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Dengue Hemorrhagic Fever (DHF) Risk Assessment for Gorontalo Regency in Indonesia Using Geographic Information System

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ABSTRACT

Inadequate planning, housing, water, sewage, and waste management in urban and semi-urban areas produced ideal conditions for dengue viruses and their mosquito vector *Aedes Aegypti* to spread throughout the region over the preceding decade. Dengue prevention is primarily focused on vector control (chemical spraying, biological control, physical removal of breeding grounds, and infrastructure enhancement) and community education in the absence of a vaccine. They have not influenced the prevalence of Dengue Hemorrhagic Fever (DHF) Public health surveillance is the systematic and continuous collection of data and information on events, health problems, and conditions that influence the occurrence and spread of disease to plan, implement, and evaluate public health practices. It is crucial in dengue management since it determines the number and distribution of cases, viral serotypes, and severity of disease in a community. The purpose of this article is to examine the use of Geographic Information Systems (GIS) to determine the spatial distribution of the DHF Risk map in the Gorontalo Regency. The GIS system's overlay operation is utilized to combine two maps, namely the DHF hazard map and the DHF vulnerability map. The findings reveal that the Gorontalo Regency is dominated by low-risk classes, with a total area of 99,716.7 ha (46.52%). The GIS approach might be used to assess transmissible DHF risk zoning, which would aid in enhancing DHF and other vector-borne disease surveillance strategies to promote prevention and control efforts.

Keywords: Dengue, risk, hazard, vulnerability, Gorontalo Regency

Introduction

DHF has become a major international public health concern (WHO Regional Publication SEARO, 2011). DHF has expanded substantially in recent decades, not only in tropical but also in sub-tropical countries, predominantly in urban and semi-urban areas (Harapan et al., 2019). Over the last three decades, the global frequency of DHF and associated epidemics has increased dramatically, paralleled by a rise in illness incidence (WHO Regional Publication SEARO, 2011). Around 70% of dengue-infected individuals live in the Asia Pacific region, primarily in developing nations such as the Philippines, Indonesia, Vietnam, and Thailand (WHO Regional Publication SEARO, 2011). Inadequate planning, housing, water, sewage, and waste management in urban and semi-urban areas created ideal circumstances for dengue viruses and their mosquito vector *Aedes Aegypti*, which had been widely distributed throughout the region during the previous decade (Gubler, 2012). Instead of a vaccine, Dengue prevention is primarily focused on vector control (chemical spraying, biological control, physical removal of breeding sites, and infrastructure

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improvement) and community education (Duncombe et al., 2012). They have not been effective in reducing the incidence of DHF (Idriani et al., 2019).

Public Health Surveillance is an activity of systematic and continuous observation of data and information on events or health problems and conditions that affect the occurrence and spread of disease to planning, implementation, and evaluation of public health practice. It is critical in dengue management because it identifies the number and distribution of cases, virus serotypes, and disease severity in a population (Duncombe et al., 2012). Geographical Information Systems (GIS) enable additional investigation of surveillance data through spatial statistical analyses and visualization of patterns and relationships between disease and the environment. GIS databases are capable of capturing, storing, analyzing, and displaying data that is linked by a common spatial coordinate system. GIS is most commonly used for data visualization in dengue surveillance, allowing for the identification of disease distribution and changes over time, as well as the identification of spatial relationships with disease risk factors (Eisen & Lozano-Fuentes, 2009). Maps for visualizing dengue surveillance data are especially useful for public health professionals advocating for increased resources, such as vector control or laboratory facilities for serological disease confirmation, because policymakers respond more positively to maps than raw numbers or graphs (Fisher & Myers, 2011). Adapting mapping and modeling solutions for use in resource-constrained disease-endemic environments must be a new frontier in vector-borne disease research (Eisen & Lozano-Fuentes, 2009). The purpose of this research was to create DHF risk maps for the Gorontalo Regency. These maps can be used to visualize DHF risk in various areas so that limited public health resources can be prioritized for dengue control in Gorontalo Regency.

Material and Methods

Study area

The selected study areas were Gorontalo Regency in Gorontalo Province (Figure 1), located at coordinates of between 0°28’23.22” and 0°55’44.08” South latitudes and 122°14’43.69” and 123°4’48.27” East longitudes. There were 19 districts and 205 villages with an area of 2143 km^2.

