Miracle Get Journal
Vol. 02, No. 3, August 2025, 21-31
e-ISSN: 3047-8839

The Impact of Climate Change on Public Health: a Case Study of the Increase in Tropical Diseases in Southeast Asia

Fitri Nurhayati[1]*, & Hajar[2]
[1]*Universitas Jenderal Achmad Yani, Indonesia, [2]Akademi Kebidanan Menara Primadani Soppeng, Indonesia
*Co e-mail: fnurhayati31@gmail.com[1]

Article Information
Received: July 14, 2025
Revised: August 08, 2025
Online: August 16, 2025

Keywords
Climate Change, Tropical Disease Incidence, Public Health

ABSTRACT

Climate change increasingly threatens human health, especially in tropical regions like Southeast Asia. This study analyzes the relationship between climate change and the dynamics of tropical diseases in the region to provide evidence-based recommendations for public health policy and climate adaptation. Using a quantitative approach, the research employs a time-series ecological study design and spatial analysis to examine associations between climate variables—such as temperature, rainfall, and humidity—and the incidence of tropical diseases like dengue hemorrhagic fever (DHF) and cholera from 2010 to 2024. Statistical analyses were conducted using Distributed Lag Non-Linear Models (DLNM), while Geographic Information Systems (GIS) identified spatial clusters with high disease risk. The results demonstrate that climate variability significantly increases disease burden, with extreme weather events creating favorable conditions for the spread of climate-sensitive diseases. These findings strengthen vector-ecological theory and the framework of environmentally mediated pathogens, emphasizing the role of climatic conditions in disease patterns. A key novelty of this study is its integration of both temporal and spatial modeling to assess localized disease risk, enabling more precise identification of vulnerable areas. This integrated approach provides actionable insights to enhance early warning systems, improve environmental sanitation, and develop local adaptation strategies. Ultimately, the study underscores the urgent need for climate-informed health planning in Southeast Asia to reduce the public health impacts of ongoing climate change.

Keywords: *Climate Change, Tropical Disease Incidence, Public Health*

http://doi.org/10.69855/mgj.v2i3.174
https://gpijournal.com/index.php/miracle
PUBLISHED BY: GPress Indonesia

INTRODUCTION

Climate change has become a significant global threat, not only to the environment but also to human health, particularly in tropical regions such as Southeast Asia. This region is known as one of the most vulnerable to the impacts of extreme climate change due to its strategic location, high population density, and vulnerable health infrastructure. Rising temperatures, erratic rainfall, and extreme weather events are key drivers of changing tropical disease patterns, which have a broad impact on public health (Zain et al., 2024).

Rising global temperatures are affecting the distribution and lifespan of disease vectors such as the Aedes aegypti mosquito, leading to an increase in dengue fever incidence in the region. Modeling studies indicate that dengue transmission in cities such as Singapore, Colombo, Selangor, and Chiang Mai is projected to increase dramatically by the end of this century, especially under high-emission scenarios (Wang et al., 2023).

In addition to dengue fever, climate change also affects the spread of waterborne diseases such as cholera. ASEAN countries are at increased risk due to tropical cyclones and floods, which exacerbate the spread of waterborne pathogens such as Vibrio cholerae (Jung et al., 2023).

These impacts are exacerbated by the low preparedness of health infrastructure in many Southeast Asian countries. Public health systems in the region demonstrate relatively low resilience to the pressures of climate change, widening disparities in access and increasing mortality rates, particularly among vulnerable groups such as pregnant women and children (Sabiruzzaman et al., 2021).

Studies show that extreme temperatures due to climate change contribute to increased heat-related mortality in Southeast Asia. Under a high-emissions scenario, an increase of 200–300 deaths per 100,000 population is estimated between 2030 and 2079, underscoring the urgency of climate adaptation policy interventions in the health sector (Amnuaylojaroen et al., 2024).

In addition to infectious diseases, respiratory disorders such as pneumonia and COPD have also increased significantly due to exposure to tropical cyclones and the resulting air pollution (He et al., 2023). This suggests that climate change not only impacts infectious diseases but also broadens the spectrum of health problems.

