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Climate Change and Health Vulnerability of Coastal Communities in Timor-Leste: A Small Island Comparative Study

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Abstract
Climate change threatens public health in small island developing states, including Timor-Leste, where adaptive capacity remains limited. This study analysed climate-related health impacts and measured the composite health vulnerability index of coastal communities in Municipios Manatuto and Baucau. A concurrent embedded mixed-methods design with a matched case-control component was used. Quantitative data came from 400 household heads: 200 cases with a facility-recorded episode of dengue, acute diarrhoea, or acute respiratory infection in the preceding 12 months, and 200 controls without such an episode, matched on sex, age group (±5 years), and suco. Qualitative data came from in-depth interviews with 24 purposively selected informants, continued until thematic saturation. Analyses used chi-square tests, Pearson correlation, and binary logistic regression, preceded by tests of normality, multicollinearity, and goodness of fit; qualitative data were examined through six-phase thematic analysis. Dengue prevalence was higher in Manatuto (7.2%) than Baucau (5.8%) and correlated positively with mean temperature ($r = 0.72$; $p < 0.001$). Under-five stunting reached 48.5% and 45.2% respectively. The composite index was 3.8 (high) in Manatuto and 3.5 (moderate-to-high) in Baucau, with the gap driven by exposure (3.8 versus 3.5) and sensitivity (4.1 versus 3.7) rather than socio-economic conditions (2.0 versus 2.3). Significant risk factors were limited clean-water access (OR = 3.45), inadequate sanitation (OR = 2.87), and subsistence farming (OR = 2.14). Because Manatuto scored 3.8 against Baucau's 3.5, adaptation should prioritise water, sanitation, and health-facility resilience in Manatuto while consolidating Baucau's adaptive-capacity advantage.

Keywords: Composite vulnerability index, climate change, climate-sensitive diseases, coastal communities.

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INTRODUCTION

Climate change has become one of the defining threats to public health in the twenty-first century, and its consequences fall most heavily on small island developing states (SIDS), whose adaptive capacity remains structurally constrained (Ramos-Horta et al., 2025; Gordon-Strachan et al., 2025; World Bank Group and Asian Development Bank, 2021). These states generate less than

1% of global greenhouse-gas emissions, yet their populations absorb a disproportionate share of the health burden arising from sea-level rise, drought, flooding, and extreme weather events. The underlying vulnerability is rooted in small territorial size, geographic remoteness, limited fiscal and technical resources, and economies anchored in climate-sensitive primary sectors. Such conditions magnify pre-existing health problems rather than creating entirely new ones, producing a form of climate injustice in which the states least responsible for global warming stand at the front line of a global health crisis. Establishing how this burden is distributed within individual island states is therefore a precondition for equitable adaptation (Gordon-Strachan et al., 2025; IFRC Climate Centre, 2021; Jansson et al., 2025).

Timor-Leste, a small island developing state in Southeast Asia, presents a pronounced vulnerability profile. The country has approximately 747 km of coastline, and two-thirds of its population lives in coastal areas and lowlands below 500 metres above sea level, where sea-level rise, seawater intrusion, coastal erosion, storm surge, and drought converge (IFRC Climate Centre, 2021; World Health Organization and Ministry of Health Timor-Leste, 2018). Mean temperature rose by 0.14°C per decade between 1971 and 2020 and is projected to rise by 0.25°C per decade to 2050, while sea level around the country has risen by 5.5 mm per year since 1993, well above the global mean of 2.8-3.6 mm per year. These pressures act upon a health system that is still developing and upon socio-economic indicators that remain fragile (Nofiano and Aghamohammadi, 2024; Ramos-Horta et al., 2025; Belo et al., 2026).

The health consequences operate through direct and indirect pathways. Direct effects include heat exposure and injury or death during weather-related disasters, whereas indirect effects include shifts in vector distribution, malnutrition, waterborne infection, and disruption of health services (WHO and Ministry of Health Timor-Leste, 2018; Lieber, 2025). Climate-sensitive conditions such as dengue, malaria, diarrhoea, and acute respiratory infection show upward trends that correlate with changes in climate parameters. In 2022, Timor-Leste recorded 5,658 dengue cases and 58 deaths, with Manatuto among the municipalities reporting the highest case counts (da Cruz et al., 2023; Mahato et al., 2025).

Nutritional vulnerability compounds this burden. Under-five stunting reaches 47.1%, the highest prevalence in Southeast Asia and the fourth highest globally, indicating a structural deficit that climate stress can readily deepen. The interaction between infectious disease, chronic undernutrition, and climatic pressure constitutes a syndemic in coastal populations and calls for analysis that integrates health, nutrition, water, and food security rather than treating them as separate domains (Titaley et al., 2023; UNICEF Timor-Leste, 2025; Proulx et al., 2024).