Data and methods

Overlay techniques were used to discover DHF risk areas, and the scale of importance was added to the input maps layer. The specified criteria's input vector or feature map was turned into a raster map layer. After that, each raster layer was categorized by using the same grid size and projection. In the GIS environment, all the raster layers with varying weights were collected, and the weight of each composite class was added using select by attribute. The weighted overlay technique was utilized to create the DHF Risk Map. It's a method for integrating analysis by applying a single measuring scale to various inputs.

Two variables that DHF risk consists of DHF vulnerability and DHF hazard that were specifically selected for this study (Figure 2 and Figure 3). The DHF hazard map consists of five factors, i.e. rainfall, temperature, wind speed, humidity, and elevation (Pakaya et al., 2021). The DHF vulnerability consists of six factors that were considered: population density, distance to the road, the radius of health facilities, the radius of educational facilities, the radius of office area, and land use (Pakaya et al., 2021). They can be calculated using Eq. (1) and (2) by the map algebra tool.

$$DHFH = 0.35R \times 0.28E \times 0.17H \times 0.14T \times 0.06S \quad (1)$$

Where DHFH is Dengue Hemorrhagic Fever Hazard Score; R is total annual rainfall score, E is elevation class score, H is average humidity score; T is average temperature score, and S is average wind speed score. The result maps were classified into five risk classes in Table 1 and Figure 2.

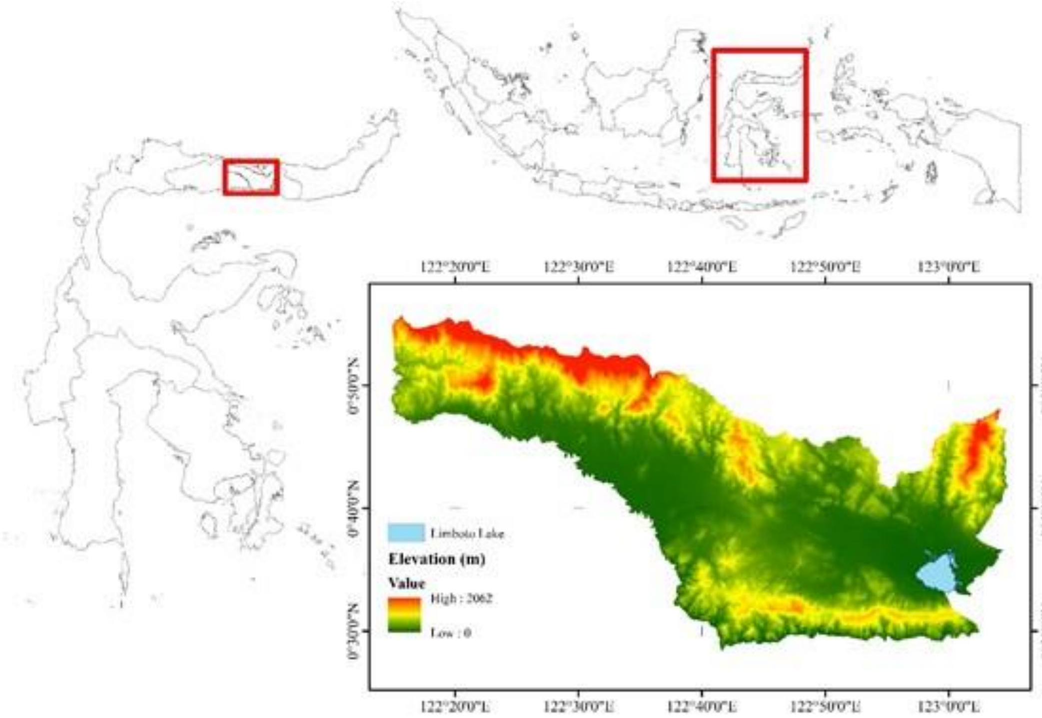

Figure 1. Location map

Table 1. Spatial distribution of DHF hazard level

DHF Hazard Level	Range Weight	Area (Ha)	% Area
Very Low	< 1,511	0.0	0.00
Low	1.511 - 2,023	28,654.0	13,37
Moderate	2.023 - 2,534	82,553.3	38,51
High	2.534 - 3,045	94,852.3	44,25
Very High	> 3,557	5,986.66	2,79
Limboto Lake	-	2,295.5	1,07
Total		**214,341.9**	**100**

$$DHFV=0.34PD\times0.21DR\times0.10REF\times0.08ROA\times0.24RHF\times0.04LU \quad (2)$$

Where DHFV is Dengue Hemorrhagic Fever Vulnerability Score, PD is Population Density Score; DR is Distance to The Road Score; REF is Radius of Educational Facilities Score; ROA is Radius of Office Area Score; RHF is Radius of Health Facilities Score, and LU is Land Use Score. The result maps were classified into five risk classes in Table 2.