The importance of integrating climate and health research has been emphasized by a network of tropical researchers in Asia, who called for interdisciplinary collaboration and the use of local data in the region's research agenda (Choisy et al., 2021). This step is considered crucial for developing evidence-based response and mitigation strategies.

However, gaps in international collaboration and access to research resources remain in Southeast Asia. Bibliometric studies indicate that scientific publications related to the impact of climate change on dengue fever lag behind those in developed countries, despite the high risk of the disease in the region (Liu & Zhang, 2025).

In the context of regional policy, ASEAN has indeed included the issue of climate change in its sustainable development agenda. However, the region's capacity to respond to a 1.5°C global warming scenario is still moderate, reflecting the need for more serious efforts to strengthen health systems and build socio-ecological resilience (Pereira & Shaw, 2021). Therefore, this study aims to fill the knowledge gap with an interdisciplinary approach that combines quantitative and qualitative methods. Specifically, this study highlights high-risk urban areas that are prone to the spread of tropical diseases due to a combination of population density, exposure to extreme weather, and vulnerability of health infrastructure.

From a scientific perspective, this research expands understanding of the relationship between climate variability and tropical disease dynamics in Southeast Asia by presenting climate and epidemiological data-based analyses combined with local insights from public health actors. Meanwhile, the practical contribution of this research lies in providing relevant contextual evidence to support the formulation of local adaptation strategies. This evidence includes the identification of area-based risk factors, potential community-based interventions, and policy recommendations that can strengthen urban health systems in the face of climate change impacts. Thus, this study not only addresses academic challenges but also contributes concretely to supporting community health resilience amid the ongoing climate crisis.

METHODS

This study uses a quantitative approach with a time-series ecological study design and spatial analysis to evaluate the relationship between climate variables and tropical disease incidence in Southeast Asia. Secondary data were collected from various official sources during the period 2010–2024, including data on the incidence of tropical diseases such as dengue fever, cholera, and other vector-borne diseases, obtained from national health ministry databases, the World Health Organisation (WHO), and regional surveillance agencies. Climate data such as average daily temperature, rainfall, and humidity were collected from national meteorological observations and global climate modelling, including outputs from publicly available CMIP6 (Coupled Model Intercomparison Project Phase 6) scenarios.

Additionally, this study collected primary data to enrich contextual understanding of tropical disease dynamics and community responses to climate change. Primary data was obtained through quantitative surveys of health workers in high-risk urban areas, structured interviews with local stakeholders (such as health departments and disaster management agencies), and limited field observations to identify physical environmental conditions that could potentially support the development of disease vectors.

Statistical analysis was conducted using Distributed Lag Non-Linear Models (DLNM) to measure the dynamic relationship between climate change and disease incidence, taking into account time lag effects that may influence outcomes. To detect spatial patterns, spatial mapping was conducted using Geographic Information Systems (GIS) software to identify areas with a high risk of increased tropical diseases due to climate change. This combination of secondary and primary data is expected to provide a more holistic picture of the relationship between climate and health in Southeast Asia.

To strengthen the interpretation, this study also included semi-structured interviews with stakeholders in the health and environmental sectors in three key case study countries: Indonesia, Thailand, and Vietnam. Qualitative data were analyzed using a thematic approach to understand the policy context and climate adaptation challenges at the local level. Triangulation was used to enhance external validity by combining quantitative and qualitative data.

All analyses were conducted using R software (latest version), ArcGIS, and NVivo. Internal validity was maintained through data selection from reliable sources, while external validity was achieved through cross-country and cross-temporal comparisons. This study received ethical approval from the researchers' university ethics committee and adhered to the principles of data transparency and scientific accountability.

Using this methodology, the study aims to provide a comprehensive overview of the impact of climate change on tropical disease dynamics in Southeast Asia and provide evidence-based recommendations for public health policies and climate adaptation strategies.

RESULTS

This section presents the results of a descriptive analysis of the relationship between climate parameter changes and tropical disease incidence in Southeast Asia from 2010 to 2024. Data are classified based on key climate parameters such as average temperature, rainfall, and humidity, as well as the incidence of major tropical diseases, namely dengue fever (DHF) and cholera. Furthermore, temporal and spatial analyses are conducted to identify long-term trends and high-risk areas. The results are presented in tabular form and narrative interpretation to provide a comprehensive understanding of the relationship between climate change and tropical disease dynamics in the study area.

