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Spatial Analysis of Dengue Hemorrhagic Fever Cases Based on Climatic Factors and Population Density Using a GIS Approach in Bogor Regency, Indonesia

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Abstract

Dengue Hemorrhagic Fever remains a major public health problem in tropical countries, including Indonesia, where climatic conditions and population density may influence disease transmission. This study aimed to analyze the spatial distribution of Dengue Hemorrhagic Fever cases in relation to climatic factors and population density in Bogor Regency, Indonesia, using a Geographic Information System approach. An ecological study design was employed using secondary data collected from all 39 sub-districts of Bogor Regency for 2023. Data on Dengue Hemorrhagic Fever cases were obtained from the Bogor Regency Health Office, climatic data were obtained from the Meteorology, Climatology, and Geophysics Agency, and population density data were obtained from the Central Statistics Agency. Descriptive spatial analyses were performed, and the spatial distribution of cases was visualized using Geographic Information System mapping. A total of 1,881 Dengue Hemorrhagic Fever cases were recorded in Bogor Regency during 2023. Considerable spatial variation in morbidity rates was observed among sub-districts. The highest morbidity rates were identified in Babakan Madang (37.95), Gunung Putri (34.11), Citeureup (33.27), Cibinong (31.86), and Cileungsi (29.64), whereas the lowest rates occurred in Sukajaya (3.84), Nanggung (4.98), Sukamakmur (5.12), Caringin (5.76), and Leuwisadeng (6.41). Areas with higher morbidity rates were predominantly located in urban and densely populated sub-districts, while lower rates were generally found in more rural areas. These findings demonstrate marked spatial heterogeneity in Dengue Hemorrhagic Fever incidence across Bogor Regency and indicate that Geographic Information System-based spatial analysis provides valuable information for identifying high-risk areas and supporting targeted surveillance, prevention, and vector control strategies.

Keywords: Bogor Regency; climatic factors; Dengue Hemorrhagic Fever; Geographic Information System; population density

1.Introduction

Global climate change is an environmental concern with significant implications for public health (Wright & Norval, 2014). Increases in global surface temperatures, altered rainfall patterns, and fluctuations in air humidity and wind speed influence the ecology of disease vectors, particularly Aedes aegypti, the primary vector of Dengue Hemorrhagic Fever (DHF) (Thai et al., 2011). These climatic variations can affect vector life cycles, population densities, vitality, and transmission capabilities, thereby elevating the risk of vector-borne disease outbreaks in various regions, especially in tropical areas (Caminade et al., 2019).

Dengue Hemorrhagic Fever remains a significant infectious disease and a major public health concern globally (Haikerwal et al., 2017). The World Health Organization (WHO) reports a continued increase in the global incidence of dengue, with the Southeast Asian region experiencing the highest number of cases (Wirawan, 2016). As a tropical and dengue-endemic nation, Indonesia continues to experience a substantial disease burden, characterized by annual fluctuations in case numbers and the potential for outbreaks in various regions (Harapan et al., 2019). These circumstances underscore the ongoing threat posed by dengue, necessitating evidence-based control strategies grounded in scientific research (Albanese & Reddy, 2021).

Demographic factors, such as population density, also significantly influence dengue transmission, independent of climate factors (Nakase et al., 2023). Elevated population density is often correlated with increased residential density, compromised environmental sanitation, and greater interaction between humans and vectors (Romeo-Aznar et al., 2018). The limited flight range of Aedes aegypti mosquitoes further predisposes densely populated areas to heightened dengue transmission risk (Stoddard et al., 2013). Consequently, a comprehensive analysis of the interplay between climatic variables and population density is crucial for a more thorough understanding of dengue incidence patterns (Guo et al., 2024).

Located in West Java Province, Bogor Regency exhibits diverse geographical and demographic characteristics, encompassing both lowlands and mountainous regions, as well as varying population densities across its sub-districts (Manessa & Supriatna, 2022). The regency is also characterized by relatively high rainfall and complex climatic variations. These conditions may facilitate the proliferation of dengue vectors and influence the spatial distribution of cases. Dengue case data in Bogor Regency demonstrate temporal fluctuations in incidence and regional variations in case distribution, suggesting the influence of environmental and population factors (Fuadiyah & Ruliansyah, 2022).

The Geographic Information System (GIS) approach is an effective method for analyzing and visualizing the spatial distribution of diseases and their determinants (Cromley, 2019). GIS facilitates the integration of epidemiological, climatological, and population density data within a spatial analysis framework, enabling more accurate identification of high-risk areas (Srinath et al., 2013). This information is crucial for informing the planning and decision-making processes involved in targeted and efficient dengue prevention and control programs.