Municípios Manatuto and Baucau are neighbouring north-coast territories that share geography, national policy, and broadly similar livelihood profiles, but differ in exposure and adaptive capacity. Manatuto has a longer, lower-lying coastline and greater susceptibility to flooding and seawater intrusion, whereas Baucau has a larger population and comparatively better access to health facilities (IFRC Climate Centre, 2021; World Bank Group and ADB, 2021). Both municipalities have experienced an increasing frequency of extreme events over the past two decades; the 2021 flash floods damaged health infrastructure, destroyed agricultural land, and severed access to services for vulnerable groups. Because the two sites operate within the same national policy environment while differing in exposure and capacity, they constitute an informative comparative case in which the geographic and socio-economic modulation of climate-related health outcomes can be examined directly (Nofiano and Aghamohammadi, 2024; Government of Timor-Leste, 2021; Su et al., 2026).

Livelihood structure links climate to health through food. Dependence on subsistence agriculture and small-scale fishing exposes households in both municipalities to production shocks driven by climate variability, and declining yields translate quickly into the nutritional status of children under five and pregnant women (Van der Merwe et al., 2022; Su et al., 2026). Empirical evidence indicates that anomalous anthropogenic warming is associated with higher stunting prevalence, while physical and economic access to food shapes nutritional security independently of exposure; the present study captures the latter through a household food-security measure. Coastal communities increasingly face a double burden of malnutrition in which persistent undernutrition coexists with diet-related noncommunicable disease (Titaley et al., 2023; Proulx et al., 2024). Caregiving and infant-feeding practices plausibly mediate these relationships, but they were not measured here and are treated as a direction for future research rather than as a stated objective (Colozza et al., 2025).

Despite this evidence base, sub-national understanding of climate-health vulnerability in Timor-Leste remains thin, and existing assessments rarely accommodate local dynamics such as settlement pattern, livelihood, and service access. Four studies illustrate the gap concretely. First, the national health vulnerability and adaptation assessment aggregates risk to country level and therefore cannot distinguish exposure or adaptive capacity between coastal municipalities (WHO and Ministry of Health Timor-Leste, 2018). Second, Nofiano and Aghamohammadi (2024) documented community-based adaptation in Timor-Leste through an exclusively qualitative single-site design, without quantified vulnerability scores or risk-factor estimates. Third, Belo et al. (2026) provide a

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rigorous multi-scale quantitative synthesis of national climate trends but do not connect those trends to household-level health outcomes. Fourth, the Pacific-wide scoping review by Kim et al (2022) identifies the absence of integrated sub-national climate-health evidence as a persistent gap, a conclusion echoed for structural determinants of vulnerability by Mathews et al (2025) and for adaptation implementation by Boyer et al (2025). Quantitative and qualitative evidence has thus been generated separately and at scales too coarse to guide municipal decision-making.

Addressing this gap, the present study pursues three objectives: to analyse the health impacts of climate change on coastal communities in Municípios Manatuto and Baucau; to measure the climate-related health vulnerability index in both municipalities; and to identify the dominant risk factors that shape that vulnerability. A concurrent mixed-methods design incorporating a matched case-control component was adopted so that quantitative estimation and qualitative explanation could be combined within a single analytical frame. The findings are intended to inform health-sector adaptation policy that is more targeted, equitable, and contextually grounded (Ramos-Horta et al., 2025; WHO, 2024; Government of Timor-Leste, 2021).

The novelty of this study is conceptual rather than procedural. By comparing two municipalities that share a national climate and health policy environment, a common north-coast ecology, and broadly similar livelihood profiles, the design holds the macro context constant and isolates locally modifiable conditions, namely water and sanitation coverage, health-infrastructure resilience, and household adaptive capacity. The comparison yields a substantive insight for Timor-Leste, because divergence in climate-sensitive disease and stunting burdens tracks differences in sensitivity and adaptive capacity more closely than differences in the climate hazard itself, implying that measurable health gains are attainable at municipal level without any change in the underlying hazard profile. The contribution is distinct from the closest prior work: Otokiti et al. (2026) compare vulnerability across small island developing states at national scale, and Nofiano and Aghamohammadi (2024) examine a single Timorese site qualitatively. Neither offers a within-country, concurrently collected quantitative and qualitative comparison at municipality level using an explicit five-dimension vulnerability index.

METHODOLOGY

Type of Research

This study employed a concurrent embedded mixed-methods design with a matched case-control component. The quantitative strand measured vulnerability and estimated risk factors, addressing the second and third objectives, while the qualitative strand explained the mechanisms

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behind those patterns, addressing the first, with triangulation supporting interpretive validity (Otokiti et al., 2026).

Time and Place of Research

Fieldwork ran from January to March 2025 in the coastal sucos of Municípios Manatuto and Baucau, north-coast Timor-Leste, which share ecology and national policy but differ in exposure and service provision. Secondary climate data for 2015-2024 came from the Timor-Leste Meteorological Directorate and ERA5 reanalysis, and health data from health-centre records and municipal reports (Belo et al., 2026).

