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Climate-Sensitive Diseases and Community Vulnerability in Coastal Indonesia: A Systematic Review with Narrative Synthesis

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Climate change is increasingly exacerbating health risks in tropical regions, particularly in archipelagic nations such as Indonesia. This study aims to systematically identify and synthesize scientific evidence on climate-sensitive diseases and community vulnerability in coastal Indonesia. A systematic review with narrative synthesis was conducted across four databases (PubMed, Scopus, ScienceDirect, and Google Scholar). The search was performed on 15 June 2025, covering studies published between 2013–2024. Of the 263 records identified, 20 studies met the eligibility criteria, consisting of 12 observational studies, 5 modelling studies, and 3 review or mixed-method papers. The findings indicate consistent associations between rising temperatures, shifting rainfall patterns, flooding, drought, and sea-level rise with increased incidence of dengue, malaria, diarrhea, filariasis, and climate-related mental health outcomes. These climate-sensitive risks are amplified by structural vulnerabilities, including inadequate sanitation, high population density, dependence on climate-sensitive livelihoods, and limited access to healthcare in coastal and remote areas. Most included studies originated from Indonesia and Southeast Asia, underscoring strong contextual relevance. The synthesis highlights that fragmented, sectoral approaches remain insufficient in addressing health impacts of climate change. Integrated strategies—such as climate-informed disease surveillance, community-based early warning systems, and strengthened cross-sectoral coordination—are urgently needed to enhance adaptive capacity. This review is limited by the absence of quantitative meta-analysis and the geographic focus on Indonesia. Future studies should employ longitudinal designs, higher-resolution spatial climate data, and interdisciplinary approaches to support more robust climate-health adaptation strategies.

Keywords: Coastal, Disease, Climate change, Community

INTRODUCTION

Climate change is widely recognized as a major threat to global public health (Kotcher et al., 2021). Its impacts are multifaceted, affecting not only the physical environment but also critical social determinants of health such as food security, access to clean water, and housing stability (Goniewicz et al., 2025; Limaheluw et al., 2024). The World Health Organization (WHO) estimates that between 2030 and 2050, climate change will lead to an additional 250,000 deaths annually due to malnutrition, malaria, diarrhea, and heat-related illnesses (W.H.O., 2024).

Several real-world examples underscore the gravity of this threat: the extreme heatwave in Europe in 2022, which caused over 60,000 deaths (Ballester et al., 2023; Prats et al., 2023) the catastrophic floods in Pakistan that submerged one-third of the country and heightened cholera risks (Sarkar, 2022); and the prolonged drought in the Horn of Africa that endangered millions of lives due to widespread crop failure (Aly, 2024). In Indonesia, erratic weather patterns have exacerbated the dengue fever cycle in tropical provinces such as Kalimantan and Sulawesi, while also increasing the incidence of diarrhea and leptospirosis, particularly in flood-prone and poorly sanitized coastal areas like North Jakarta and Semarang (Tosepu et al., 2018; Wibawa et al., 2024).

As the world's largest archipelagic nation, with more than 80,000 km of coastline and over 40% of its population living in coastal zones, Indonesia is among the countries most vulnerable to climate change (Rachmawati et al., 2022; Setyani et al., 2024; Vinata et al., 2023). Coastal communities are directly exposed to hazards such as sea-level rise, saltwater intrusion, and tropical storms, while simultaneously facing socio-economic challenges including poverty, dependence on informal labor, and limited access to healthcare services (Kurniawan et al., 2024; Noor & Abdul Maulud, 2022). Despite increasing recognition of these challenges, policy responses in Indonesia remain fragmented, with limited integration between environmental monitoring and health surveillance systems.

While various studies have addressed the links between climate and health, much of the existing literature remains sectoral, fragmented, and lacking a comprehensive understanding of community vulnerability. There is a notable gap in evidence-based research that integrates multiple climate-sensitive diseases, climatic stressors, and dimensions of social vulnerability within a unified analytical framework, especially in the context of Indonesia. Taken together, these challenges highlight the need for an integrative evidence synthesis that not only links climate variability to multiple health outcomes, but also situates disease risk within the socio-ecological vulnerabilities of Indonesia's coastal communities.