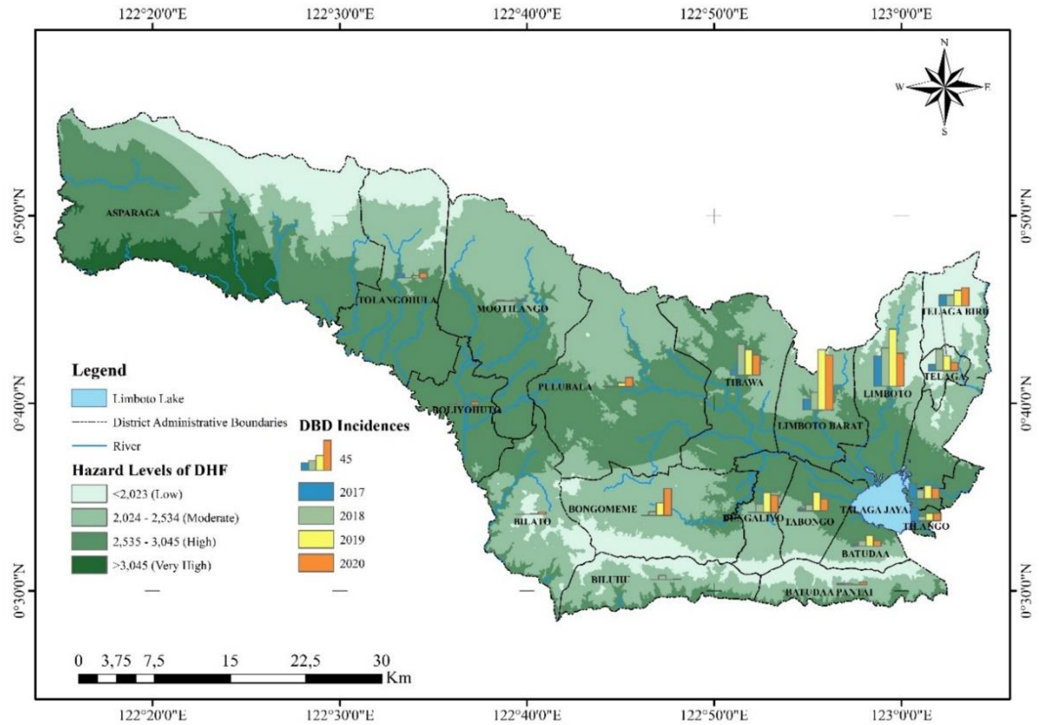

Figure 2. Hazard Classes of DHF

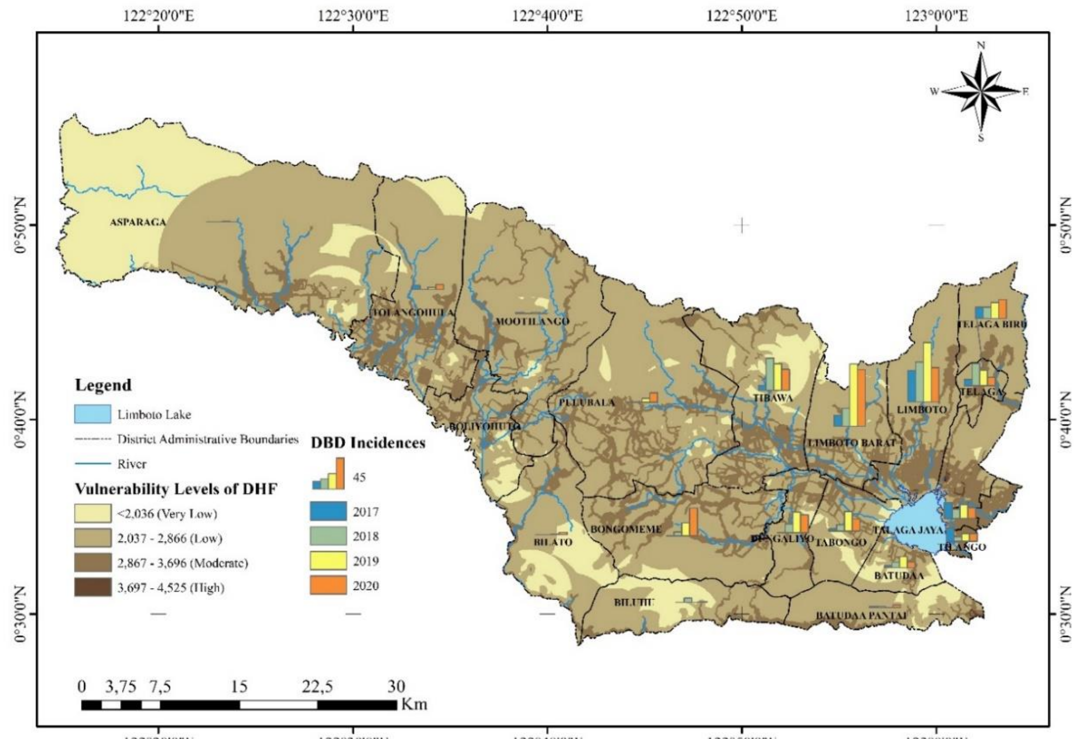

Figure 3. Vulnaribility classes of DHF

Table 2. Spatial distribution of DHF vulnerability level

DHF Vulnerability Level	Range Weight	Area (Ha)	% Area
Very Low	<2.036	34,425.6	16.06
Low	2.036 – 2.866	139,493.5	65.08
Moderate	2.866 – 3.696	37,963.8	17.71
High	3.696 – 4.525	163.5	0.08
Very High	>4.525	0.0	0.00
Limboto Lake		2,295.5	1.07
Total		**214,341.9**	**100**

Results and Discussion

The WGS 84 / UTM zone 51 N georeferenced layers were used to create a GIS-based model, which was then used to identify risk locations in the Gorontalo Regency's DHF class risk research regions. Figure 4 depicts the model's final results for each research area. It was classified into five risk classes for DHF, namely very low (<4.378), low (4.378-6.260), moderate (6.260-8.142), high (8.142-10.025), and very high (>10.025). Gorontalo Regency is dominated by a low-risk class covering an area of 99,716.7 ha or 46.52% of the total area. It is distributed in the outskirts of the sub-district where most of the area is agricultural land, plantations, and forests, and is far from road access, such as Asparaga, Batudaa Pantai, Bilihu, Bilato (Figure 4). Areas with a high-risk class have a very small percentage, namely 0.08% of the total area or only 163.5 ha which is distributed in dense areas or built areas, high building density, high population density, public areas, and bad environments, such as Limboto, Limboto Barat, Telaga, Telaga Biru, Telaga Jaya, and Tilango. These aspects in DHF transmission have also been highlighted in numerous research because the potential for transmission of DHF from mosquitoes to humans is getting higher. After all, the interaction between humans is quite large in the area and suitable breeding environment. Figure 1 also shows a high correlation between the incidence of DHF over four years (2017-2020) and the distribution of risk classes. Areas that have a high population and are located close to the city center (Limboto) are directly proportional to the incidence of DHF and high-risk classes. In this perspective, using GIS, an attempt was made to combine environmental parameters with spatial and temporal dengue incidence to assign the highest risk locations in Gorontalo Regency. Direct and indirect exposure to the environment might affect DHF transmission patterns. Changes in environmental conditions, which influence the distributional pattern and trend of dengue transmission, provide a better understanding of the direct implications. However, environmental factors have indirect effects on DHF transmission through the dynamics of landscape structures and the human population (Ajim Ali & Ahmad, 2018).