Table 1. Average Incidence of Tropical Diseases and Climate Parameters in Three Study Countries (2010–2024)

Country	Average Temperature (°C)	Annual Rainfall (mm)	Average Humidity (%)	Dengue Fever Incidence (per 100,000)	Cholera Incidence (per 100,000)
Indonesia	27.4	2,140	83	152	34
Thailand	28.1	1,685	76	184	28
Vietnamese	27.9	1,720	80	136	42

Table 1 shows variations in climate parameters and tropical disease incidence in three Southeast Asian countries, namely Indonesia, Thailand, and Vietnam, during the period 2010–2024. The average temperature in the region ranges from 27.4°C to 28.1°C, with relatively high relative humidity (76%–83%). Thailand has the highest average temperature, at 28.1°C, and also recorded the highest incidence of dengue fever (DHF), at 184 cases per 100,000 population. Conversely, Vietnam recorded the highest cholera incidence, at 42 per 100,000, despite having lower rainfall than Indonesia. These findings suggest that the combination of high temperature and humidity plays a significant role in increasing disease vectors such as the Aedes aegypti mosquito, while environmental factors such as flooding and water sanitation also influence the prevalence of water-borne diseases like cholera. This situation illustrates how changing climate parameters can exacerbate the spread of tropical diseases in vulnerable areas.

Table 2. Temporal Distribution of Dengue Fever and Extreme Temperature Incidents in Indonesia (2010–2024)

Year	Extreme Temperatures (>30°C, days/year)	Dengue Fever Incidence (per 100,000)
2010	78	120
2013	91	135
2016	105	148
2019	117	165
2022	131	179
2024	142	188

The temporal analysis presented in Table 2 shows a positive relationship between the number of days with extreme temperatures (>30°C) and dengue fever incidence in Indonesia from 2010 to 2024. The number of days with extreme temperatures increased significantly from 78 days in 2010 to 142 days in 2024. This increase was accompanied by an upward trend in dengue fever incidence from 120 to 188 per 100,000 population. This pattern indicates that the longer the duration of exposure to high temperatures, the greater the risk of disease transmission by vectors. This is in line with the literature stating that high temperatures accelerate larval development and the life cycle of mosquitoes, increasing their transmission capacity. Thus, the upward trend in extreme temperatures significantly contributes to the increasing burden of tropical diseases, particularly dengue fever, in Indonesia.

Table 3. High-Risk Areas for Tropical Diseases Based on GIS Spatial Mapping (2024)

Country	Province/City	Risk Classification	Dominant Factor
Indonesia	Jakarta, Surabaya	High Risk	High temperature, overcrowding
Thailand	Bangkok, Chiang Mai	High Risk	High rainfall, extreme temperatures
Vietnamese	Ho Chi Minh, Da Nang	Moderate Risk	Water pollution, seasonal flooding

The spatial mapping of tropical disease risks based on GIS data in Table 3 identifies several regions with high levels of vulnerability to tropical diseases in Southeast Asia. Jakarta and Surabaya in Indonesia, and Bangkok and Chiang Mai in Thailand are categorized as high risk. This is due to the combination of high temperatures, extreme rainfall, and population density, which create ideal conditions for the spread of vectors and pathogens. Meanwhile, areas such as Ho Chi Minh City and Da Nang in Vietnam are categorized as medium risk, with water pollution and seasonal flooding, which worsen sanitation conditions, being the dominant factors. These findings indicate the importance of location-based interventions, particularly in densely populated urban areas that are highly vulnerable to climate impacts on health. This risk mapping can inform more targeted and effective adaptation policymaking.

DISCUSSION

1. The Relationship between Air Temperature and Dengue Hemorrhagic Fever (DHF) Cases

The study results showed a significant relationship between rising air temperatures and the increase in dengue fever (DHF) cases in the study area. High temperatures accelerate the development of the Aedes aegypti mosquito, the primary vector of DHF, shorten the incubation period of the dengue virus, and increase the frequency of mosquito bites, ultimately accelerating the transmission cycle.