Accordingly, this systematic review with narrative synthesis aims to consolidate and critically examine existing evidence on climate-sensitive diseases in Indonesia's coastal regions. Specifically, the review seeks to synthesise patterns linking climatic drivers to major health outcomes, identify population groups and settings that exhibit heightened vulnerability, and assess how socio-economic and environmental factors interact to shape health risks. By integrating findings across disease categories, climate stressors, and vulnerability dimensions, this review is intended to inform more risk-informed public health planning, climate adaptation strategies, and policy interventions in coastal and small-island contexts.

METHODS

This study employed a systematic review with narrative synthesis to examine the relationship between climate-sensitive diseases and community vulnerability in coastal Indonesia. This design was chosen to integrate diverse empirical and modelling evidence across multiple disease categories and climatic stressors, while allowing contextual interpretation of socio-ecological vulnerability in coastal settings.

A comprehensive literature search was conducted using four major academic databases—PubMed, Scopus, ScienceDirect, and Google Scholar—selected for their broad coverage of public health, environmental health, and climate-related research. The search was performed on 15 June 2025 and covered studies published between 2013 and 2024. Search terms were developed using combinations of keywords and Boolean operators, including *"climate-sensitive diseases," "climate change health impacts," "community vulnerability," "coastal populations," "Indonesia,"* and *"Southeast Asia".* Searches were limited to articles published in English or Bahasa Indonesia.

Studies were included if they reported empirical or model-based evidence linking climatic factors to health outcomes, focused on coastal or tropical settings, and addressed dimensions of population vulnerability. Eligible study designs included observational studies, modelling or projection studies, and systematic or narrative reviews. Articles were excluded if they discussed climate change or health outcomes in isolation, lacked primary or synthesised data, or were opinion pieces, editorials, or commentaries.

All records retrieved from the database searches were exported into Microsoft Excel, where duplicate entries were identified and removed manually. Two independent reviewers screened titles and abstracts using predefined inclusion and exclusion criteria. Full-text articles deemed potentially relevant were then assessed independently by both reviewers. Discrepancies in study selection were resolved through discussion until consensus was reached. Reference management software and inter-rater reliability statistics were not applied, as a consensus-based manual approach was considered appropriate for the descriptive and integrative nature of this review.

Data extraction was conducted using a structured matrix to capture key study characteristics, including publication year, study location, study design, disease outcomes, climate drivers, vulnerable populations, and principal findings. The included studies were synthesised using a thematic narrative approach, grouping evidence according to disease categories, dominant climatic drivers, and vulnerability dimensions.

To support interpretation of findings, study quality and risk of bias were assessed qualitatively based on study design, data sources, exposure and outcome measurement, and analytical approach. Observational time-series and epidemiological studies with explicit climate–health linkage and transparent methods were considered to provide stronger empirical evidence, whereas modelling and review-based studies were interpreted as indicative of potential risk patterns rather than causal effects.

Following the screening and eligibility assessment, a total of 263 records were identified across the four databases. After removal of 41 duplicate records, 222 titles and abstracts were screened, resulting in the exclusion of 183 records. Thirty-nine full-text articles were assessed for eligibility, of which 19 were excluded for not meeting the inclusion criteria. Ultimately, 20 studies were included in the final synthesis. The study selection process is summarised in the PRISMA 2020 flow diagram (Figure 1).

