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Mobile for Development

Climate Tech in Timor-Leste: Strengthening climate adaptation and resilience

August 2025

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Definitions of terms

Artificial intelligence

AI is comprised of widely different technologies that can be broadly defined as "self-learning, adaptive systems". AI has the capability to understand language, solve problems, recognise pictures and learn by analysing patterns in large sets of data.[1]

Anticipatory action

Acting ahead of predicted hazards to prevent or reduce acute humanitarian impacts before they fully unfold. Effective implementation of anticipatory action ideally requires a pre-agreed trigger (rule-based decision based on measurable forecasts), pre-agreed activities (to support at risk communities between the trigger and full impact) and pre-agreed financing (funding based on the trigger).[2]

Climate adaptation

Adjusting to actual or expected changes brought about by climate change. These are incremental changes in response to climate trends such as droughts.[3]

Climate-smart agriculture

An approach to farming that aims to increase agricultural productivity and resilience to climate change while reducing greenhouse gas emissions where possible. It promotes sustainable practices such as crop diversification, efficient water management, and the use of technology to improve farming practices.

The GSMA supports the use of mobile and digital technologies in climate-smart agriculture to help farmers adapt to changing climate conditions, access weather forecasts and optimise resource use.[4]

Climate mitigation

Reducing greenhouse gas emissions and transitioning to a low-carbon economy to slow the rate of climate change. Examples include generating electricity from renewable sources, shifting away from internal combustion engine vehicles and reducing agricultural emissions.[5]

Climate resilience

The capacity of social, economic and environmental systems to cope with a hazardous event, trend or disturbance, responding or reorganising in ways that maintain their essential function, identity and structure, while also maintaining the capacity for adaptation, learning and transformation.

The GSMA uses the "Three As" framework of climate resilience to support communities and vulnerable groups to:

- Anticipate climate variability and risks from extreme climate events, thus supporting preparedness and planning (e.g. through early warning systems)
- Adapt to multiple, long-term and evolving climate change risks (e.g. through precision agriculture and long-term weather forecasting)
- Absorb adverse conditions, emergencies or disasters (e.g. through access to credit and insurance in the event of a climate disaster).[6]

Climate tech

For the purposes of this report, climate technology or climate tech, refers to a broad set of digital technologies that support:

- Actions taken to reduce greenhouse gas emissions and mitigate climate change
- Actions taken to build the resilience of the most vulnerable communities to climate change stressors and threats
- Actions that drive the sustainable use, management and protection of natural resources and the environment in areas most vulnerable and exposed to climate change.[7]

Community-based early warning system

Anticipatory action that empowers communities to monitor and prepare for risks, rather than respond to disasters.[8]

1 International Telecommunication Union (ITU). (n.d.). Artificial intelligence for good.
2 United Nations Office for the Coordination of Humanitarian Affairs (UN OCHA) (n.d.). Anticipatory action.
3 GSMA. (2025). ClimateTech Green Glossary.
4 Ibid.
5 Ibid.
6 Ibid.
7 Ibid.
8 University College London (17 February 2023). Community-based early warning systems.

Digital climate advisory services
Tailored advisory content based on dynamic agroclimatic conditions at the farm level, for example, information on soil type, crops cultivated, length of cropping cycle and weather forecasts. These services enable relevant advice at the right time on planting, input application, crop management and harvesting.[9]

Disaster risk reduction
Preventing new and reducing existing disaster risk and managing residual risk, all of which help to strengthen resilience and support sustainable development.[10]

Early Action Protocol
Articulates a national plan to trigger early actions in advance of a weather or non-weather-related hazard.[11]

El Niño
The warming of sea surface temperature that occurs every few years, typically concentrated in the central-east equatorial Pacific. An El Niño is declared when sea temperatures in the tropical eastern Pacific rise 0.5°C above the long-term average. El Niño is felt strongly in the tropical eastern Pacific with warmer than average weather.

Early warning system
An integrated system of hazard monitoring, forecasting and prediction, disaster risk assessment, communication and preparedness activities, systems and processes that enables individuals, communities, governments, businesses and others to take timely action to reduce disaster risks in advance of hazardous events.[12]

Geospatial mapping
A spatial visualisation method that enables the creation of customised maps. The primary aim is to show items with geographic coordinates, providing a representation of the physical world on a map. Various approaches, solutions and geographic information systems (GIS) software can be used to analyse existing geospatial data and geographical and terrestrial databases.[13]

Internet of Things
The coordination of multiple machines, devices and appliances connected to the internet through multiple networks.[14]

Machine learning
A subfield of AI broadly defined as the capability of a machine to imitate intelligent human behaviour.[15]

Multi-hazard early warning system
Addresses several hazards and/or impacts of similar or different types in contexts where hazardous events may occur alone, simultaneously, in a cascade or cumulatively over time, taking into account the potential interrelated effects.[16]

Hydrological monitoring station
Used to monitor the hydrological parameters of rivers, lakes, reservoirs, channels and groundwater (temperature, level, flow rate, etc.) in real time, allowing relevant departments to forecast, prevent and mitigate natural hazards. Hydrological monitoring stations can be used for meteorological research, disaster prevention and mitigation, scientific research and other fields.[17]

Precision agriculture
Services that provide advice to farmers tailored to the farm- or sub-farm level. A sub-use case of digital advisory, precision agriculture services rely on drones, on-farm sensors and soil testing to customise advisory content and identify appropriate interventions. These services are typically provided by agritechs that commercialise a data collection technology such as drones or soil testing.[18]

Public-private partnership
A mechanism for governments to procure and implement public infrastructure and/or services using the resources and expertise of the private sector.[19]

9 GSMA. (2022). Data-driven advisory services for climate-smart smallholder agriculture.
10 United Nations Office for Disaster Risk Reduction (UNDRR). (2017). Disaster risk reduction. The Sendai Framework Terminology on Disaster Risk Reduction.
11 International Federation of Red Cross (IFR). (2022). Simplified Early Action Protocol.
12 UNDRR. (n.d.). Definition: Early Warning System.
13 Virginia Polytechnic Institute and State University. (2025). An Introduction to Geospatial Mapping: Understanding Geospatial Mapping.
14 GSMA. (2016). What is the Internet of Things (IoT)?
15 Brown, S. (21 April 2021). Machine learning, explained. MIT Management Sloan School.
16 UNDRR. (2017). Disaster risk reduction. The Sendai Framework Terminology on Disaster Risk Reduction.
17 Hunan Rika Electronic Tech Co., Ltd. (n.d.). Hydrological Monitoring Solution.
18 Adapted from GSMA, 2022.
19 Public-Private Partnership Resource Center (PPPRC). (n.d.). What are PPPs? World Bank.