This study analyzes the relationship between climatic elements, population density, and Dengue Hemorrhagic Fever cases in Bogor Regency using a GIS approach. The results are expected to provide a spatial overview of dengue risk and inform the formulation of targeted dengue control strategies based on regional and environmental factors.

2. Materials and Methods

This study employs an ecological study design with a spatial analysis approach utilizing a Geographic Information System (GIS) to investigate the relationship between climatic factors, population density, and the incidence of Dengue Hemorrhagic Fever (DHF) in Bogor Regency in 2023. The study area encompasses all sub-districts within Bogor Regency. The study population consists of all documented dengue cases during 2023, and a total sampling method is employed, incorporating the entire population as the research sample.

The data utilized are secondary and include the number of dengue cases per sub-district, obtained from the Bogor Regency Health Office; climatic data, specifically air temperature, air humidity, rainfall, and wind speed, sourced from the Meteorology, Climatology, and Geophysics Agency (BMKG); and population density data per sub-district, acquired from the Central Statistics Agency (BPS) of Bogor Regency. All data were compiled and aligned with the administrative boundaries of the Bogor Regency sub-districts for the year 2023. Data were analyzed using descriptive statistics and spatial analysis. Spatial visualization of dengue distribution was performed using QGIS software.

3. Results

Based on the 2023 data, Bogor Regency recorded a total of 1,881 Dengue Hemorrhagic Fever (DHF) cases. The distribution of DHF morbidity rates varied considerably among the 39 sub-districts, indicating differences in disease burden across the region (Figure 1). The highest DHF morbidity rate was observed in Babakan Madang (37.95 cases), followed by Gunung Putri (34.11 cases), Citeureup (33.27 cases), Cibinong (31.86 cases), and Cileungsi (29.64 cases). Other sub-districts with relatively high morbidity rates included Cariu (28.72 cases), Tajurhalang (27.58 cases), Parung Panjang (26.14 cases), Gunung Sindur

(25.02 cases), Sukaraja (24.36 cases), and Parung (23.88 cases). In contrast, the lowest DHF morbidity rates were reported in Sukajaya (3.84 cases), Nanggung (4.98 cases), Sukamakmur (5.12 cases), Caringin (5.76 cases), Leuwisadeng (6.41 cases), and Tenjolaya (6.89 cases). Most of the remaining sub-districts exhibited intermediate morbidity rates ranging from approximately 7 to 22 cases (Table 1). Overall, the results demonstrate substantial spatial variation in DHF morbidity across Bogor Regency, with several urban and densely populated sub-districts exhibiting higher morbidity rates than the more rural areas.

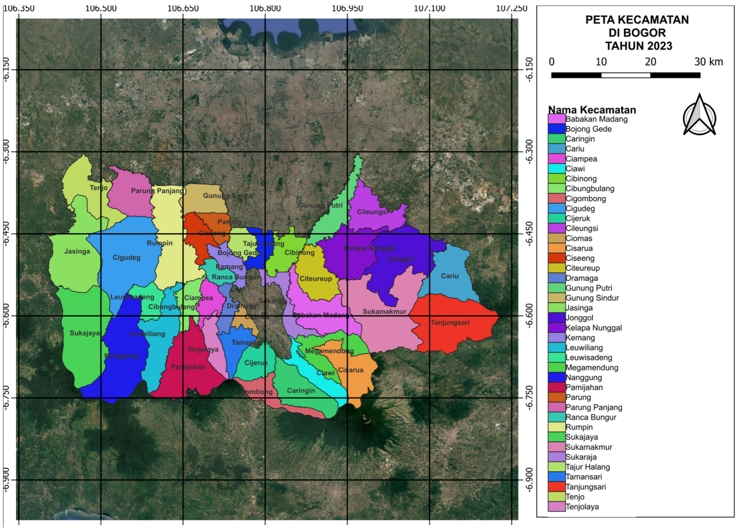

Figure 1. Map of the Sub-districts in Bogor Regency, 2023

Table 1. Dengue Hemorrhagic Fever (DHF) Morbidity Rate by Sub-district in Bogor Regency, 2023

No.	Sub-district	DHF Morbidity Rate	Unit	Year
1	Babakan Madang	37.95	Cases	2023
2	Bojong Gede	22.05	Cases	2023
3	Caringin	5.76	Cases	2023
4	Cariu	28.72	Cases	2023
5	Ciampea	16.59	Cases	2023
6	Ciawi	18.64	Cases	2023
7	Cibinong	31.86	Cases	2023
8	Cibungbulang	14.88	Cases	2023
9	Cigombong	11.35	Cases	2023
10	Cijeruk	9.73	Cases	2023
11	Cileungsi	29.64	Cases	2023
12	Ciomas	20.51	Cases	2023
13	Cisarua	12.84	Cases	2023
14	Citeureup	33.27	Cases	2023
15	Dramaga	15.92	Cases	2023
16	Gunung Putri	34.11	Cases	2023
17	Jasinga	7.68	Cases	2023
18	Jonggol	17.45	Cases	2023
19	Kemang	19.83	Cases	2023
20	Klapanunggal	21.96	Cases	2023
21	Leuwiliang	13.22	Cases	2023
22	Leuwisadeng	6.41	Cases	2023
23	Megamendung	10.54	Cases	2023
24	Nanggung	4.98	Cases	2023
25	Pamijahan	8.37	Cases	2023
26	Parung	23.88	Cases	2023
27	Parung Panjang	26.14	Cases	2023