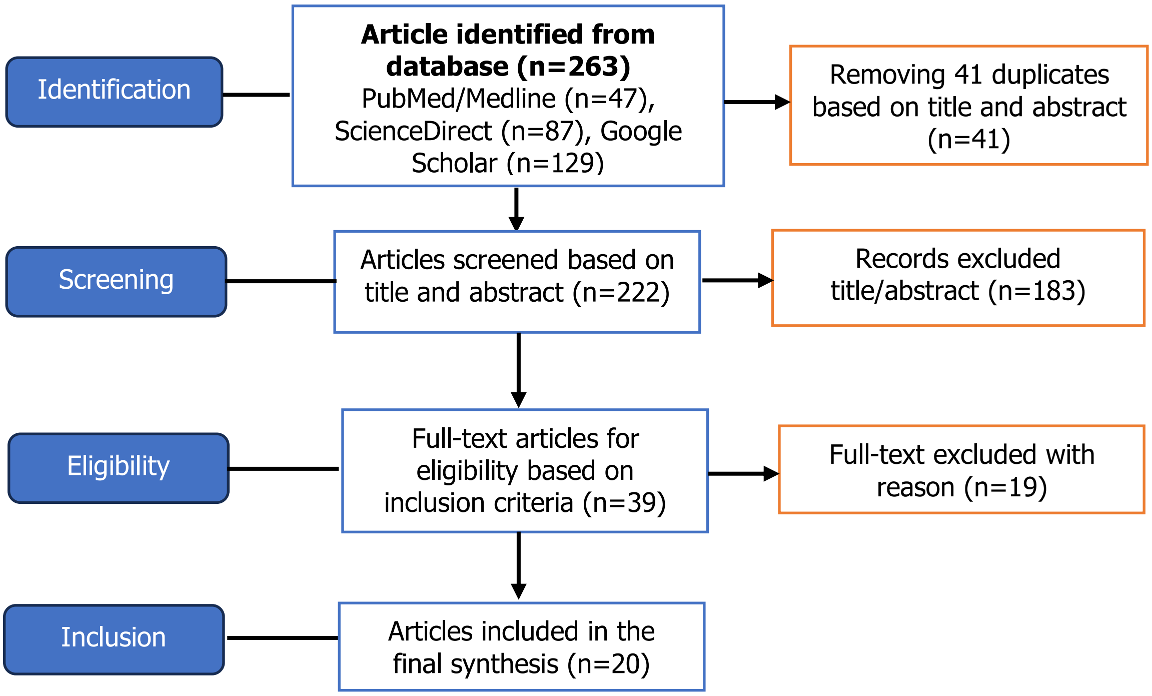

Figure 1. PRISMA flow diagram illustrating the selection process of articles included in the final literature synthesis

RESULTS AND DISCUSSION

Study Characteristics

A total of 20 studies met the eligibility criteria and were included in the final synthesis. The included studies comprised 12 observational studies, 5 modelling studies, and 3 review or mixed-method papers. Most studies were conducted in Indonesia, with additional evidence from other coastal settings in Southeast Asia, including Malaysia, Singapore, and Vietnam. The reviewed studies addressed a range of climate-sensitive health outcomes, particularly dengue, malaria, diarrhoeal diseases, leptospirosis, filariasis, and climate-related mental health conditions. Key characteristics of the included studies such as study location, design, disease focus, climate drivers, and identified vulnerability dimensions—are summarised in Table 1.

Table 1
Characteristics of research subjects

No	Author & Year	Study Location	Study design	Data source	Diseases covered	Climate factor	Vulnerable population	Key findings
1	Oktari et al. (2022)	Indonesia	Review / policy analysis	Policy documents, reports	General (health impacts of climate-related disasters)	Floods, droughts, extreme heat	Coastal communities, elderly, children, women	Many policies remain non-integrative; improved cross-sector coordination needed.
2	Mustofa et al. (2021)	Indonesia	Observational & spatial analysis (temperature hotspot mapping)	Climate model outputs / local temperature data	Heat-related health risks	Extreme temperature	Socioeconomic groups; urban heat island residents	Temperature hotspots can guide local climate adaptation priorities.
3	Ichsan & Waru (2019)	Indonesia	Qualitative / descriptive (policy/context analysis)	Qualitative data / secondary sources	General climate-related impacts	Rainfall, temperature, sea level	Social & economic groups with low adaptability	High vulnerability requires integrated health and