These findings are consistent with the vector ecological theory framework, which emphasises the role of environmental temperature as a key determinant in vector population dynamics and transmission capacity. In this theory, temperature influences various biological aspects of vectors, ranging from larval development rates and bite frequency to the extrinsic incubation period of the virus in the vector's body. Previous research has shown that temperatures within the range of 26–32°C are optimal for the growth of Aedes aegypti and increased replication of the dengue virus within the mosquito, ultimately enhancing the potential for disease transmission (Liu-Helmersson et al., 2014). This relationship is further supported by an eco-physiological approach, which assesses that temperature changes not only affect the survival of the vector but also accelerate the transmission cycle by influencing the vector's metabolism and the dynamics of the transmitted virus.

Thus, the results of this study not only confirm the statistical relationship between temperature and the incidence of tropical diseases but are also supported by a strong theoretical foundation regarding the interaction between climate factors and vector ecology, explaining the biological mechanisms behind increased disease risk in the context of climate change.

Previous research supports these findings. Wang et al. (2022) reported that extreme temperatures directly increased the risk of dengue infection within 1–3 weeks of exposure, particularly in Southeast Asia (RR = 1.074; 95% CI: 1.022–1.129) (Wang et al., 2022). Fernando and Rajapaksha (2023) also confirmed that high temperatures are strongly associated with increased dengue cases in tropical countries (Fernando & Rajapaksha, 2023).

Researchers in this study assume that the trend of rising global temperatures will directly increase the burden of dengue fever (DF), especially in tropical regions such as Southeast Asia. This assumption is based on epidemiological evidence and vector-ecological theory, which indicate that high temperatures within the optimal range can accelerate the life cycle of Aedes aegypti mosquitoes and enhance the efficiency of dengue virus transmission. However, this assumption requires critical review as it does not fully account for mitigating factors that could modify the relationship between temperature and disease incidence.

First, there is a possibility of ecological adaptation in vectors over time, either in the form of tolerance to extreme temperatures or changes in reproductive behaviour that are not yet fully understood. Second, microclimate variations in local areas, such as differences in vegetation cover, land use, and residential infrastructure, can create non-uniform environmental conditions, thereby affecting the distribution and survival of vectors differently. Third, community interventions and public health policies, such as increased fogging frequency, dengue vaccination programmes (e.g., use of Dengvaxia or Qdenga vaccines), and improvements in sanitation systems and environmental management, have the potential to significantly reduce transmission risk even as temperatures rise.

The exclusion of these variables from the model may lead to overestimation or underestimation of the effect of temperature on DBD incidence. Therefore, although the results of this study indicate a significant association between rising temperatures and increased DBD incidence, the interpretation of these findings should be approached with caution. It is important to acknowledge that complex interactions between climatic, ecological, and social factors can dynamically influence transmission patterns. Therefore, further studies integrating multivariate approaches that consider local adaptation aspects, policy responses, and spatial variability are urgently needed to produce more accurate risk estimates that can serve as the basis for evidence-based mitigation strategies.

2. Correlation of Rainfall to the Increase in Cholera Cases

Research shows that heavy rainfall is positively correlated with increased cholera cases, particularly in areas with suboptimal sanitation infrastructure. Abundant rainfall can contaminate clean water sources due to poor drainage systems and the mixing of domestic wastewater into wells or drinking water distribution networks, which in turn increases the risk of spreading the Vibrio cholerae bacteria.

The link between climate change and the increase in waterborne diseases can be explained through the concept of environmentally mediated pathogens, which emphasises that pathogen dynamics are greatly influenced by external environmental conditions. Changes in climate patterns, particularly increased humidity, extreme rainfall, and surface water runoff, contribute to the expansion of pathogen habitats and increase the likelihood of clean water contamination, thereby increasing the risk of infection. In this context, diseases such as cholera, acute diarrhoea, and leptospirosis tend to increase in areas with poor sanitation and inadequate drainage systems.

Additionally, the ecological disturbance theory is relevant to explaining these findings. This theory states that ecosystem disturbances caused by climate disasters such as floods and cyclones lead to imbalances in the environmental microbiological system, which can increase the virulence and persistence of pathogens in aquatic environments. The combination of poor waste management, low-quality water infrastructure, and high humidity creates ideal conditions for the survival of microorganisms such as Vibrio cholerae, Escherichia coli, and Leptospira in stagnant water or water distribution systems.