Acronyms and abbreviations

AI	Artificial Intelligence
AWS	Automatic weather station
CBDRM	Community-based disaster risk management
CBEWS	Community-based early warning system
CREWS	Climate risk and early warning systems
DCAS	Digital climate advisory services
DPI	Digital public infrastructure
DRR	Disaster risk reduction
EAP	Early Action Protocol
EW4All	Early Warnings for All initiative
EWS	Early warning system
GIS	Geographic information system
HIS	Health information system
IoT	Internet of Things
MHEWS	Multi-hazard early warning system
NAP	National Adaptation Plan
PPP	Public-private partnership
SIDS	Small Island Developing States
SMS	Short message service
WASH	Water, sanitation and hygiene

Executive summary

Timor-Leste, an island nation with a population of almost 1.4 million people, is highly vulnerable to climate change.

Classified as both a Small Island Developing State (SIDS), and a Least Developed Country (LDC) by the United Nations, Timor-Leste is a young, post-conflict nation where an estimated one-quarter of the population live below the international poverty line.[20] Highly exposed to natural hazards like cyclones, earthquakes, tsunamis and heavy rainfall, the risk from these events is compounded by weak infrastructure and limited social protection systems, making the population exceptionally vulnerable to the impacts of climate change.

With more than 25% of the population experiencing acute food insecurity in 2024,[21] and projections indicating that extreme weather events could reduce GDP by up to 5% in worst-case scenarios, strengthening climate resilience is critical to safeguarding lives, communities, livelihoods and the economy.

Climate technology, or climate tech, offers significant potential to strengthen climate adaptation and resilience, including to extreme weather events and natural hazards, in agriculture and food security and public health. However, this opportunity remains untapped in Timor-Leste.

The country has made some progress in digital initiatives for climate resilience and adaptation, including the implementation of a flood early warning system (EWS) in the capital, Dili, and the ongoing development of a national multi-hazard early warning system (MHEWS) with investment from the Green Climate Fund (GCF). However, the uptake of climate tech for strengthening climate adaptation and resilience in other key areas has been slow.

The experience of countries with similar geographic, socio-economic and institutional contexts suggests there are several high-impact and practical opportunities for Timor-Leste to use climate tech to help communities better anticipate, adapt to and absorb climate risks. These include:

- **Mobile dissemination of early warnings** for natural hazards and disease outbreaks, using SMS and smartphone apps as part of a multi-channel delivery system to reach as many people as possible
- **Digital community-based early warning systems (CBEWS)** that include, empower and protect communities
- A **national multi-hazard early warning system** (MHEWS)
- **Mobile agricultural climate advisory services**, offering farmers timely, tailored guidance on local climate-related risks and adaptation measures
- **Mobile and digital solutions for disease surveillance**
- **Integrated climate and health data systems** to support evidence-based decision-making and targeted climate adaptation and resilience measures

If grounded in inclusive, context-specific design and implementation strategies, these targeted interventions could significantly help strengthen climate adaptation and resilience in Timor-Leste.

20 World Bank. (2025). Timor-Leste. Projected international poverty rate for 2024, based on international poverty rate ($2.15 in 2017 PPP).
21 World Food Programme (WFP). (18 April 2024). Timor-Leste facing high food insecurity, latest report warns. News release.

Timor-Leste is building an enabling environment for climate tech, but there are several barriers.

Timor-Leste is actively laying the foundation for a more enabling environment for climate tech adoption. Policies like Timor Digital (2032)[22] and the National Adaptation Plan (NAP) (2021) indicate the government's commitment to climate adaptation and resilience, as well as the use of digital tools for sustainable development.

Connectivity infrastructure is set to improve with a new submarine cable connection to Australia expected to be operational soon, as well as the recent launch of Starlink satellite services.

Planned regional integration with ASEAN in October 2025 is also expected to catalyse greater investment, facilitate peer-to-peer learning and spur innovation through enhanced cross-border collaboration.

However, significant barriers remain. Internet penetration stands at just 35% of the population, with even lower rates in rural areas where almost two-thirds of Timorese live. Adult literacy rates are approximately 70%, and literacy and digital skills gaps are particularly pronounced in rural communities. Financing for climate adaptation and resilience initiatives is a major constraint. Furthermore, limited technical expertise, weak interagency coordination and a nascent private sector with limited capacity for climate tech innovation continue to pose challenges to the development, deployment and sustainability of climate tech initiatives.

There are strategic opportunities to better leverage climate tech to help Timor-Leste's communities anticipate, adapt to and absorb the impacts of climate change:

- **Adopting mobile-based solutions:** Climate tech solutions must prioritise last-mile delivery on feature phones in addition to smartphone-based tools. Offline functionality is essential, and interfaces must support local languages with audio options for those with low literacy.
- **Building on existing initiatives and investments while diversifying funding mechanisms:** Current financing gaps require blended finance approaches combining donor grants, private investment and government funding. Where feasible, strengthening existing digital initiatives rather than launching parallel ones could also reduce costs where existing infrastructure is fit for purpose.
- **Strengthening technical capacity:** Sustainable implementation requires significant investment in technical training for government officials, technical personnel and communities. Regional knowledge exchange with Pacific SIDS and ASEAN countries could provide strong opportunities to accelerate learning and capacity building.
- **Fostering private sector innovation in climate tech:** Local entrepreneurs could be supported through government procurement, regulatory sandboxes and connections with regional climate tech leaders. Initial efforts could focus on demonstrated needs like agricultural climate advisory and early warning systems (EWS).
- **Including communities in climate tech solutions:** Successful adoption of climate tech requires genuine community inclusion, integrating traditional governance structures and Indigenous knowledge with modern digital tools. This is particularly important for Timor-Leste, where traditional knowledge-based customs and practices, referred to as tara bandu, are used to adjudicate disputes and manage resources.