Table 3. Spatial distribution of DHF risk level

DHF Risk Level	Range Weight	Area (Ha)	% Area
Very Low	<4.378	28,030.2	13.08
Low	4.378 – 6.260	99,716.7	46.52
Moderate	6.260 – 8.142	55,369.8	25.83
High	8.142 – 10.025	27,597.0	12.88
Very High	>10.025	1,332.7	0.62
Limboto Lake		2,295.5	1.07
Total		**214,341.9**	**100**

The current study's findings are consistent with those of several other research. Dengue fever has become more common as population density, housing density, and the concentration of people in a confined area have increased (Ajim Ali & Ahmad, 2018; Khormi & Kumar, 2011; Dom et al., 2016; Dom et al., 2013). The breeding habits of Aedes Mosquitoes in urban and peri-urban environments were studied, and it was discovered that congested urban locations give the best breeding conditions (Sarfraz et al., 2014). The highest rates of DHF were found in connecting houses and residential neighborhoods. As a result, it is possible that as the population grows, many environmental conditions will change, such as housing types, modes of living, land use, local neighborhoods, and so on, all of which may be directly or indirectly related to DHF risk and thus likely increase DHF risk in areas where the disease is already endemic. Many DHF endemic locations could benefit from a similar study using the same methods. Similar research could aid researchers in determining which local environmental, climatological, and socioeconomic aspects to use as decision-making criteria (Ajim & Ahmad, 2018). This would aid decision-makers in determining which regions should be treated intensively to reduce mosquito breeding and the prevalence of DHF.

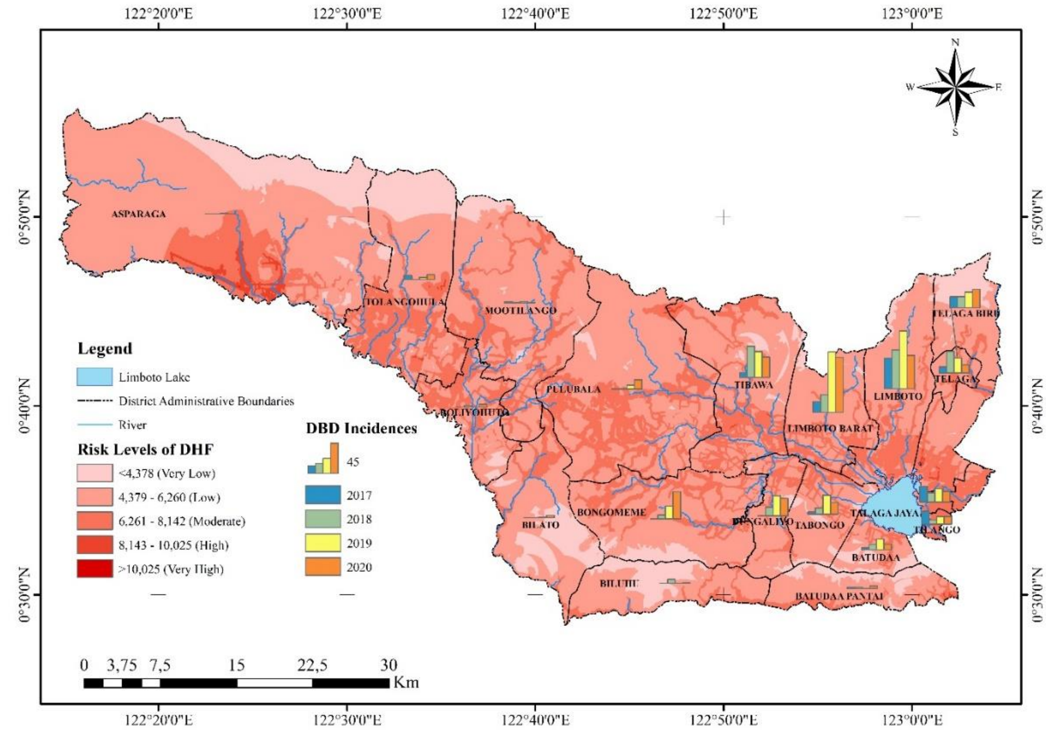

Figure 4. Risk Classes of DHF

The spatial association between cases and disease can be displayed and modeled using GIS and spatial-temporal modeling methods. Due to the powerful application of GIS technology to superimpose the temporal and spatial distributions based on ecological determinants such as landscape ecology, climate, vector population, and human presence and activity, spatial-temporal modeling can help us understand the distribution of DHF outbreaks in space and time. Improved dengue surveillance coordination, such as the issue of control strategy timing, can lead to an integrated management model for public health intervention based on a strong ecological understanding of the illness (Dom et al., 2016). The endemic area of DHF would expand in both time (length of season) and space (geographic area) under socio-environmental conditions (e.g. optimal climate, inadequate urban planning, ecosystem change etc.) (Dom et al., 2016).