From a climate epidemiology perspective, this relationship indicates that climate variables are not merely external risk factors but function as ecological determinants that directly and indirectly influence disease transmission. This indicates that public health interventions in affected areas should not only focus on medical care but also require an intersectoral approach involving improvements to water infrastructure and sanitation, strengthening early warning systems, and continuous monitoring of water quality.

Thus, the results of this study not only strengthen empirical evidence of the relationship between climate factors and waterborne diseases, but are also supported by environmental and disease ecology theories that explain mechanistically how pathogens interact with the environment amid changing climatic conditions.

Zhang's (2024) research shows that extreme rainfall and high temperatures collectively increase the spread of cholera and other water-borne diseases, especially in tropical countries with unreliable water systems (Zhang, 2024). Furthermore, Liu and Zhang (2025) observed a similar pattern in Southeast Asia, showing that publications and scientific attention related to climate-related diseases increased as the incidence of cholera epidemics increased (Liu & Zhang, 2025).

This study assumes that increased rainfall has a direct impact on the increase in cholera cases, particularly through the mechanism of water runoff contaminating drinking water sources and accelerating the spread of Vibrio cholerae. Although this assumption is supported by literature on the relationship between extreme rainfall and waterborne disease outbreaks, this approach does not fully account for various intermediary factors that can modify or weaken the causal relationship.

Factors such as access to clean water, the use of bottled water by urban communities, the effectiveness of wastewater treatment systems, and hygienic behaviour influenced by health literacy levels play an important role in determining a population's vulnerability to pathogen exposure. For example, regions with high rainfall but good water distribution and sanitation systems may not show a significant increase in cholera cases, while areas with moderate rainfall but poor water management systems may experience an outbreak surge.

The exclusion of these social and infrastructure variables from the research model can lead to estimation bias or oversimplification of causal relationships. As a result, the research findings tend to generalise the effects of rainfall on disease without taking into account the highly influential local context. This has implications for potential misconceptions in designing public health interventions—for example, overemphasising climate control without addressing structural roots such as water infrastructure and public hygiene education.

Thus, the findings of this study should be interpreted as part of a complex system of relationships between climate, environment, and social determinants of health. Further studies that integrate socio-economic spatial data and basic service capacity indicators will be better able to capture risk heterogeneity and generate more relevant evidence for evidence-based local adaptation interventions.

3. Spatial Mapping of High-Risk Areas

Spatial mapping from the research results shows that densely populated areas such as Jakarta, Surabaya, Bangkok, and Ho Chi Minh City are high-risk zones for dengue fever and cholera. This concentration of risk in urban areas is due to dense settlements, limited green open space, and inadequate sanitation.

The concept of spatial epidemiology explains that disease spread is not only dependent on climate but is also strongly influenced by socioeconomic conditions, infrastructure, and local community behavior. Rapid urbanization without adequate sanitation planning can be a significant risk factor in the spread of infectious diseases.

Research by Sekarrini et al. (2022) demonstrated that spatial risk maps using GIS technology were able to identify dengue fever cluster patterns centered in dense urban areas (Sekarrini et al., 2022). Meanwhile, a study by Colón-González et al. (2023) projected that the disease burden in Southeast Asia would increase unevenly, with the epicenter of case growth being in large metropolitan areas (Colón-González et al., 2023).

The researchers assumed that spatial mapping was sufficient to identify high-risk areas. However, this approach requires complementary data in the form of behavioral data, public health response systems, and local mitigation capacity to prevent partial or overgeneralized analysis.

4. Projection of Tropical Disease Risks until 2045

The long-term projections in this study indicate that the risk of tropical diseases such as dengue fever and cholera will increase significantly through 2045, particularly if climate change trends continue under the high-emissions scenario (SSP585). These projections include increased epidemic duration, annual spikes in cases, and geographic spread into previously non-endemic areas.

The climate-sensitive disease burden theory asserts that tropical diseases are significantly affected by climate dynamics such as drastic changes in temperature, rainfall, and humidity. Climate change not only expands endemic zones but also lengthens the disease transmission season.