22 See: Timor Digital 2032.

To be effective in Timor-Leste, climate tech solutions must be tailored to its geography, cultural and linguistic diversity, and socio-economic realities. Solutions should be affordable, locally owned, and work with traditional governance and knowledge systems. Long-term impact will depend on building local capacity and fostering strong, inclusive partnerships.

For climate tech to be effective in Timor-Leste, several factors must be considered. First, its **geography**. Solutions must be tailored to the country's mountainous terrain, diverse microclimates and specific hazards such as coastal flooding, landslides and drought. Generic approaches are unlikely to deliver the relevance or accuracy needed for local decision-making.

Climate tech initiatives must also accommodate Timor-Leste's **linguistic diversity** by offering solutions in multiple languages.

Integrating **traditional knowledge** practices and aligning with existing **community governance** and social structures will be key to ensuring local ownership and sustained adoption.

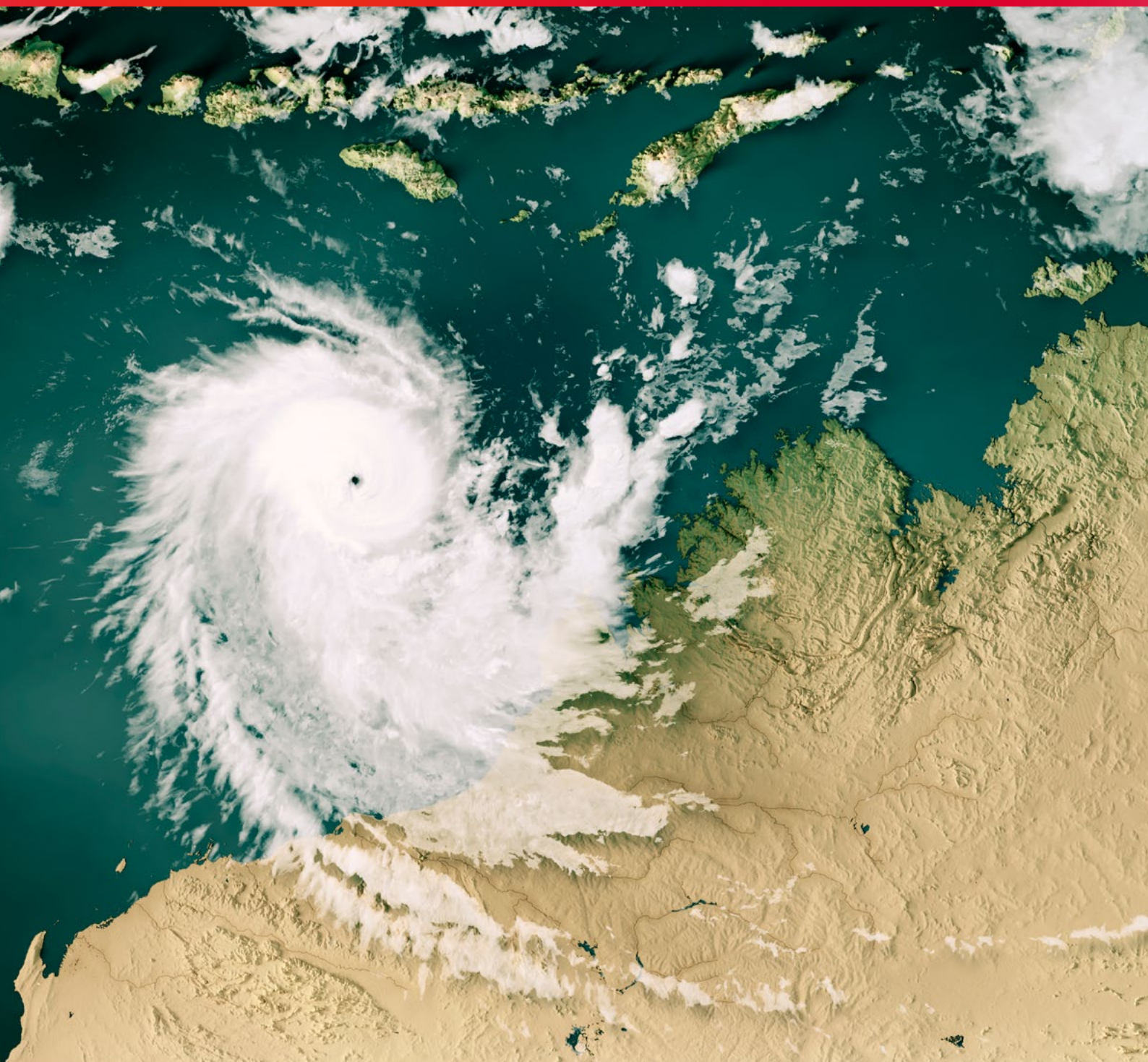
With a quarter of Timor-Leste's population estimated to be living below the international poverty line in 2024, climate tech solutions must be designed with **affordability** in mind.

Finally, sustainability will depend on building **long-term local capacity**. This includes ensuring community participation from the outset, fostering technical self-reliance through local training and capacity building and establishing sustainable financing mechanisms that reduce dependence on external funding and expertise over time.

The opportunity is significant, with anticipated improvements in connectivity infrastructure and regional integration creating favourable conditions for scaling climate tech initiatives for climate adaptation and resilience.

However, realising this potential will require both sustained commitment and strong collaboration between government, development partners, the private sector and local communities to build long-term, inclusive, locally-owned solutions.

01.
Introduction



1.1
Climate change in Small Island Developing States

Climate change, driven by rising greenhouse gas emissions caused primarily by human activity, is having a profound long-term impact on global temperatures and weather patterns. This has resulted in more frequent heatwaves, accelerated melting of ice leading to rising sea levels and increased occurrences of extreme weather events such as floods, wildfires, storms and droughts. These changes are threatening the lives and livelihoods of communities, affecting their access to life-sustaining resources such as clean water and sufficient food and creating more urgent and frequent health risks.

Small Island Developing States (SIDS), which include 39 countries and 18 territories, are far from homogeneous but their geography makes them all exceptionally vulnerable to climate change.[23,24] While SIDS account for only 1% of global greenhouse gas emissions, they suffer some of the worst impacts of climate change (Figure 1).