Population and Sample

The population comprised household heads in the coastal sucos of both municipalities. Cases were household heads with at least one member having a facility-diagnosed climate-sensitive disease (dengue, acute diarrhoea, or acute respiratory infection) recorded in the preceding 12 months; controls were household heads in the same area without such an episode, individually matched on sex, age group within ±5 years, and suco of residence. Sample size followed the Lemeshow formula (1:1 ratio, 95% confidence, 80% power, exposure proportion 0.44, expected odds ratio 2.0), giving a minimum of 196 per group; 400 household heads were recruited by multistage random sampling. Inclusion required five years of residence and written consent; exclusions were incomplete records and inability to complete the interview. Twenty-four qualitative informants were selected purposively, with saturation reached after 21 interviews.

Data Collection Techniques and Instrument Development

Structured interviews captured demographics, climate exposure, health status, water and sanitation access, food security, and adaptive capacity; in-depth interviews followed a semi-structured guide. Instruments were translated into Tetum and back-translated, and enumerators completed three days of training in interviewing, record verification, and ethics. Content validity was confirmed by five experts (index = 0.86), and reliability testing with 30 household heads outside the sampling frame yielded Cronbach's alpha of 0.71 to 0.81, except adaptive capacity at 0.68, which is interpreted with caution and retained only as one of five equally weighted index dimensions. Ethical clearance was obtained from [institution name and clearance number to be inserted]. Operational definitions and measurement scales appear in Table 1.

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Table 1. Operational Definitions and Measurement Scales of Study Variables

Variable	Operational definition	Measurement scale and categorisation
Climate-sensitive disease (dependent variable)	Facility-recorded episode of dengue, acute diarrhoea, or ARI in any household member during the preceding 12 months, verified from medical records	Nominal; 0 = absent (control), 1 = present (case)
Access to clean water	Main household drinking-water source and continuity of supply during the dry season, classified using the JMP service ladder	Ordinal, dichotomised; 0 = adequate (improved source available at least six days per week), 1 = limited
Sanitation	Type of toilet facility used by the household and whether it is shared	Nominal; 0 = improved and not shared, 1 = unimproved, shared, or open defecation
Dependence on subsistence farming	Main source of household income and share of food consumed that is self-produced	Nominal; 0 = non-subsistence livelihood, 1 = subsistence farming or fishing as main livelihood
Educational attainment	Highest level of formal education completed by the household head	Ordinal, dichotomised; 0 = senior secondary or above, 1 = below senior secondary
Household income	Total reported household cash income in the month preceding the survey	Ratio (US$), dichotomised at US$40 per month
Flood exposure 2021	Household dwelling or land inundated during the 2021 flash floods, self-reported and cross-checked with suco records	Nominal; 0 = not affected, 1 = affected
Social-network access	Membership of at least one community, religious, or mutual-aid group providing assistance during disasters	Nominal; 0 = has network, 1 = has no network
Climate exposure	Ten-item scale on perceived frequency and intensity of extreme heat, drought, flooding, storm surge, and seawater intrusion over the past five years	Five-point Likert (1 = never to 5 = very frequent); mean score 1-5
Sensitivity	Composite of under-five and elderly household members, chronic illness, undernutrition, and dependence on climate-sensitive livelihoods	Mean score 1-5 (1 = very low to 5 = very high sensitivity)
Adaptive capacity	Twelve-item scale covering productive assets, savings, access to climate information, livelihood alternatives, and early-warning awareness	Five-point Likert; mean score 1-5 (Cronbach's alpha 0.68)
Health-infrastructure resilience	Facility audit of travel distance to the nearest health facility, history of facility flooding, cold-chain reliability, and staffing adequacy	Score 1-5 assigned by two independent auditors
Composite Vulnerability Index (CVI)	Equally weighted mean of five dimensions: exposure, sensitivity, adaptive capacity (reverse-scored), health infrastructure (reverse-scored), and socio-economic conditions (reverse-scored)	Continuous 1-5; 1.0-2.3 low, 2.4-3.4 moderate, 3.5-4.2 high, above 4.2 very high

JMP = WHO/UNICEF Joint Monitoring Programme service ladder; CVI = Composite Vulnerability Index. Source: Author's construction (2025).

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Data Analysis Techniques

Quantitative analysis addressed the second and third objectives using chi-square tests, binary logistic regression with odds ratios and 95% confidence intervals, and Pearson correlation at a 0.05 significance level. Normality, multicollinearity, linearity of the logit, and influential observations were checked before modelling, and model adequacy was confirmed by a significant omnibus test, a non-significant Hosmer-Lemeshow statistic (chi-square = 6.42; df = 8; p = 0.601), and a Nagelkerke R-squared of 0.31, with Spearman's rho as a sensitivity check.

Vulnerability was quantified with the Composite Vulnerability Index, averaging five equally weighted dimensions scored from 1 to 5, with adaptive capacity, health infrastructure, and socio-economic conditions reverse-scored (Jansson et al., 2025).

Qualitative data were analysed thematically in six phases, with independent double coding (Cohen's kappa = 0.82), reflexive journalling, an external audit of the coding tree, and member checking. Both strands were then integrated through method and source triangulation to answer the research problem, and confidentiality and voluntary participation were upheld throughout (Levy et al., 2016).