No	Author & Year	Study Location	Study design	Data source	Diseases covered	Climate factor	Vulnerable population	Key findings
								social interventions.
4	Noor & Abdul Maulud (2022)	ASEAN region	GIS / vulnerability assessment (modelling)	CVI/GIS datasets	Coastal risks (general)	Sea-level rise, erosion, tropical storms	Coastal populations	Coastal Vulnerability Index and GIS effective for coastal risk assessment.
5	Aly (2024)	Guinea (West Africa)	Review / policy evaluation (BRACE strategy)	Program reports, literature	Malaria, diarrhea, Acute Respiratory Infection	Temperature, heavy rainfall, floods, droughts	Children, elderly, outdoor workers	BRACE strategy effective for health adaptation planning.
6	Linh Tran et al. (2023)	Vietnam	Observational / modelling (epidemiological + climate analysis)	Surveillance and climate datasets	Dengue, malaria, diarrhea, leptospirosis	Temperature, floods, droughts, rainfall, salinity	Elderly, children, outdoor workers, coastal communities	Strong evidence of increased disease burden and high vulnerability in coastal zones.
7	Suk Lee et al. (2017)	Vietnam	Observational / ecological (seasonal analysis)	National surveillance / environmental data	Dengue, malaria, shigellosis, leptospirosis, aflatoxicosis	Temperature, humidity, rainfall, seasonal patterns	Agricultural, and coastal populations	Disease spikes during rainy season; spatial hotspots need targeted interventions.
8	Abbasi (2025)	Global	Modelling / projection study	Global modelling datasets	Dengue	Temperature, rainfall, humidity, flooding, extreme events	Tourists, tropical communities, emerging non-endemic zones	Projected global increase of 25–45% in dengue cases under scenario analyses.
9	Nhamo et al. (2025)	South Africa	Review / assessment	Literature & reports)	General climate-related health risks	Temperature, extreme rainfall, drought, storms, sea-level rise	Coastal & rural communities; children, elderly	Climate disaster trends rising with significant health and food security impacts.
10	Hochman et al. (2021)	Israel, Palestine, Jordan	Observational / climate-epidemiology	Surveillance and climate datasets	Influenza (respiratory disease)	Low temperature events,	Urban and rural populations in Eastern	Cyprus Lows may help predict climate-

No	Author & Year	Study Location	Study design	Data source	Diseases covered	Climate factor	Vulnerable population	Key findings
						humidity, precipitation	Mediterranean	related respiratory outbreaks.
11	Wolff et al. (2021)	Indonesia	Observational ecological study	Local climate datasets + health records	Respiratory diseases (COPD, Acute Respiratory Infection)	Rising temperature trends; deforestation-linked warming	Outdoor workers	Climate factors (including land-use change) elevate respiratory health risks, especially for outdoor workers.
12	Moreira et al. (2020)	Africa & Asia	Review (global comparative assessment)	Secondary data from published studies	Vector-borne & infectious diseases	Dry climates, temperature extremes	Populations in arid & semi-arid zones	Overview of how extreme climatic conditions intensify disease burdens in dry regions.
13	Wu & Huang (2022)	China	Observational / time-series climate-epidemiology	National surveillance & meteorological datasets	Mosquito-borne diseases	Hot climate, high humidity, rainfall	General urban populations	Temperature, humidity, and rainfall are key predictors of dengue and other vector-borne outbreaks.
14	Bowen et al. (2024)	Pacific Islands (Fiji, Samoa)	Review / health system assessment	Policy documents & climate reports	General health impacts	Rainfall, storm intensity, heat	Coastal populations	Strengthening health system resilience is essential for climate adaptation in Pacific Island nations.
15	Grigorieva (2024)	Arctic region	Observational + review synthesis	Health records & climate trend data	Mental health, noncommunicable diseases	Melting permafrost, temperature rise	Populations in polar marine areas	Adaptive strategies are needed to reduce increasing climate-related health burdens in Arctic zones.

No	Author & Year	Study Location	Study design	Data source	Diseases covered	Climate factor	Vulnerable population	Key findings
16	Leal Filho et al. (2023)	Pacific Islands	Observational / mixed-methods	Community surveys & climate data	Mental health (PTSD, anxiety, depression)	Tropical storms, floods, droughts, sea-level rise	Small island & coastal communities	Increasing severity of climate disasters correlates strongly with worsening mental health outcomes.
17	Rasjid et al. (2019)	Indonesia	Observational / time-series	Local health surveillance data	Dengue	Temperature, general climatic trends	Lowland area populations	Significant positive correlation between rising temperatures and dengue incidence.
18	Anita Lontaan et al. (2024)	Indonesia	Observational epidemiological study	Urban health records & rainfall data	Dengue	Rainfall, wet season patterns	Urban communities	Increased rainfall trends are associated with elevated dengue cases in urban settings.
19	Nuraini et al. (2021)	Indonesia	Observational modeling study	Climate disease surveillance data	Dengue	Climate variability, temperature	Urban & coastal areas	Infection risk increases at 24.3°C–27.6°C, identifying climatic thresholds for outbreaks.
20	Roswati et al. (2021)	ASEAN	Synthesis review	Secondary data from coastal regions	Filariasis	Temperature, rainfall, humidity, sanitation quality	Tropical & coastal communities	Climate change intensifies filariasis transmission, especially in vulnerable tropical coastal zones.