Conclusion

The final Dengue Risk Map of Gorontalo Regency as prepared through the combination of DHFH model and DHFV model shows that the risk zones are mainly found in those areas where there are congested areas or built-up areas, high building density, high population density, and poor environmental. Gorontalo Regency is dominated by low-risk classes, with a total area of 99,716.7 ha (46.52%). GIS for modeling and mapping of DHF risk zonation can display construct results with the spatial relationships. It gives useful information about the spatial distribution of DHF risk for decision-makers and experts from different regions.

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References

Ajim Ali, S. & Ahmad, A. (2018). Using analytic hierarchy process with GIS for Dengue risk mapping in Kolkata Municipal Corporation, West Bengal, India. *Spat. Inf. Res., 26*, 449–469 (2018).

Dom, N. C., Ahmad, A. H., Latif, Z. A. & Ismail, R. (2016). Application of geographical information system-based analytical hierarchy process as a tool for dengue risk assessment. *Asian Pacific J. Trop. Dis., 6*(12), 928–935. doi:10.1016/S2222-1808(16)61158-1

Dom, N. C., Ahmad, A. H., Latif, Z. A., Ismail, R. & Pradhan, B. (2013). Coupling of remote sensing data and environmental-related parameters for dengue transmission risk assessment in Subang Jaya, Malaysia. *Geocarto Int., 28*(3), 258–272. https://doi.org/10.1080/10106049.2012.696726

Duncombe, J., Clements, A., Hu, W., Weinstrein, P., Ritchie, S., & Espino, F. E. (2012). Review: Geographical information systems for dengue surveillance. *Am. J. Trop. Med. Hyg.,* 86(5), 753–755. doi: 10.4269/ajtmh.2012.11-0650

Eisen, L. & Lozano-Fuentes, S. (2009). Use of mapping and spatial and space-time modeling approaches in operational control of Aedes aegypti and dengue. *PLoS Negl. Trop. Dis., 3*(4), 1–7. doi: 10.1371/journal.pntd.0000411

Fisher, R. P., & Myers, B. A. (2011). Free and simple GIS as appropriate for health mapping in a low resource setting: A case study in eastern Indonesia. *Int. J. Health Geogr., 10*, 1–11

Gubler, D. J. (2012). The economic burden of dengue. *Am. J. Trop. Med. Hyg., 86*(5), 743–744. doi: 10.4269/ajtmh.2012.12-0157

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 Res. Notes, 12,* 4–9. doi: 10.1186/s13104-019-4379-9

Idriani, E., Rahmaniati, M. M., & Kurniawan, R. (2019). Dengue surveillance information system: An android-based early warning system for the outbreak of Dengue in Padang, Indonesia. Indian Journal of Public Health Research and Development. *Indian J. Public Heal. Res. Dev., 10*(5), 1386–1390.

Khormi, H. M. & Kumar, L. (2011). Modeling dengue fever risk based on socioeconomic parameters, nationality and age groups: GIS and remote sensing based case study. *Sci. Total Environ., 409*(22), 4713–4719. doi: 10.1016/j.scitotenv.2011.08.028.

Pakaya, R., Hano, H. Y. & Olii, M. R. (2021). Integrasi AHP-SIG untuk Prediksi Distribusi Spasial Tingkat Bahaya Demam Berdarah Dengue Di Kabupaten Gorontalo. *Al-Sihah Public Heal. Sci. J., 13*, 1-5.

Pakaya, R., Olii, M. R. & Hano, Y. H. (2021). Dengue Hemorrhagic Fever (DHF) vulnerability assessment and mapping in Gorontalo Regency using multi-criteria analysis (AHP) model and geoinformation techniques. *Int. J. Public Heal. Sci.,* 11, 1-5.

Sarfraz, M. S., Tripathi, N. K., Faruque, F. S., Bajwa, U. I., Kitamoto, A., & Souris, M. (2014). Mapping urban and peri-urban breeding habitats of Aedes mosquitoes using a fuzzy analytical hierarchical process based on climatic and physical parameters. *Geospat. Health, 8*(3), S685–S697. doi: 10.4081/gh.2014.297.

WHO Regional Publication SEARO. (2011). *Comprehensive guidelines for prevention and control of dengue and dengue haemorrhagic fever*. WHO Regional Publication SEARO.