Figure 1:
Climate-related impacts in SIDS

On average, **18% of the total population** of SIDS is affected by a climate-related disaster compared to 6% in other countries

The disaster mortality rate in SIDS is **more than double** the global average

From 1970 to 2020, **SIDS lost $153 billion** due to extreme weather events, a significant amount relative to their average GDP of $13.7 billion

Source: UNDP[25]

Most SIDS are categorised as low- and middle-income countries (LMICs) and face even more pronounced challenges as limited financial, technical and human resources hinder the implementation of effective climate adaptation and resilience strategies. In addition, more than 40% of SIDS have unsustainable levels of debt, seriously limiting their ability to invest in climate resilience and adaptation.[26]

SIDS have therefore been at the forefront of the global climate justice movement. For example, they have advocated for keeping the 1.5°C target for global warming established in the Paris Agreement,[27] arguing that an increase to a 2°C limit would put their countries at very high risk of devastation.[28,29]

23 SIDS are a group of 39 Member States and 18 Associate Members of United Nations Regional Commissions located in the Caribbean, the Pacific and the Atlantic, Indian Ocean and South China Sea (AIS). See: UNDRR, Small Island Developing States (SIDS).
24 SIDS may be high-income, middle-income or low-income countries but share common features, such as small economies, populations and land masses, combined with large ocean territories, proportionally long coastlines and remoteness from other population centres. See: UK Parliament. (2024). The UK Small Island Developing States Strategy: Fourth Report of Session 2023–24.
25 UNDP. (30 April 2024). Small Island Developing States are on the frontlines of climate change –here's why.
26 Moreira da Silva, J. (29 May 2024). Why small island states need scaled finance and amplified action. World Economic Forum.
27 IPCC. (2022). Chapter 15: Small Islands. IPCC Sixth Assessment Report: Impacts, Adaptation and Vulnerability.
28 UNDP. (30 April 2024). Small Island Developing States are on the frontlines of climate change –here's why.
29 Ibid. In 2023, Vanuatu led a global coalition that resulted in the historic UN resolution requesting the International Court of Justice to hold polluting countries legally accountable for failing to tackle the climate emergency.

1.2
The impacts of climate change in Timor-Leste

1.2.1 Background

Timor-Leste is a SIDS located northwest of Australia and to the east of the Indonesian archipelago, comprising the mountainous region of East Timor, the Oecusse-Ambeno region in the northwest of the island of Timor, as well as the islands of Atauro and Jaco (Figure 2). It gained independence in 2002 and is one of the youngest and smallest countries in the world, with an estimated population of just under 1.4 million in 2024.[30] The country experienced severe economic stress from 2017 to 2021 due to political instability as well as numerous external shocks, including the COVID-19 pandemic and several extreme weather events.[31]

Figure 2:
Map of Timor-Leste

Population
1.384 MILLION

Size
14,870 SQ KM

Population density
90/SQ KM

Urban/rural
37% Urban **63%** Rural

Sex ratio
104 : 100 Male Female

Population density range
1,425 people/sq km in Dili (capital)

vs

29 people/sq km in Manatuto

Population age (2022)
42% Under 18 **70%** Under 30

Administration
14 municipalities
67 subdistricts
442 Sucos/villages

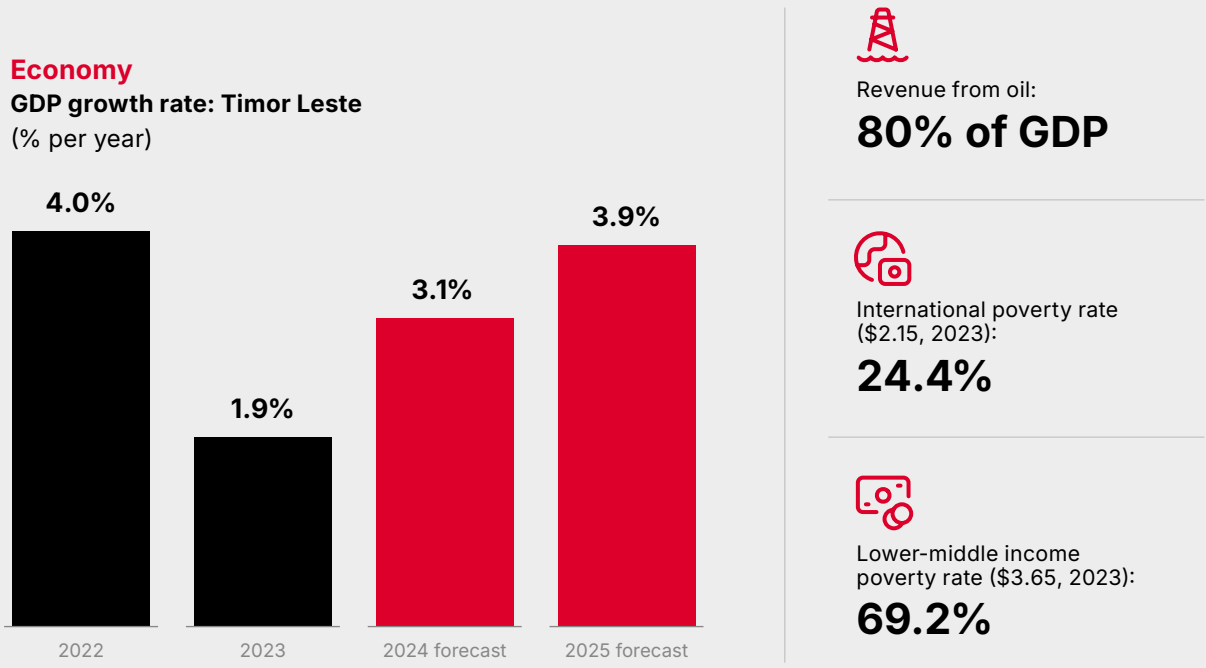
Source: Timor-Leste: National Adaptation Plan (2021)[32]
Source: World Bank (2023)[33]

30 World Bank Data Portal: Timor-Leste.
31 World Bank Country Profile: Timor-Leste.
32 See: Timor-Leste's National Adaptation Plan.
33 World Bank Group. (July 2023). Timor-Leste Economic Report.

Since 2022, Timor-Leste has had an increasingly positive economic growth outlook, with growth at 4% of GDP in 2024 compared to 2.4% in 2023.[34] The country will also be admitted to the Association of Southeast Asian Nations (ASEAN) in 2025,[35] and this regional integration is expected to strengthen its institutions, build investor confidence and drive foreign investment.