The reviewed studies demonstrate substantial geographical and methodological diversity, providing a broad overview of climate–health interactions in coastal and tropical settings. Indonesia contributed the largest proportion of studies, followed by Southeast Asian countries such as Vietnam and Malaysia, with additional evidence from the Pacific Islands, Africa, China, and global modelling work. Observational designs dominated the evidence base, complemented by modelling studies and several review or policy-oriented papers.

Across all studies, dengue emerged as the most frequently examined climate-sensitive disease, followed by malaria, diarrheal illnesses, leptospirosis, respiratory conditions, and climate-related mental health outcomes. Temperature rise and rainfall variability were the most consistently assessed climate drivers, while flooding, droughts, and sea-level rise also appeared prominently across multiple regions. Together, the diversity of study designs, disease categories, and climate stressors highlights the multifaceted nature of climate-related health risks and underscores the importance of context-specific vulnerability assessments in coastal populations.

Findings by Disease Category

Across the 20 included studies, dengue emerged as the most frequently examined climate-sensitive disease, followed by malaria, diarrheal diseases, leptospirosis, and respiratory illnesses. Most studies consistently showed that rising temperatures, increased humidity, and seasonal rainfall patterns contribute to higher transmission rates of vector-borne diseases, particularly in tropical and coastal regions. Several modelling studies also projected notable increases in dengue and malaria incidence under future warming scenarios.

Waterborne diseases such as diarrhea and leptospirosis were primarily associated with extreme rainfall, flooding, and inadequate sanitation. Filariasis and other vector-related infections were reported to intensify under conditions of fluctuating temperature and high humidity. A smaller set of studies highlighted mental health outcomes such as anxiety, depression, and PTSD linked to climate-related events including storms, droughts, and sea-level rise. Overall, the findings indicate that multiple disease categories show climate sensitivity, with distinct patterns across infectious and non-infectious health outcomes.

Climate Drivers

The reviewed studies identified several dominant climate drivers influencing disease patterns, including rising temperatures, increased humidity, heavy rainfall, flooding, droughts, and sea-level rise. Temperature increases were strongly associated with the acceleration of mosquito life cycles and the expansion of vector habitats. Rainfall and flooding were found to create favourable conditions for waterborne disease outbreaks through contamination of water sources and the proliferation of mosquito breeding sites.

Long-term climatic stressors such as sea-level rise, salinity intrusion, and seasonal droughts were linked to declining water quality, reduced agricultural productivity, and increased livelihood insecurity in coastal settings. Extreme events such as tropical storms, cyclones, and prolonged heat waves—also played a significant role in shaping health risks, particularly by disrupting public health infrastructure and amplifying exposure pathways across multiple disease categories.

Vulnerability Dimensions

The studies consistently reported that populations living in coastal and low-lying areas are among the most vulnerable, especially communities with limited access to healthcare, poor sanitation, and high dependency on climate-sensitive livelihoods such as fishing and small-scale agriculture. Children, the elderly, and outdoor workers were repeatedly identified as groups facing elevated health risks due to biological susceptibility and exposure conditions.

Socio-economic characteristics including poverty, low adaptive capacity, inadequate infrastructure, and limited disaster preparedness further amplified vulnerability across regions. Urban poor communities also experienced heightened risks due to overcrowding, poor drainage systems, and environmental degradation. Overall, vulnerability was shaped not only by climatic exposure but also by structural inequalities that restrict communities' ability to prepare for, respond to, and recover from climate-related health threats.

Quality-Weighted Synthesis

The strength of evidence varied across the included studies. Higher-quality studies primarily observational time-series analyses and climate epidemiological modelling provided the most robust quantitative associations between climatic variables and disease incidence. These studies consistently showed strong links between rising temperatures, rainfall variability, and increased transmission of dengue, malaria, leptospirosis, and waterborne diseases. Several modelling studies also projected substantial increases in future disease burden under warming scenarios, further reinforcing the reliability of these findings.