RESULTS AND DISCUSSION

RESULTS

This section reports the empirical findings only, and comparison with existing literature is presented in the Discussion. The results show that coastal communities in Municipios Manatuto and Baucau experience a range of health impacts associated with climate change. Response rates reached 100% for the matched quantitative sample, and no participant withdrew during fieldwork. Demographic characteristics are presented first, followed by disease prevalence, risk-factor estimates, and vulnerability index scores. Qualitative themes are reported afterwards as primary data. Quantitative and qualitative findings are presented in the form of tables, figures, and narrative descriptions below.

Table 2. Demographic Characteristics of Respondents in Municipios Manatuto and Baucau

Characteristics	Manatuto	Baucau	*p*
Average age (years)	38.5 ± 12.3	40.2 ± 11.8	0.142
Gender (M: F)	52:48	51:49	0.876
Education < high school (%)	62.0	55.5	0.031*
Farmers/fishermen	68.5	61.0	0.048*

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(%)			
Revenue < US$40/month (%)	71.0	64.5	0.035*
Limited access to clean water (%)	58.5	44.0	<0.001**
Inadequate sanitation (%)	52.0	39.5	0.008**

*Remarks: * significant at p < 0.05; ** significant at p < 0.01. Source: Primary data (2025).*

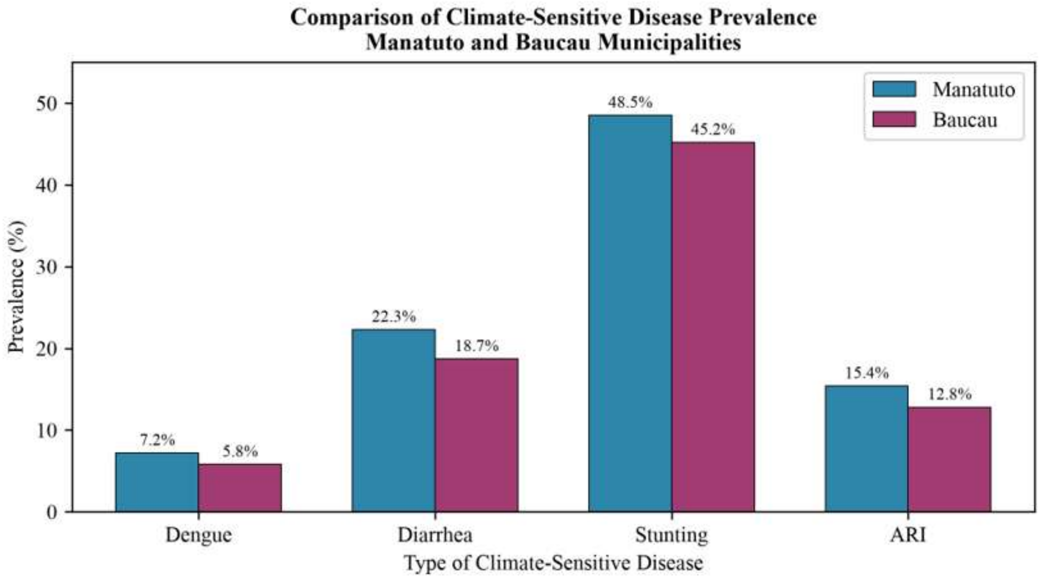

Figure 1. Comparison of the Prevalence of Climate Sensitive Diseases in Manatuto and Baucau Municipalities

Figure 1 shows that the prevalence of dengue in Manatuto (7.2%) is higher than in Baucau (5.8%). The same pattern appears for diarrhoea, at 22.3% against 18.7%. Acute respiratory infection follows the same direction, at 15.4% against 12.8%. The prevalence of under-five stunting is also higher in Manatuto (48.5%) than in Baucau (45.2%). All four differences therefore run in the same direction, with Manatuto recording the higher burden on every indicator measured. The largest absolute gap is observed for diarrhoea, at 3.6 percentage points.

Table 3. Logistic Regression Analysis of Climate Sensitive Disease Risk Factors

Variable	OR	95% CI	P-value
Access to clean water is limited	3.45	2.12–5.61	<0.001**
Sanitation is inadequate	2.87	1.76–4.68	<0.001**
Subsistence farming	2.14	1.32–3.47	0.002**
Low level of education	1.92	1.18–3.12	0.008*
Floods in 2021	2.53	1.55–4.13	0.001**
Don't have a social network	1.76	1.05–2.95	0.031*

*OR = Odds Ratio; CI = Confidence Interval; * p < 0.05; ** p < 0.01. Source: Primary data (2025).*

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Table 3 shows that limited access to clean water is the largest risk factor (OR = 3.45; 95% CI 2.12-5.61). Inadequate sanitation follows (OR = 2.87; 95% CI 1.76-4.68), together with household inundation during the 2021 floods (OR = 2.53; 95% CI 1.55-4.13). Dependence on subsistence farming also remains significant (OR = 2.14; 95% CI 1.32-3.47). Low educational attainment (OR = 1.92) and absence of a social network (OR = 1.76) retain significance in the adjusted model. All six variables have confidence intervals that exclude unity, and the model explains 31% of the variance in outcome status. These estimates correspond to the descriptive finding that 58.5% of respondents in Manatuto had limited access to clean water compared with 44.0% in Baucau.