Despite this positive outlook and investments in both infrastructure and human development, Timor-Leste is designated as a least-developed country (LDC) by the UN, which means it faces severe structural impediments to sustainable development, is highly vulnerable to economic and environmental shocks and has low levels of human development. Challenges such as malnutrition and limited access to basic services such as education and healthcare persist.[36] Timor-Leste has one of the lowest incomes per capita in the world. The economy is undiversified and heavily dependent on oil exports, with declining oil revenue making its future growth uncertain (Figure 3).[37] A large proportion of the population relies on subsistence agriculture.[38]

Figure 3:
Overview of Timor-Leste



Source: Asian Development Bank, 2024

34 Government of Timor-Leste. (25 March 2025). National Economy Grew by 4% in 2024.
35 Bangkok Post. (29 May 2025). ASEAN leaders agree to admit Timor-Leste.
36 UN ESCAP. (1 March 2024). Timor-Leste: Structural transformation and economic diversification towards a sustainable graduation from LDC category.
37 Ibid.
38 Cambridge Industrial Innovation Policy. (29 September 2023). The Development Crossroads of Small Island States: the case of Timor-Leste.

1.2.2 The impacts of climate change

As a SIDS, Timor-Leste is exceptionally vulnerable to the impacts of climate change. The country is at high risk of natural hazards, including cyclones, earthquakes, tsunamis and heavy rainfall. These risks are exacerbated by inadequate infrastructure and social welfare systems.[39] Extreme weather events and natural hazards have already caused significant losses to communities. For example, in April 2021, Tropical Cyclone Seroja brought torrential rain to the country, leading to flash floods and landslides. These events damaged critical infrastructure, devastated agriculture and claimed at least 42 lives.[40]

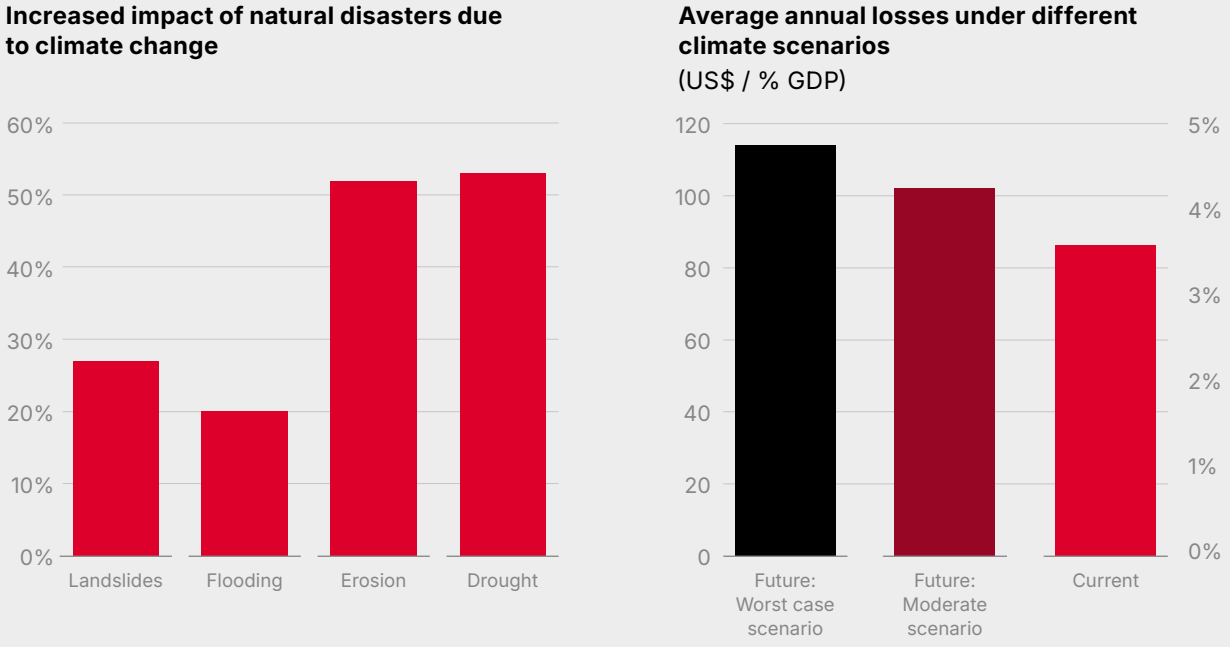
The most vulnerable communities and groups, including rural women, smallholder farmers, persons with disabilities, people living in risk-prone areas and those without secure land tenure, are particularly affected by climate-related events.[41] Women, who have equal rights to land in Timor-Leste by law but not in practice, tend to suffer disproportionately as recovery services are frequently linked to land ownership, primarily the domain of men.[42]

The impacts of these events are also uneven between the capital, Dili, and rural areas, where more than 65% of the population resides.[43] In Dili, urban infrastructure such as homes and roads are significantly affected, while in rural areas, the impact tends to be on agricultural production. Given that more than two-thirds of households are engaged in some form of agriculture[44] and more than 25% of the population is facing acute food insecurity, agricultural losses have a significant impact on vulnerable households.[45]

It is projected that worst-case scenarios in an extreme weather event could reduce Timor-Leste's annual GDP by 5% (Figure 4). It is therefore essential to strengthen climate resilience for the well-being of its communities.

Figure 4:

Climate change impacts and predicted losses from extreme weather events in different scenarios



Source: Timor-Leste Economic report: Fit for purpose – creating a stable, inclusive, resilient financial sector[46]

39 World Bank. (n.d.). Climate Change Knowledge Portal: Timor-Leste.
40 European Civil Protection and Humanitarian Operations (ECHO). (6 April 2021). Timor-Leste, Indonesia, Australia - Tropical Cyclone SEROJA (GDACS, JTWC, BNPB, Government of Timor-Leste, DG ECHO , Copernicus EMS) (ECHO Daily Flash of 6 April 2021).
41 Oxfam. (September 2023). Community Experiences of Climate Change and its Impacts in Timor-Leste.
42 Ibid.
43 Timor-Leste National Institute of Statistics et al. (2023). Timor-Leste Population and Housing Census 2022.
44 Iyengar, K. (29 February 2024). Addressing Timor-Leste's Food Security and Nutrition. Development Asia.
45 Integrated Food Security Phase Classification (IPC). (2024). IPC Timor-Leste Acute Food Insecurity Analysis: November 2023 - September 2024.
46 World Bank. (2024). Timor-Leste Economic Report 2024: Fit for Purpose: Crafting a Stable, Inclusive and Resilient Financial Sector.