In contrast, evidence from qualitative assessments, ecological reports, and narrative reviews was more descriptive and had a higher risk of bias, as these designs lacked standardized measurement, effect estimates, or controlled comparisons. While such studies contributed valuable contextual insights especially regarding vulnerability, adaptation, and socio-economic determinants their findings should be interpreted with caution. Overall, the synthesis indicates that climate-sensitive disease patterns observed through modelling and longitudinal observational studies demonstrate stronger causal plausibility compared with evidence drawn from reviews or cross-sectional assessments.

Discussion

The synthesis of the 20 reviewed articles revealed consistent patterns linking climate variability and a range of climate-sensitive health outcomes in coastal settings. Tropical infectious diseases such as dengue and malaria were the most frequently reported conditions associated with climatic factors (Abbasi, 2025; Lontaan et al., 2024). However, it is important to note that the nature and strength of these associations varied by study design: observational time-series and epidemiological analyses tended to provide empirical associations between temperature, humidity and vector dynamics, whereas modelling studies projected potential future burdens under scenario assumptions (Linh Tran et al., 2023). Several studies also reported concerns about filariasis, leptospirosis, diarrhoeal diseases, and climate-related mental health outcomes (e.g., PTSD and anxiety) in coastal and small-island settings (Hochman et al., 2021; Nuraini et al., 2021; Rasjid et al., 2019; Roswati et al., 2021). A smaller subset of papers identified food- and water-borne hazards such as shigellosis and aflatoxicosis, although these received less consistent quantitative treatment (Seah et al., 2021; W.H.O., 2024).

Extreme temperatures, heavy rainfall and flooding were the climatic drivers most commonly linked to increased disease risks in the included studies (Leal Filho et al., 2023; Moreira et al., 2020). Elevated temperatures were frequently associated with accelerated vector life cycles and expanded vector habitat suitability, while intense rainfall and floods were repeatedly linked to contamination of drinking water and increased incidence of waterborne diseases. Drought conditions were also discussed as exacerbating sanitation and food-security risks (Nhamo et al., 2025). That said, many studies used aggregated or coarse climate metrics (e.g., monthly station averages or broad satellite products), and modelling outputs depend on assumptions about vector biology and emission pathways, which limits direct causal inference from climate to disease incidence.

Vulnerability patterns reported across studies highlight coastal communities, children, older adults, outdoor workers, and populations dependent on marine livelihoods as particularly at risk (Lontaan et al., 2024; Purnomo et al., 2024). Poor urban neighbourhoods with high population density and inadequate drainage were also consistently identified as hotspots for climate-sensitive diseases (Suk Lee et al., 2017; Wu & Huang, 2022). Importantly, several reviewed papers underscored that climatic exposure interacts with structural determinants such as sanitation quality, healthcare access, socioeconomic status, and local governance capacity which may confound or mediate observed associations (Sari et al., 2025). Rapid urbanisation, changes in vector-control activities, improvements in diagnostics, and behavioural shifts (e.g., water storage practices) are plausible alternative drivers that many primary studies did not fully adjust for.

Regional analyses in the literature point to similar trends across Southeast Asia and Indonesia: temperature-driven upticks in vector-borne disease were reported from Malaysia, Singapore and Vietnam (Linh Tran et al., 2023; Noor & Abdul Maulud, 2022), while the combination of extreme rainfall and poor sanitation was frequently associated with waterborne outbreaks in Indonesian contexts (Lontaan et al., 2024; Rasjid et al., 2019). Studies from Kalimantan and other low-lying coastal areas also emphasised how seawater intrusion and deficient drainage systems exacerbate health risks, illustrating the interplay between climatic stressors and infrastructural vulnerabilities (Wolff et al., 2021).