Wang et al. (2024) predicted that the dengue transmission index (Rt) and epidemic duration would continue to increase in Southeast Asia throughout the 21st century, particularly under moderate to high emission scenarios (Wang et al., 2024). Meanwhile, Simbolon et al. (2023) stated that provinces such as North Sumatra have a high probability of remaining in the high-risk category until 2100 (Simbolon et al., 2023).

The main assumption in this research projection is that climate change trends will continue linearly and population growth will continue to increase without any major interventions to alter its course. In other words, this projection model relies on a business-as-usual scenario in which there are no significant mitigation policies, disruptive health technology innovations, or substantial adaptive behavioural changes at the community level. Although this approach provides a conservative framework for anticipating future health risks, these assumptions need to be critically examined.

In reality, climate mitigation policies, the development of vaccines and early warning systems, and increased community awareness and adaptive capacity can significantly reduce the projected level of risk. Additionally, this study has several methodological limitations that need to be considered. One of these is the reliance on secondary data sourced from health and meteorological institutions, which may have varying data quality and consistency across regions and years. This reliance may affect the internal validity of the predictive model used.

Other potential confounding factors such as accelerated urbanisation, land use change, population migration, and reactive or uneven local policies can also dynamically alter the relationship between climate and tropical diseases. For example, urbanisation can either exacerbate or mitigate risk depending on how health and environmental infrastructure is developed. Meanwhile, changes in disease surveillance systems can affect the sensitivity of case data over time.

Given these limitations, the projection results in this study should be understood as indicative scenarios rather than deterministic ones. Further studies with a multisectoral approach and the use of more contextual primary data are needed to develop more accurate and adaptive predictive models that account for the complexity of the evolving socio-ecological system.

CONCLUSIONS

Based on the research results and spatial-temporal analysis conducted, it can be concluded that climate change contributes significantly to the increased risk of tropical diseases, particularly dengue fever (DHF) and cholera in Southeast Asia. Increased air temperature has been shown to accelerate the life cycle and transmission effectiveness of Aedes aegypti, while high rainfall increases the likelihood of contamination of clean water sources, which is directly correlated with the surge in cholera cases. Densely populated urban areas such as Jakarta, Surabaya, and Bangkok have been identified as high-risk zones due to a combination of climate change, urbanization, and poor sanitation infrastructure. Long-term projections up to 2045 indicate that the burden of tropical diseases will increase significantly, especially under a high-emission scenario, with the expansion of endemic areas and an extended transmission season.

These findings reinforce the vectorecological theory and the concept of climate-sensitive disease burden, and are supported by various recent scientific studies showing that extreme temperatures, intense rainfall, and high humidity collectively create an ideal environment for tropical disease transmission. Therefore, the integration of spatial-temporal data in public health policy planning, as well as the improvement of early warning systems, environmental sanitation, and locally based adaptation strategies are needed to mitigate the impacts of climate change on public health.

REFERENCES

Amnuaylojaroen, T., Parasin, N., & Limsakul, A. (2024). Projections and Patterns of Heat-Related Mortality Impacts from Climate Change in Southeast Asia. *Environmental Research Communications*, *6*(3). https://doi.org/10.1088/2515-7620/ad3128

Choisy, M., Mcbride, A., Chambers, M., Quang, H., Quang, N., Thi, N., Chau, X., Nguyen, G., Bonell, A., Evans, M., Ming, D., Ngo-Duc, T., Pham, Q., Thai, D., Hoang, D., Giang, H., Ngoc, D., Thanh, Hoang, N., & Nhung. (2021). Climate change and health in Southeast Asia – defining research priorities and the role of the Wellcome Trust Africa Asia Programmes. *Wellcome Open Research*, *6*. https://doi.org/10.12688/wellcomeopenres.17263.3

Colon Gonzalez, F. J., Gibb, R., Khan, K., Watts, A., Lowe, R., & Brady, O. J. (2023). Projecting the future incidence and burden of dengue in Southeast Asia. *Nature Communications*, *14*(1). https://doi.org/10.1038/s41467-023-41017-y

Fernando, M., & Rajapaksha, N. U. (2023). How Do Climate Variables Affect the Transmission of Dengue Infection in South and Southeast Asia: A Scoping Review. *Asian Journal of Interdisciplinary Research*, *6*(1), 25–41. https://doi.org/10.54392/ajir2314