1.3
Climate tech for climate adaptation and resilience

Climate tech for climate adaptation and resilience: the Three As framework

Climate resilience refers to the ability of social, economic and environmental systems to cope with hazardous events, trends or disturbances. This involves responding or reorganising in ways that preserve their essential functions, identity and structure, while also maintaining the capacity to adapt, learn and transform in the face of future shocks.[47]

Climate adaptation is the process of adjusting to actual or anticipated climate change impacts, such as droughts, rising temperatures or erratic rainfall. These adjustments aim to reduce harm or take advantage of beneficial opportunities created by changing climate conditions.[48]

Climate mitigation, by contrast, focuses on reducing greenhouse gas emissions and transitioning to a low-carbon economy to slow the pace of climate change.[49]

The GSMA's "Three As" framework—Anticipate, Adapt, Absorb—guides our work on climate adaptation and resilience, particularly in supporting vulnerable communities in LMICs.[50] This framework emphasises preparing for risks, minimising their impact and making long-term adjustments to cope with climate change.

Figure 5:
The Three As of climate resilience and adaptation

Anticipate

Actions that predict climate variability and risks from extreme climate events to support preparedness and planning

(e.g. early warning systems)

Adapt

Actions that help adjust to multiple, long-term and evolving climate change risks

(e.g. through precision agriculture and long-term weather forecasting)

Absorb

Actions that help reduce adverse conditions, emergencies or disasters

(e.g. through access to credit and insurance in the event of a climate disaster)

Source: GSMA Mobile for Development

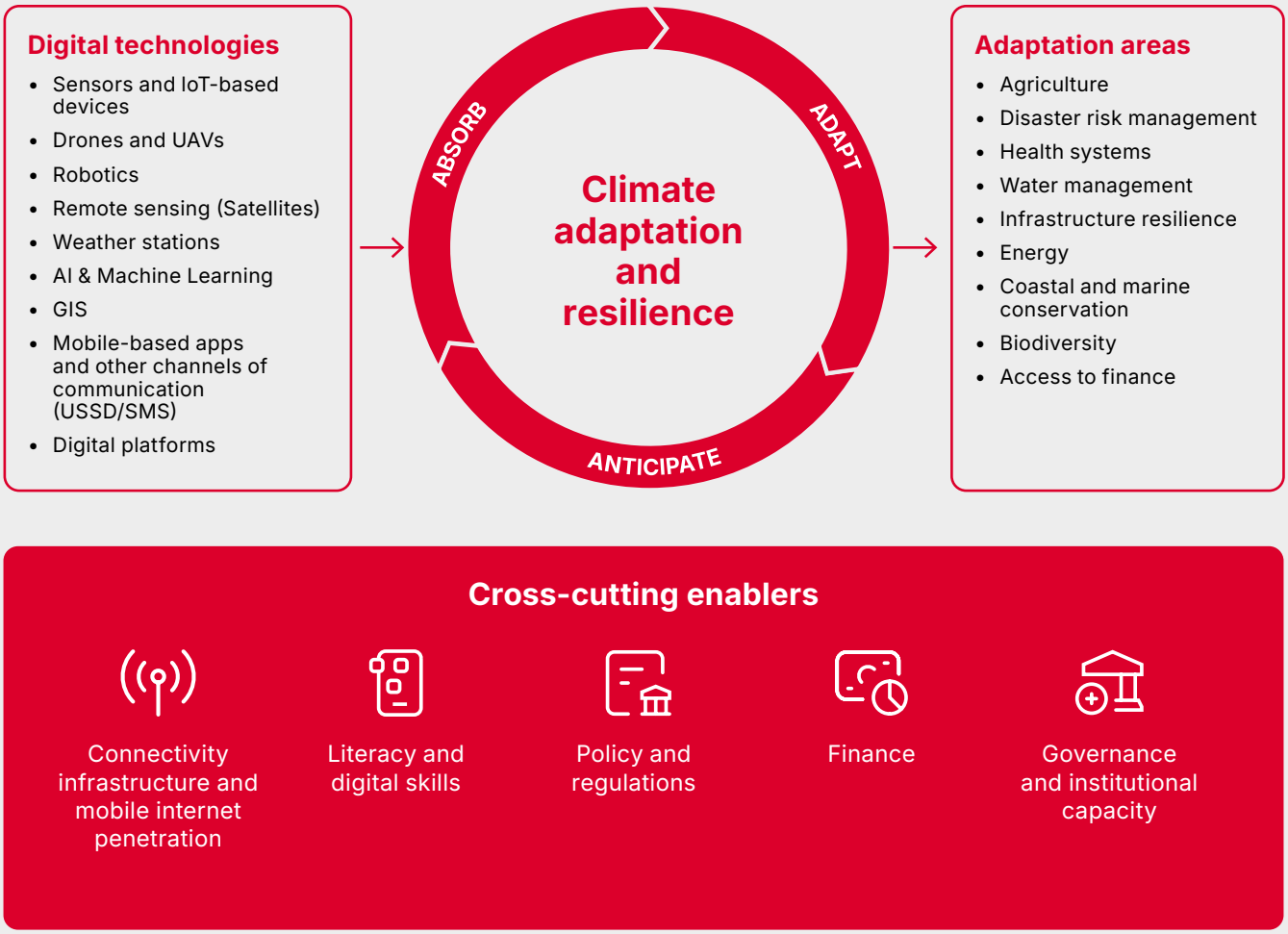
47 GSMA. (2025). ClimateTech Green Glossary.
48 Ibid.
49 Ibid.
50 Ibid.

Rapid advances in digital technology and connectivity are creating new opportunities to strengthen climate resilience and adaptation, including:

- Supporting actions to reduce greenhouse gas emissions and mitigate the impacts of climate change
- Improving the ability of vulnerable populations to withstand climate-related stressors and threats
- Enabling the sustainable use, protection and management of natural resources, especially in areas most exposed to climate impacts[51]

When the right conditions are in place, climate tech can significantly reduce the vulnerability of communities to climate change by improving access to information, enabling EWS, enhancing decision-making and supporting more effective resource management (Figure 6).