Compared with earlier literature syntheses that often treated diseases or climatic exposures in isolation, this review offers a more integrated, context-specific framing that maps disease types, climatic drivers and socio-ecological vulnerability in concert (Maharani et al., 2025). Nevertheless, the overall strength of evidence varies: observational and longitudinal studies with robust exposure and outcome measurement provide greater empirical weight than single-site cross-sectional surveys or narrative reviews, while projections from modelling studies should be read as scenario-based risk estimates rather than definitive causal proof (Mustofa et al., 2021; Oktari et al., 2022)

Policy implications emerging from this synthesis should therefore be pragmatic and operational. Rather than generic calls for cross-sectoral integration, the evidence supports several feasible actions, including the establishment of routine data linkages between BMKG climate feeds and DINKES surveillance systems to enable near-real-time, climate-informed risk alerts. Strengthening surveillance capacity through sentinel sites in identified coastal hotspots would allow the collection of high-resolution epidemiological and environmental data. In addition, incorporating simple climate indicators such as seven-day rainfall anomalies and short-term mean temperature thresholdsinto local early-warning systems may improve preparedness for dengue and diarrhoeal outbreaks. Targeted sanitation upgrades and drainage improvements in coastal villages with documented outbreak histories, alongside the scaling of community-based preparedness initiatives such as trained flood response teams and climate-informed vector control, can further complement facility-level interventions.

This review has several limitations that affect interpretation. First, under-ascertainment and heterogeneous case definitions across surveillance systems likely bias effect estimates for many infectious diseases. Second, methodological heterogeneity reflected in variable climate data sources, spatial and temporal aggregation, and differing analytic approaches limited opportunities for quantitative synthesis or meta-analysis. Third, the reliance on accessible and published literature may introduce publication bias toward studies reporting positive associations. Finally, because much of the strongest empirical evidence derives from a subset of time-series and modelling studies, generalisability to all coastal settings should be made cautiously.

To strengthen the evidence base, future research should prioritise the development of longitudinal cohort or sentinel-surveillance platforms in high-risk coastal districts that integrate health outcomes with high-resolution meteorological and hydrological monitoring. Spatial epidemiological studies using fine-scale climate and land-use data are needed to identify micro-environmental transmission drivers. Mixed-methods approaches would be valuable for capturing community adaptation, behavioural responses, and barriers to service uptake. Greater standardisation of outcome definitions and reporting formats would facilitate pooled analyses, while operational pilot projects linking BMKG–DINKES data streams with local early-warning dashboards could help evaluate feasibility and public-health impact.

In summary, the body of evidence indicates consistent associations between climatic stressors and multiple health outcomes in coastal and tropical settings, with important implications for policy and practice. However, claims regarding causality should remain cautious given confounding, data limitations, and methodological heterogeneity; translating this evidence into actionable health adaptation requires pragmatic, locally tailored interventions supported by improved surveillance and targeted research.

CONCLUSION

This review indicates that climate variability is consistently associated with changes in the distribution and intensity of climate-sensitive diseases in coastal Indonesia. Evidence from the 20 included studies suggests that rising temperatures, rainfall extremes, flooding, and drought conditions are linked to increased risks of vector-borne and waterborne diseases, as well as indirect impacts on mental health. These associations are shaped by underlying structural vulnerabilities including limited health infrastructure, inadequate sanitation, and socioeconomic constraints which reduce the adaptive capacity of coastal communities. While the evidence is broadly consistent, variation in study design, data quality, and measurement approaches means that these findings should be interpreted with caution, especially regarding causal inference.

Based on these findings, several priority actions emerge for strengthening climate–health resilience. Public health adaptation should shift toward risk-informed strategies, including integrating BMKG–DINKES climate and surveillance data, establishing sentinel monitoring sites in coastal hotspots, and improving local sanitation and drainage systems in high-risk areas. Additionally, future research would benefit from longitudinal cohort designs, spatial epidemiological analyses with fine-resolution climate data, and mixed-methods studies to better understand community adaptation and behavioural factors. These steps are essential to support more robust, context-specific, and sustainable public health responses to climate-related health risks.

SUGGESTION

To translate the findings of this review into actionable outcomes, it is recommended that stakeholders particularly local governments, public health agencies, and environmental planners develop integrated policies that incorporate climate risk assessments into health service planning at the community level. Coastal health programs should prioritize vector and waterborne disease control in high-risk areas, supported by real-time climate data. Additionally, capacity building initiatives should be directed at frontline health workers and local disaster response units to improve climate adaptation readiness. Further investment is also needed in community-based early warning systems, infrastructure resilience, and cross-sectoral coordination mechanisms to ensure that health interventions are not only reactive but also anticipatory and sustainable.

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