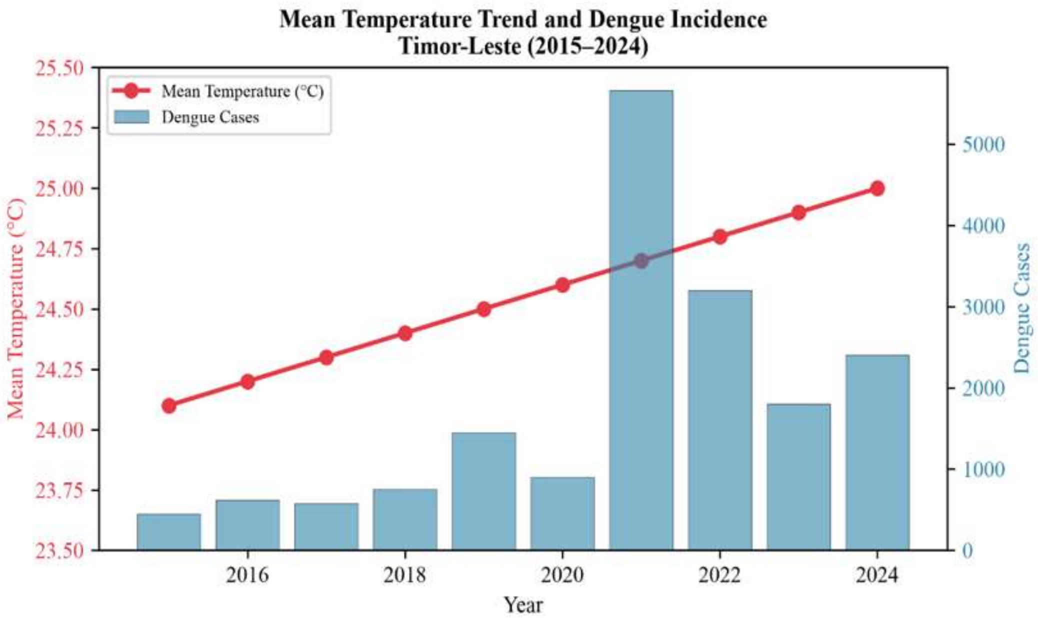

Figure 2. Trends in Average Temperature and Dengue Incidence in Timor-Leste (2015–2024)

Figure 2 depicts the trend of increasing mean annual temperature, from 24.1 degrees Celsius in 2015 to 25.0 degrees Celsius in 2024. Dengue cases peaked in 2022, when 5,658 cases were recorded nationally. The correlation between mean temperature and dengue incidence was positive and statistically significant ($r = 0.72$; $p < 0.001$). The sensitivity analysis using Spearman's rho produced a consistent coefficient. Annual case counts nevertheless fluctuate more sharply than the temperature series, which indicates that temperature alone does not track the observed peaks. Because this is an ecological, time-series association, no causal inference is drawn from it in this section.

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Table 4. Climate Change Vulnerability Index in Municipios Manatuto and Baucau

Dimensions of Vulnerability	**Manatuto**	**Baucau**
Exposure	3.8	3.5
Sensitivity	4.1	3.7
Adaptive capacity	2.2	2.5
Health infrastructure	2.5	2.8
Socio-economic	2.0	2.3

Score 1 = very low to 5 = very high. Source: Analysis of primary and secondary data (2025).

