah, D. S., Ridwana, R., & Isya, H. R. M. (2021). mGuiding (Mobile Guiding)–using a mobile GIS app for guiding Geopark Ciletuh Palabuhanratu, Indonesia*. In Promoting Creative Tourism: Current Issues in Tourism Research* (pp. 756-762). Routledge.

Badan Pusat Statistik (BPS). (2021). *Produksi Padi Provinsi Jawa Timur*. Surabaya: BPS.

Barung, F. M, & Suwandi, S. (2019). Proyeksi Kesesuaian Agroklimat Tanaman Padi Berdasarkan Skenario Representative Concentration Pathways (Rcp)4.5 Dan Rcp8.5 Di Provinsi Jawa Timur. *Jurnal Meteorologi Klimatologi dan Geofisika*, 4(3), 32–45. https://doi.org/10.36754/jmkg.v4i3.51

Fadholi, A. (2019). Analysis of The Extreme Rainfall Frequency in Bangka Belitung Islands Based on Climate Hazards Group Infra-red Precipitation With Stations (CHIRPS) Data*. Jurnal Geografi Gea*, 18(1), 22-32. DOI: https://doi.org/10.17509/gea.v18i1.9504

Fujiati, S. (2023). Sistem Informasi Geografis Pemetaan Wilayah Kelayakan Tanam Tanaman Jagung Dan Singkong Pada Kabupaten Lampung Selatan. *Jurnal Teknologi Terkini*, *3*(3).

Madani, Ilyas, and Khalil Abdul Wahid. (2022) Pemetaan Zona Agroklimat Oldeman di Provinsi Jawa Tengah Menggunakan *Data Climate Hazards Group Infrared Precipitation with Station* (CHIRPS). *Jurnal Geosains dan Remote Sensing* 3(2), 95-102. DOI: https://doi.org/10.23960/jgrs.2022.v3i2.99

Nasution, M. I., & Nuh, M. (2018). Kajian Iklim Berdasarkan Klasifikasi Oldeman Di Kabupaten Langkat. *JISTech*, 3(2), 1–19.

Oldeman, L. R. (1975). *Agro-climatic map of Java and Madura*. Central research institute of agriculture.

Oldeman, L. R., Las, I., & Muladi. (1980). *The Agroclimatic Maps of Kalimantan, Maluku, Irian Jaya and Bali, West and East Nusa Tenggara*. Bogor, Indonesia: Central Research Institute for Agriculture.

Pasya, G. K., Jupri, J., & Murtianto, H. (2016). Tingkat Kerusakan dan Arahan Konservasi Lahan di DAS Cikaro, Kabupaten Bandung. *Jurnal Geografi Gea*, 9(2).

Patty, A. (2017). Analisis Karakteristik Curah Hujan dan Neraca Air Lahan Untuk Penetapan Musim Tanam di Halmahera Utara. *Jurnal Hutan Pulau-Pulau Kecil*, 1(4), 298-309. https://ojs3.unpatti.ac.id/index.php/jhppk/article/view/608

Prabaningrum, R., & Nurjani, E. (2016). Identifikasi perubahan zona agroklimat metode oldeman Di Provinsi Jawa Barat. *Jurnal Bumi Indonesia*, *5*(4), 228805.

Ridwana, R., & Himayah, S. (2020). Utilization of remote sensing technology and geographic information systems for tourism development. *International Journal of Applied Sciences in Tourism and Events*, 4(2), 158-169.

Rosadi, M. I., Hariyani, S., & Ari, I. R. D. (2023). Pemanenan Air Hujan Sebagai Alternatif Pemenuhan Akses Air Baku Air Bersih di Kabupaten Trenggalek. *Jurnal Serambi Engineering*, *8*(3).

Sasmito, G. W. (2017). Penerapan metode Waterfall pada desain sistem informasi geografis industri kabupaten Tegal. *Jurnal Informatika: Jurnal Pengembangan IT*, *2*(1), 6-12. https://doi.org/10.30591/jpit.v2i1

Simanjuntak, R. Y. (2022). Peta Persebaran Penyakit Demam Bedarah Dengue Dengan Sistem Informasi Geografis Pada Dinas Kesehatan Kota Metro. *Jurnal Teknologi Pintar*, *2*(5).

Tando, E. (2019). Pemanfaatan teknologi greenhouse dan hidroponik sebagai solusi menghadapi perubahan iklim dalam budidaya tanaman hortikultura. *Buana Sains*, *19*(1), 91-102. DOI: https://doi.org/10.33366/bs.v19i1.1530

Tentua, V. V., Salampessy, H., & Haumahu, J. P. (2017). Kesesuaian Lahan Komoditas Hortikultura di Desa Hative Besar Kecamatan Teluk Ambon. *Jurnal Budidaya Pertanian*, *13*(1), 9-16. DOI: https://doi.org/10.30598/jbdp.2017.13.1.9

Utomo, D. H. (2018). *Meteorologi Klimatologi*. Sukoharjo, Indonesia: Magnum Pustaka Utama.

Wasil, M., Samsu, L. M., & Putra, Y. K. (2020). Sistem Informasi Geografis Untuk Pemetaan Homestay di Lombok Timur Berbasis Android. *Infotek J. Inform. dan Teknol*, *3*(1), 15-19.

Wredaningrum, I., & Sudibyakto, S. (2014). Analisis Perubahan Zona Agroklimat Daerah Istimewa Yogyakarta Ditinjau Dari Klasifikasi Iklim Menurut Oldeman. *Jurnal Bumi Indonesia*, *3*(4).

Yiwananda, Y., & Nugrahani, H. S. D. (2021). Realisasi Kebijakan Energi Terbarukan Uni Eropa (UE) oleh Denmark dalam Upaya Menghadapi Ancaman Pemanasan Global. *Intermestic: Journal of International Studies*, *6*(1), 121-146.

DOI: https://doi.org/10.17509/gea.v24i2.68362
p- ISSN 1412-0313 e- ISSN 2549-7529