No.	Sub-district	DHF Morbidity Rate	Unit	Year
28	Ranca Bungur	12.09	Cases	2023
29	Rumpin	18.27	Cases	2023
30	Sukajaya	3.84	Cases	2023
31	Sukamakmur	5.12	Cases	2023
32	Sukaraja	24.36	Cases	2023
33	Tajurhalang	27.58	Cases	2023
34	Tamansari	14.06	Cases	2023
35	Tanjungsari	9.21	Cases	2023
36	Tenjo	16.44	Cases	2023
37	Tenjolaya	6.89	Cases	2023
38	Ciseeng	21.34	Cases	2023
39	Gunung Sindur	25.02	Cases	2023

4. Discussion

The total number of Dengue Hemorrhagic Fever (DHF) cases recorded in Bogor Regency during 2023 was 1,881 cases. This finding indicates that dengue remains a significant public health concern in the region. The high number of cases reflects the continued transmission of dengue virus within the population and highlights the importance of spatially targeted surveillance and control efforts.

The distribution of DHF morbidity rates across sub-districts in Bogor Regency shows substantial spatial variation (Table 2). Several sub-districts recorded relatively high morbidity rates, including Babakan Madang (37.95 cases), Gunung Putri (34.11 cases), Citeureup (33.27 cases), and Cibinong (31.86 cases). These areas are characterized by higher levels of population concentration and urban development, which may facilitate dengue transmission through increased human–vector contact and higher availability of artificial breeding sites for *Aedes* mosquitoes.

In contrast, sub-districts such as Sukajaya (3.84 cases), Nanggung (4.98 cases), and Sukamakmur (5.12 cases) exhibited comparatively low morbidity rates. These areas are generally less densely populated and more rural in nature, which may limit the intensity of dengue transmission due to lower human density and reduced vector–host interaction. The observed spatial heterogeneity in DHF morbidity suggests that dengue risk is not evenly distributed across Bogor Regency. Sub-districts with moderate to high morbidity rates are predominantly located in areas with higher population density and greater levels of urbanization. This pattern supports the hypothesis that population density plays an important role in shaping dengue transmission dynamics by influencing mosquito breeding habitats, human mobility, and contact rates.

The spatial distribution of DHF cases identified in this study provides essential information for public health planning. Areas with high morbidity rates can be considered priority zones for intensified vector control measures, community-based interventions, and early warning systems. The integration of epidemiological data with geographic information system (GIS) analysis enables a more precise identification of high-risk areas and supports evidence-based decision-making for dengue prevention and control strategies.

5. Conclusions

This study demonstrates that the distribution of Dengue Hemorrhagic Fever (DHF) cases in Bogor Regency in 2023 exhibits clear spatial variation at the sub-district level. A total of 1,881 DHF cases were recorded, with higher morbidity rates concentrated in sub-districts characterized by higher population density, such as Babakan Madang, Gunung Putri, Citeureup, and Cibinong. In contrast, sub-districts with lower population density generally showed lower DHF morbidity rates. The spatial analysis using a Geographic Information System (GIS) approach highlights the important role of population density in influencing dengue transmission risk. These findings suggest that GIS-based mapping is an effective tool for identifying high-risk areas and can support targeted dengue surveillance, prevention, and vector control strategies. Future studies are recommended to incorporate additional climatic and environmental variables to further improve dengue risk assessment and early warning systems.

References

Albanese, C. V., & Reddy, S. (2021). The Current State: Epidemiology and Working Toward Eradication. Physical Medicine and Rehabilitation Clinics of North America, 32(3), 467–476. https://doi.org/10.1016/J.PMR.2021.02.003

Bibliography is arranged alphabetically:

Caminade, C., Caminade, C., McIntyre, K. M., McIntyre, K. M., & Jones, A. E. (2019). Impact of Recent and Future Climate Change on Vector-Borne Diseases. Annals of the New York Academy of Sciences, 1436(1), 157–173. https://doi.org/10.1111/NYAS.13950

Cromley, E. K. (2019). Using GIS to Address Epidemiologic Research Questions. Current Epidemiology Reports, 6(2), 162–173. https://doi.org/10.1007/S40471-019-00193-6

Dewi, A. P., Arifiani, D., Wulansari, T. Y. I., Senjaya, S. K., Wanda, I. F., Hutabarat, P. W. K., … & Satrio, R. D. (2023, December). Preliminary study on variations in local varieties of bornean ironwood (*Eusideroxylon zwageri* Teijsm. & Binn.) based on vegetative characters. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1271, No. 1, p. 012024). IOP Publishing.