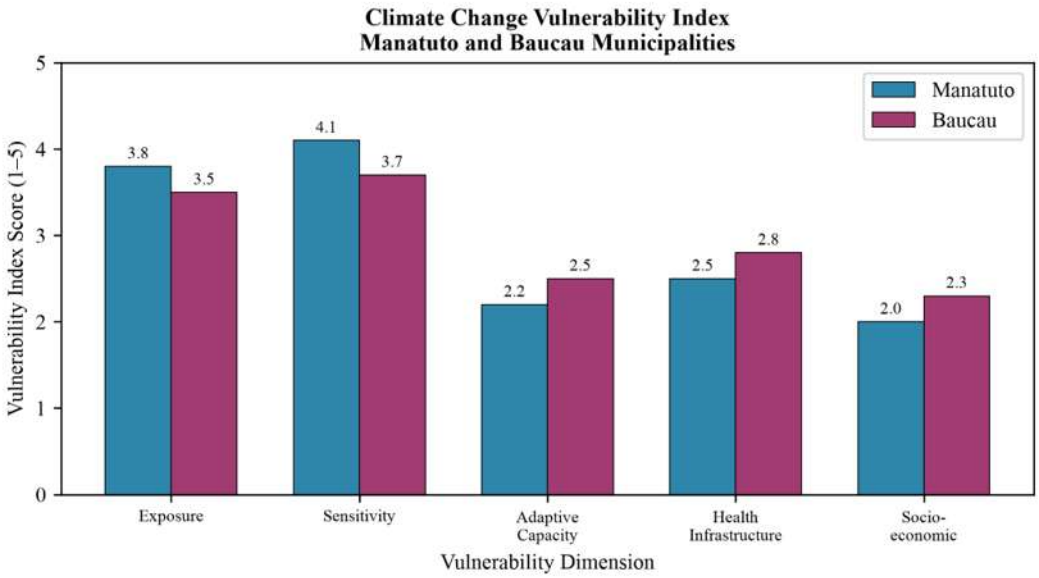

Figure 3. Climate Change Vulnerability Index for Municípios Manatuto and Baucau

Figure 3 shows that Manatuto records a higher score on the exposure dimension, at 3.8 against 3.5. The same applies to sensitivity, at 4.1 against 3.7. Baucau scores more favourably on adaptive capacity, at 2.5 against 2.2. It also scores more favourably on health infrastructure, at 2.8 against 2.5, and on socio-economic conditions, at 2.3 against 2.0. The resulting composite health vulnerability index is 3.8 for Manatuto, within the high category, and 3.5 for Baucau, at the lower boundary of the same category. The gap between the two municipalities is therefore concentrated in the exposure and sensitivity dimensions.

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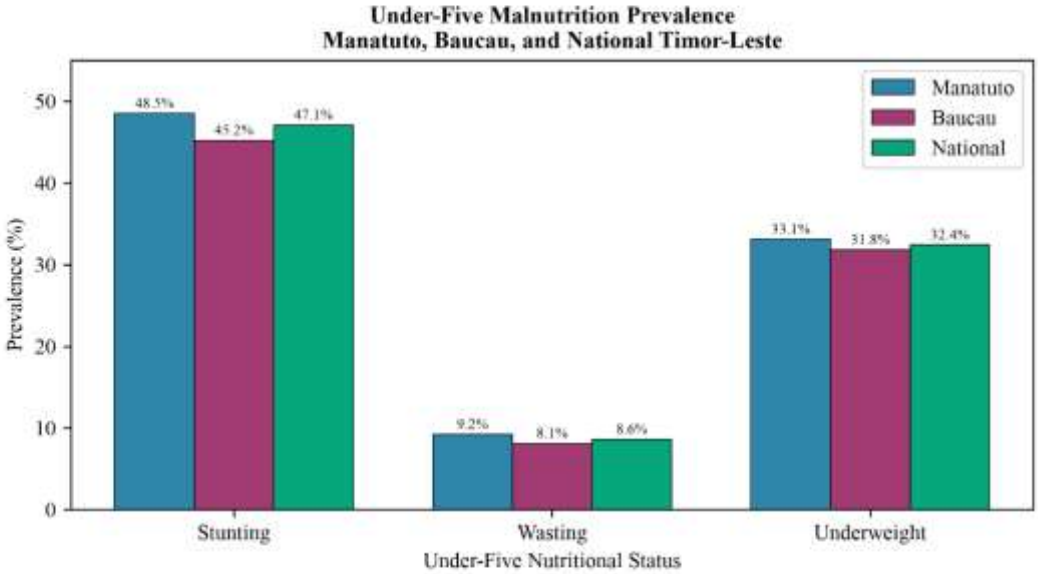

Figure 4. Prevalence of Under-Five Malnutrition in Manatuto, Baucau and Timor-Leste

Figure 4 shows that the prevalence of stunting reaches 48.5% in Manatuto and 45.2% in Baucau. Both values lie close to the national average of 47.1%. The prevalence of wasting is 9.2% in Manatuto, slightly higher than 8.1% in Baucau and 8.6% nationally. Underweight prevalence reaches 33.1% in Manatuto and 31.8% in Baucau. Manatuto therefore records the higher figure on all three anthropometric indicators. The difference between the two municipalities is largest for stunting, at 3.3 percentage points.

Thematic analysis of the 24 in-depth interviews produced four themes. Coding generated 61 initial codes, which were grouped into eleven categories and then into the four themes reported below. The themes were consistent across both municipalities, although the intensity of the experiences described differed between them. Each theme is presented as primary data, with interview excerpts reported independently of any literature comparison. Excerpts were selected to represent the range of informant categories rather than only the most emphatic statements. Discrepant accounts are reported alongside dominant ones.

Theme 1: climate change experienced as the loss of a predictable calendar. Informants in both municipalities described seasonal change less as a statistical trend than as the collapse of the agricultural calendar their households had relied on. A farmer in Manatuto explained: “the current rainy season is unpredictable, sometimes it floods, sometimes there is a long dry season, crops are damaged.” An elderly traditional leader in the same municipality contrasted present conditions with the past: “before, we planted when the first rain came in November and we were never wrong. Now

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the rain comes in January, or it comes for three days and stops. The young people no longer ask us when to plant, because our knowledge no longer fits the sky."

A fisher in Baucau described the same uncertainty at sea: "the wind changes without warning, so we go out less. On the days we cannot go out, we eat only maize." Two mothers of children under five linked this unpredictability directly to the household food cycle, describing periods of two to three months in which the household ate one main meal a day.