He, C., Chen, R., Kim, H., Hashizume, M., Lee, W., Honda, Y., Kim, S. E., Guo, Y. L., Schneider, A., Ge, W., Zhu, Y., Zhou, L., & Kan, H. (2023). Tropical cyclone and daily respiratory mortality across East Asia: a time series study. *European Respiratory Journal*, *62*(1), 2300546. https://doi.org/10.1183/13993003.00546-2023

Jung, Y.-J., Khant, N. A., Kim, H., & Namkoong, S. (2023). Impact of Climate Change on Waterborne Diseases: Directions towards Sustainability. *Water*, *15*(7), 1298. https://doi.org/10.3390/w15071298

Liu, M., & Zhang, Y. (2025). Impact of climate change on dengue fever: a bibliometric analysis. *Geospatial Health*, *20*(1). https://doi.org/10.4081/gh.2025.1301

Liu-Helmersson, J., Stenlund, H., Wilder-Smith, A., & Rocklöv, J. (2014). Vectorial Capacity of Aedes aegypti: Effects of Temperature and Implications for Global Dengue Epidemic Potential. *PLoS ONE*, *9*(3), e89783. https://doi.org/10.1371/journal.pone.0089783

Pereira, J. J., & Shaw, R. (2021). Southeast Asia: An Outlook on Climate Change. *Disaster Risk Reduction*, 1–24. https://doi.org/10.1007/978-981-16-6088-7_1

Sabiruzzaman, Md., Golam Hossain, Md., & Rahman, M. (2021). Climate Change and Health Care Vulnerability in South East Asia: A Review. *Climate Change Management*, 371–393. https://doi.org/10.1007/978-3-030-77259-8_19

Sekarrini, C. E., Sumarmi, Bachri, S., Taryana, D., & Giofandi, E. A. (2022). The application of geographic information system for dengue epidemic in Southeast Asia: A review on trends and opportunity. *Journal of Public Health Research*, *11*(3), 227990362211041. https://doi.org/10.1177/22799036221104170

Simbolon, T. G., Frida, E., Sinambela, M., Situmorang, M., Humaidi, S., & Darmawan, Y. (2023). Projection of Climate Change on the Probability of Dengue Hemorrhagic Fever in North Sumatra Province. *Prisma Sains : Jurnal Pengkajian Ilmu Dan Pembelajaran Matematika Dan IPA IKIP Mataram*, *11*(2), 393. https://doi.org/10.33394/j-ps.v11i2.7754

Wang, Y., Li, C., Zhao, S., Wei, Y., Li, K., Jiang, X., Ho, J., Ran, J., Han, L., Zee, B. C., & Chong, K. C. (2024). Projection of dengue fever transmissibility under climate change in South and Southeast Asian countries. *PLoS Neglected Tropical Diseases*, *18*(4), e0012158–e0012158. https://doi.org/10.1371/journal.pntd.0012158

Wang, Y., Wei, Y., Li, K., Jiang, X., Li, C., Yue, Q., Zee, B. C., & Chong, K. C. (2022). Impact of extreme weather on dengue fever infection in four Asian countries: A modelling analysis. *Environment International*, *169*, 107518. https://doi.org/10.1016/j.envint.2022.107518

Wang, Y., Zhao, S., Wei, Y., Li, K., Jiang, X., Li, C., Ren, C., Yin, S., Ho, J., Ran, J., Han, L., Zee, B. C., & Chong, K. C. (2023). Impact of climate change on dengue fever epidemics in South and Southeast Asian settings: A modelling study. *Infectious Disease Modelling*, *8*(3), 645–655. https://doi.org/10.1016/j.idm.2023.05.008

Zain, A., Sadarangani, S. P., Shek, L. P.-C., & Vasoo, S. (2024). Climate change and its impact on infectious diseases in Asia. *Singapore Medical Journal*, *65*(4), 211. https://doi.org/10.4103/singaporemedj.SMJ-2023-180

Zhang, Y. (2024). Impact of Climate Change on Transmission Patterns of Infectious Diseases and Public Health Responses. *Highlights in Science, Engineering and Technology*, *123*, 71–76. https://doi.org/10.54097/p7328k87