Fuadiyah, M. E. A., & Ruliansyah, A. (2022). Spatio-Temporal Analysis of Dengue Cases in Kuningan District Since 2008-2017. Balaba, 45–52. https://doi.org/10.22435/blb.v18i1.5212

Guo, X., Zhang, Z., Zhang, X., & Feng, S. (2024). Spatiotemporal changes of climatic disasters and population displacements in Africa. Climate and Development, 1–11. https://doi.org/10.1080/17565529.2024.2323523

Haikerwal, A., Bhatt, M. L., & Saxena, S. K. (2017). Reducing the Global Burden of Dengue: Steps toward Preventive Methods. 2(1), 028–033. https://doi.org/10.17352/APM.000009

Harapan, H., Michie, A., Mudatsir, M., Sasmono, R. T., & Imrie, A. (2019). Epidemiology of dengue hemorrhagic fever in Indonesia: analysis of five decades data from the National Disease Surveillance. BMC Research Notes, 12(1), 350–350. https://doi.org/10.1186/S13104-019-4379-9

Manessa, M. D. M., & Supriatna, S. (2022). Kajian dan Evaluasi Bencana Tanah Longsor di Kecamatan Tanjungsari terhadap RTRW Kabupaten Bogor. Jurnal Wilayah Dan Lingkungan, 10(1), 86–96. https://doi.org/10.14710/jwl.10.1.86-96

Mustaqim, W. A., & Nikmah, I. A. (2024). *Sistematika tumbuhan*. Universitas Indonesia Publishing, Jakarta.

Romeo-Aznar, V., Paul, R., Paul, R., Telle, O., Pascual, M., & Pascual, M. (2018). Mosquito-borne transmission in urban landscapes: the missing link between vector abundance and human density. Proceedings of The Royal Society B: Biological Sciences, 285(1884), 20180826. https://doi.org/10.1098/RSPB.2018.0826

Satrio, R. D. (2021a). *Genetic mapping and identification of drought tolerance genes in rice plants* (Doctoral dissertation, IPB University). [Indonesian]

Satrio, R. D., Fendiyanto, M. H., & Miftahudin, M. (2024). Tools and techniques used at global scale through genomics, transcriptomics, proteomics, and metabolomics to investigate plant stress responses at the molecular level. In *Molecular dynamics of plant stress and its management* (pp. 555–607). Springer Nature Singapore, Singapore.

Satrio, R. D., Fendiyanto, M. H., Supena, E. D. J., Suharsono, S., & Miftahudin, M. (2021b). Genome-wide SNP discovery, linkage mapping, and analysis of QTL for morpho-physiological traits in rice during vegetative stage under drought stress. *Physiology and Molecular Biology of Plants, 27*(11), 2635–2650.

Srinath, I., Szonyi, B., Esteve-Gassent, M. D., Lupiani, B., Gautam, R., Clavijo, A., Park, S., & Ivanek-Miojevic, R. (2013). Geographical Information Systems: A Tool to Map and Analyze Disease Spread. Online Journal of Public Health Informatics, 5(1). https://doi.org/10.5210/OJPHI.V5I1.4443

Stoddard, S. T., Stoddard, S. T., Forshey, B. M., Morrison, A. C., Paz-Soldan, V. A., Vazquez-Prokopec, G. M., Vazquez-Prokopec, G. M., Astete, H., Reiner, R. C., Reiner, R. C., & Vilcarromero, S. (2013). House-to-house human movement drives dengue virus transmission. Proceedings of the National Academy of Sciences of the United States of America, 110(3), 994–999. https://doi.org/10.1073/PNAS.1213349110

Thai, K. T. D., Anders, K. L., & Anders, K. L. (2011). The role of climate variability and change in the transmission dynamics and geographic distribution of dengue. Experimental Biology and Medicine, 236(8), 944–954. https://doi.org/10.1258/EBM.2011.010402

Wirawan, D. N. (2016). Masalah Demam Berdarah Dengue (DBD) dan Ketersediaan Vaksin. Public Health and Preventive Medicine Archive, 4(2), 118–119. https://doi.org/10.15562/PHPMA.V4I2.63

Wright, C. Y., & Norval, M. (2014). Climate change: One of the greatest threats to public health in the 21st century. South African Medical Journal, 104(8), 578–578. https://doi.org/10.7196/SAMJ.8606