Theme 2: floods and drought as interruptions to water and health services. Informants described a recurring sequence in which flooding contaminates shallow wells and drought empties them. A suco chief in Manatuto recounted that after the 2021 flood "the well water turned brown for two weeks; we still drank it because there was nothing else, and then the children had diarrhoea."

Health-centre staff described the effect on service delivery. A nurse in Baucau stated: "puskesmas are often flooded during the rainy season, medicines are at risk of being damaged." A midwife in Manatuto added detail on the consequences for continuity of care: "when the road is cut, pregnant women cannot reach us and we cannot reach them. Last year we lost two months of routine immunisation in the eastern aldeias." A community health volunteer described carrying a vaccine cold box on foot for three hours after a bridge collapsed. Notably, one Baucau informant reported the opposite experience, crediting a rehabilitated gravity-fed water system with keeping supply stable through the 2023 dry season, a discrepant case retained in the analysis.

Theme 3: declining agricultural and fishery yields and household food security. Informants consistently connected environmental variability to what their families eat. A farmer in Baucau estimated that his maize harvest had halved over a decade: "we used to fill four sacks, now two, sometimes one; we sell nothing, we only eat." A fish trader in Manatuto described shrinking catches and rising prices, while a mother of three explained the substitution that follows: "when there is no fish, we buy instant noodles because they are cheap and the children eat them without complaining." Several informants described selling livestock or borrowing from relatives to cover food and transport costs after a poor harvest. Two households reported withdrawing a child from school for a term to reduce expenditure. Informants in Manatuto described these coping measures as recurring annually, whereas Baucau informants more often described them as occasional.

Theme 4: limited and unevenly distributed adaptive capacity. Informants in both municipalities described coping rather than planned adaptation. In Manatuto, respondents reported no household savings, no crop insurance, and reliance on customary mutual aid that is itself strained when an entire aldeia is affected at once, as one respondent explained: "when the flood comes, it comes to everyone, so there is no one to borrow from."

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In Baucau, informants more frequently mentioned concrete resources, including radio-based weather information, a functioning suco disaster committee, and small-scale trading as an alternative income source. Health staff in both sites identified the absence of a formal early-warning link between meteorological services and health facilities. Several informants stated that they had never received guidance on protecting drinking water after a flood, and one suco chief in Manatuto noted that disaster planning documents existed but had never been discussed with residents.

Together, the four themes describe a chain running from climatic unpredictability through water, food, and service disruption to household health outcomes, with the coping resources available at the final link visibly thinner in Manatuto than in Baucau.

DISCUSSION

The composite health vulnerability index of 3.8 in Manatuto and 3.5 in Baucau places both municipalities in the high category and corroborates the Lancet Countdown finding that populations of small island developing states carry a disproportionate climate-related health burden despite minimal contributions to global emissions (Gordon-Strachan et al., 2025; Ramos-Horta et al., 2025).

The structure of the gap between the two municipalities is analytically more informative than its size. Manatuto scores higher on exposure (3.8 versus 3.5) and sensitivity (4.1 versus 3.7), whereas Baucau holds a consistent advantage on adaptive capacity, health infrastructure, and socio-economic conditions. Because both sites share a national policy environment and a similar coastal ecology, the divergence is attributable primarily to Manatuto's longer, lower-lying coastline and to the thinner service and asset base documented in the qualitative data, a pattern consistent with comparative vulnerability assessments across small island developing states and with structural accounts of climate-health inequity (Otokiti et al., 2026; Jansson et al., 2025; Mathews et al., 2025).

Dengue prevalence was higher in Manatuto (7.2%) than in Baucau (5.8%), and national dengue incidence correlated positively with mean temperature ($r = 0.72$), in line with reports of post-monsoon increases in Timor-Leste (da Cruz et al., 2023; Mahato et al., 2025). The correlation is ecological and cannot establish that warming caused the additional transmission. Water-storage practice is a plausible confounder, since piped supply is less reliable in Manatuto and households store water in open containers for longer, creating larval habitat independently of temperature. Vector-control intensity and case ascertainment were not measured, and reporting completeness changed across the series. The defensible conclusion is that higher temperature is associated with higher dengue incidence, while the relative weight of climatic and non-climatic drivers remains

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undetermined. Within that constraint, Manatuto's disadvantage in water storage and service access remains a credible and locally modifiable mechanism (Chan et al., 2025).

Stunting prevalence of 48.5% in Manatuto and 45.2% in Baucau confirms that chronic malnutrition remains urgent in coastal Timor-Leste, consistent with national data placing the country among the highest-burden settings globally (Titaley et al., 2023; UNICEF Timor-Leste, 2025). The 3.3-percentage-point difference aligns with Manatuto's higher sensitivity score and with qualitative accounts of dietary substitution among households reporting no savings or alternative income. Cross-country evidence indicates that rising temperature affects child nutritional status directly while rainfall operates indirectly through household food production, and comparative work confirms that socio-economic determinants shape stunting risk (Van der Merwe et al., 2022; Colozza et al., 2025; Van der Spek et al., 2024; Kumari and Kamal, 2026; Lavanya et al., 2026). Stunting reduction therefore cannot be separated from adaptation that strengthens local food systems and extends social protection.

Limited access to clean water was the strongest risk factor (OR = 3.45) and most directly explains Manatuto's disadvantage: 58.5% of respondents there reported limited access compared with 44.0% in Baucau, a gap of 14.5 percentage points that maps onto the corresponding diarrhoea prevalence of 22.3% versus 18.7%. This accords with evidence that drought reduces clean-water sources while floods contaminate them, and with studies linking water quality and sanitation to under-five diarrhoea (Levy et al., 2016; Karakullukcu and Dilaver, 2025; Lieber, 2025; Samuel et al., 2026). Because coverage is locally modifiable, this dimension is where the vulnerability gap is most tractable to municipal intervention.

Dependence on subsistence farming was also significant (OR = 2.14) and again favours Baucau, with 68.5% of Manatuto respondents dependent on farming or fishing compared with 61.0%. Reliance on a single climate-sensitive sector exposes households to production shocks; the 2021 floods destroyed thousands of hectares of rice fields, threatening food security and straining local health systems (Su et al., 2026; Proulx et al., 2024). Qualitative data indicate that livelihood diversification is more advanced in Baucau, where informants described small-scale trading as a fallback, which helps explain that municipality's higher adaptive-capacity score.

The qualitative themes explain this asymmetry. Informants described unpredictable seasons, floods, and droughts as everyday disruptions to food production and service access, while health staff identified inundated facilities and threatened cold chains. These accounts correspond to national assessments and Pacific adaptation studies identifying infrastructure and inter-sectoral coordination as critical weak points (IFRC Climate Centre, 2021; WHO and Ministry of Health Timor-Leste,

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2018; Boyer et al., 2025). The contrast between Manatuto informants reporting exhausted mutual-aid networks and Baucau informants describing functioning suco disaster committees and radio-based weather information supplies a mechanism for the adaptive-capacity gap of 2.2 versus 2.5, indicating that institutional and informational resources, rather than hazard exposure alone, differentiate the two municipalities.

Sea level is rising at 5.5 mm per year around Timor-Leste and bears more heavily on Manatuto given its longer and lower-lying coastline. Seawater intrusion reduces clean-water availability and feeds back into the water-access pathway identified as the strongest risk factor here, while coastal erosion threatens settlements and infrastructure. Sea-level rise also carries mental-health consequences through resource loss, dislocation, and uncertainty, a psychosocial dimension frequently omitted from vulnerability assessments (Kabir and Hamamura, 2024; Kim et al., 2022). Because this dimension was not measured, the reported scores probably understate vulnerability, particularly in Manatuto.

Timor-Leste has adopted a Health National Adaptation Plan and a Nationally Determined Contribution covering coastal adaptation and loss-and-damage mechanisms, yet municipal implementation remains constrained by resources, technical capacity, and inter-sectoral coordination. Climate-resilient health systems require investment in disaster-resistant infrastructure, community-based early warning, improved surveillance, and a strengthened workforce (Government of Timor-Leste, 2021; WHO, 2024). The comparative evidence suggests a sequencing rule: because the gap lies in sensitivity and adaptive capacity rather than exposure, water, sanitation, and facility resilience in Manatuto should be prioritised, while arrangements that work in Baucau merit documentation and replication.

Several limitations qualify these interpretations. The retrospective design is susceptible to recall and selection bias, and facility-based ascertainment missed home-treated episodes, potentially understating burden where access is weaker. Matching on sex, age group, and suco leaves residual confounding from unmeasured factors such as water-storage practice and housing quality, and the adaptive-capacity scale returned an alpha of 0.68, so those scores are indicative only. The temperature-dengue correlation is vulnerable to the ecological fallacy, caregiving practices and psychosocial outcomes were not measured, climate data derive from secondary sources, and generalisation is limited to comparable coastal settings. Triangulation of methods and sources nonetheless strengthens the credibility of the findings (Kim et al., 2022).

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CONCLUSION

This study concludes that climate change is meaningfully associated with the health of coastal communities in Municípios Manatuto and Baucau. Both municipalities fall within the high vulnerability category, yet their burdens are structured differently: Manatuto is disadvantaged by greater exposure and sensitivity, whereas Baucau is comparatively protected by stronger adaptive capacity, more resilient health infrastructure, and more favourable socio-economic conditions.

The decisive point is that the gap between the two municipalities lies less in the climate hazard itself than in locally modifiable conditions, namely access to clean water and sanitation, household exposure to flooding, and dependence on climate-sensitive livelihoods. Qualitative accounts reinforce this reading, describing an increasingly unpredictable agricultural calendar, disrupted water and health services, and coping resources that are thinnest where institutional support is weakest.

Measurable health gains are therefore attainable at municipal level without any change in the underlying hazard. Adaptation should integrate climate-resilient health systems, expanded water and sanitation coverage, livelihood diversification, community nutrition, and early warning that formally links meteorological services to health facilities, prioritising the more vulnerable municipality. Given the retrospective and ecological constraints of this design, prospective and multi-municipality research is needed to confirm these relationships.

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