Figure 6:
Climate tech for climate adaptation and resilience: the GSMA's Three As framework



Source: GSMA Mobile for Development

51 Ibid.

02.
Research objectives and methodology

2.1
Research objectives

This report examines the potential of climate tech to strengthen climate adaptation and resilience in Timor-Leste, with a focus on the most pressing climate-related challenges in three key areas:

- Extreme weather events and natural hazards
- Agriculture and food security
- Public health

These three areas were selected based on several criteria: alignment with national development priorities, the urgency of reducing climate vulnerability, the demonstrated impact of climate tech in comparable low-income or SIDS contexts and the potential for cross-sectoral benefits.

Building on an assessment of Timor-Leste's climate vulnerabilities in these sectors and a review of existing climate tech initiatives, this report identifies relevant, high-impact use cases from similar contexts that could inform Timor-Leste's climate adaptation and resilience efforts.

Specifically, the report:

- **Assesses key climate-related challenges and the current use of climate tech** across the three identified areas
- **Identifies opportunities to scale climate tech solutions and highlights relevant case studies** from SIDS and LMICs with similar climate risks and development contexts
- **Examines how Timor-Leste's enabling environment supports or constrains the adoption of climate tech** for climate adaptation and resilience
- **Proposes strategies to accelerate the uptake of climate tech** to enhance adaptation and resilience

The report provides actionable recommendations for stakeholders in Timor-Leste, including government, the private sector, NGOs and development partners working to reduce climate vulnerability in the country through the adoption and scaling of climate tech.

It also offers insights and case studies that stakeholders in LMICs and SIDS facing similar climate risks may find valuable.

2.2
Research methodology and scope

2.2.1 Research methodology

This research included extensive desk research as well as interviews with key experts from the public, private and development sectors in Timor-Leste and in other SIDS involved in digitally enabled climate adaptation and resilience initiatives.

Methodology	Objective
Desk research using academic and grey literature (news articles, blogs, industry reports, publications by donors, development agencies and NGOs)	• Understand the climate tech landscape in SIDS and LMICs and how climate tech is being used for adaptation and resilience to extreme weather events and natural hazards, agriculture and food security and public health • Identify climate-related challenges and current adoption of climate tech in Timor-Leste in these three areas • Identify relevant and replicable climate tech use cases from other SIDS and comparable LMICs to inform Timor-Leste's adoption strategy
Interviews with key stakeholders in Timor-Leste (regulators, policymakers, researchers, tech companies, NGOs, donors, development partners)	• Develop a detailed understanding of current climate-related challenges and the adoption of climate tech in Timor-Leste to manage extreme weather events and natural hazards, agriculture and food security and public health • Capture insights on the key opportunities of climate tech to strengthen climate adaptation and resilience in these three areas • Identify the most notable barriers and viable strategies for climate tech adoption
Interviews with climate tech experts, practitioners and donor and development partners in SIDS and LMICs	• Explore replicable and scalable climate tech initiatives from comparable contexts to inform climate adaptation and resilience efforts in Timor-Leste

2.2.2 Scope

This report explores the potential of climate tech to support climate adaptation and resilience in Timor-Leste in three key areas: extreme weather events and natural hazards, agriculture and food security and public health. It does not aim to provide an exhaustive review of all climate tech applications relevant for the country. Instead, it highlights opportunities where targeted interventions could have the greatest impact.

The report also does not focus on how climate tech can mitigate the impacts of climate change. While mitigation is a critical component of combatting climate change, Timor-Leste's low contribution to global greenhouse gas emissions limits the impact of mitigation efforts. In addition, Timor-Leste is among the countries most vulnerable to the immediate and intensifying impacts of climate change, including extreme weather events, threats to food systems and public health risks. Therefore, prioritising climate adaptation and resilience allows for an approach that aligns with the country's needs in the short to medium term.

2.2.3 Contextual comparisons

This report presents examples from similar contexts that could help advance climate tech in Timor-Leste and support climate adaptation and resilience initiatives. To select these contexts, five criteria were applied:

Climate vulnerability profile
Exposure to similar climate hazards and similar levels of vulnerability

Economic development and structure
Similar GDP per capita, structure of the economy, and development constraints

Digital infrastructure
Comparable connectivity infrastructure and accessibility and affordability of digital services and devices

Governance and institutional capacity
Similar governance structures and implementation constraints

Literacy and digital skills
Comparable literacy rates, digital skills and technical capacity

Based on these criteria, examples are provided from the following contexts, which are highly comparable and can provide lessons for Timor-Leste:

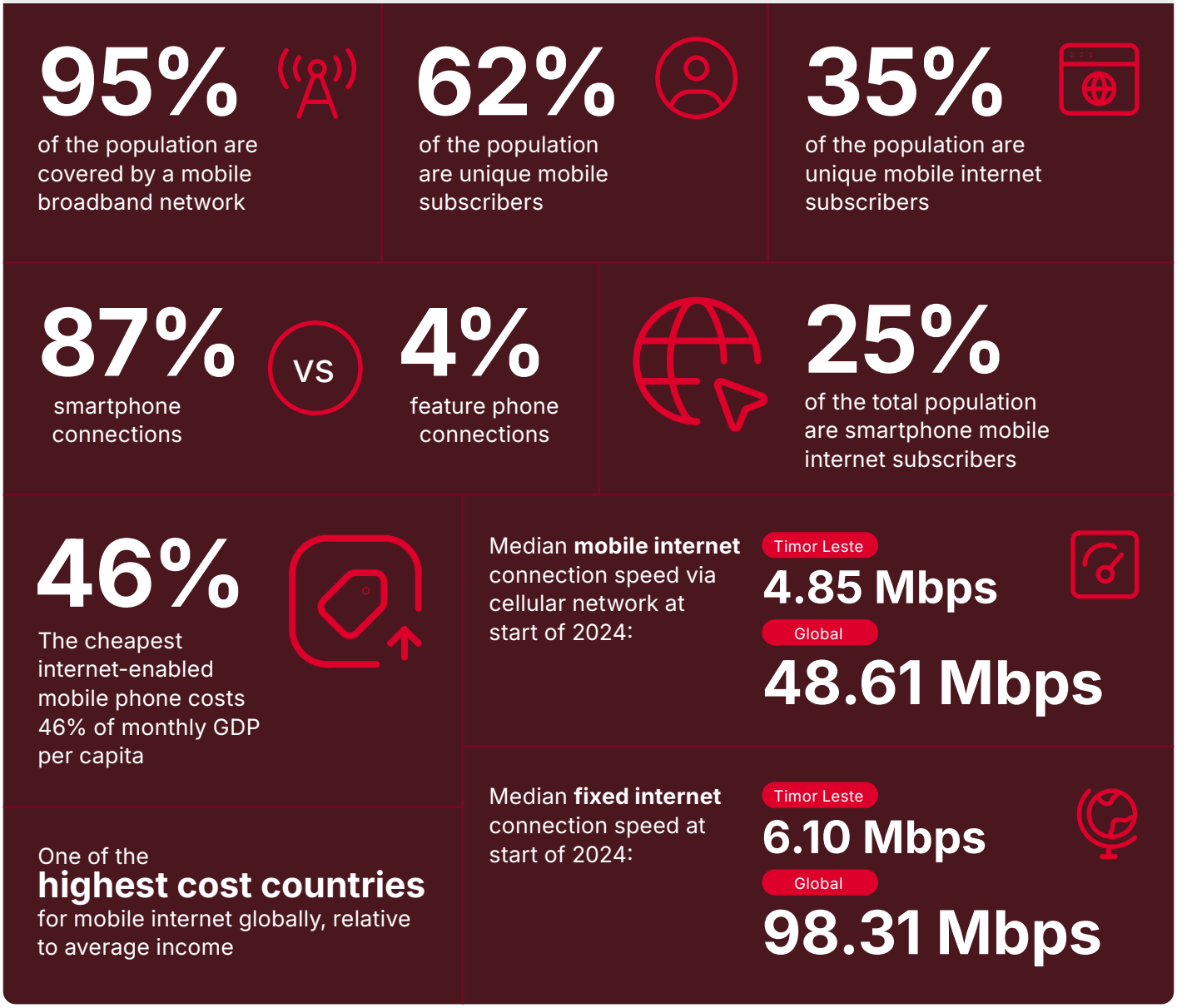
Region/country	Comparability
Eastern Indonesia *(especially Nusa Tenggara Timur, NTT)*	Very high similarity across all five dimensions
Pacific SIDS *(Tonga, Samoa, Fiji, Vanuatu, Papua New Guinea)*	High similarity across all dimensions, especially climate vulnerability
Nepal *(mountainous regions)*	High similarity, especially development status and governance
Myanmar *(coastal regions)*	High similarity, especially development status and governance

03.
Climate adaptation and resilience in Timor-Leste: contextual factors

The assessment of climate tech opportunities for climate adaptation and resilience in Timor-Leste is grounded in the current capacities and limitations of the country, including connectivity infrastructure and mobile internet penetration; policies and regulations; digital skills and literacy; the availability of financial resources for climate adaptation and resilience initiatives; and public and private sector capacity.

3.1
Connectivity infrastructure and mobile internet penetration

Figure 7:
Snapshot of connectivity infrastructure and mobile internet penetration in Timor-Leste



Sources: GSMA Mobile Connectivity Index[52], GSMA Intelligence, OOKLA[53]
Note: All statistics Q1 2025 unless indicated otherwise

52 See: GSMA Mobile Connectivity Index.
53 See: OOKLA website.

Connectivity in Timor-Leste remains a significant challenge. Although much of the population has access to network coverage, international digital connectivity relies on satellites and microwave links, resulting in high latency, limited bandwidth and high operational costs. Digital connectivity depends primarily on terrestrial radio links to Indonesia's networks or satellite connections to Australia and Singapore. Consequently, Timor-Leste experiences some of the poorest quality digital connectivity in the world at prohibitively high costs.[54] Many people earn approximately $2 a day and would need to spend half that amount on daily access.[55] Just 35% of the population are unique mobile internet subscribers and smartphones remain out of reach for a large segment of the rural population due to affordability challenges.

Limited connectivity infrastructure has also slowed the development of basic digital public infrastructure (DPI), such as digital identity, data sharing and payments, which help accelerate the adoption of digital tools in sectors facing climate risk. For example, digital IDs can enable faster identification of and access to at-risk communities or households, and disbursement of funds to hazard-affected communities. In 2024, Timor-Leste was ranked 159 out of 193 countries in the UN E-Government Development Index (EGDI), indicating a significant need for the development of DPI.[56]

In November 2024, the government inaugurated the Timor-Leste South Submarine Cable (TLSSC), linking the country directly to Darwin, Australia.[57] This new infrastructure is currently being tested.[58] When operational, it is expected to significantly enhance the quality of connectivity and reduce costs. Additionally, plans by the Australian government to integrate Timor-Leste in the North-West Cable System promise further advancements.

Starlink, an international telecommunications provider that is a subsidiary of American aerospace company SpaceX, launched services in Timor-Leste in December 2024. Starlink satellites operate closer to Earth, reducing the lag time between satellite and ground stations and resulting in much higher internet speeds for its users.[59] Although is too early to assess the long-term impact, Starlink is seeing uptake in the country, especially in urban areas. However, prices remain out of reach for average households, ranging from $40–$50/month, with high initial investment in the Starlink hardware kit, reportedly around $400 per kit. Hence, while it opens some opportunities, the high cost will limit its impact.

These developments in connectivity infrastructure, once complete, will help advance the types of digital solutions that could support climate adaptation and resilience in the country, making this an opportune moment for Timor-Leste to identify and initiate high-impact digital initiatives.

54 UNDP. (2023). Timor-Leste. Multidimensional Poverty Index 2023.
55 Akara, M. and Sirait, R. (22 October 2024). A cable to connect Timor-Leste, but can it bridge the digital divide? The Interpreter.
56 The E-Government Development Index is comprised of three sub-components: an online services index, a telecommunications infrastructure index and a human capital index. See: UN E-Government Knowledge Base: Timor-Leste.
57 Government of Timor-Leste. (25 June 2024). Government Carries Out First Submarine Fiber Optic Cable Installation.
58 Aman. (31 January 2025). Lusa – Business News – Timor-Leste: Tests on Australia fibre optic internet link underway – minister.
59 Salgado Alvarez, D. (18 December 2024). Starlink Launches High-Speed Internet Service in Timor-Leste. Asia Matters for America.

3.2
Literacy and digital skills

Basic literacy in Timor-Leste has improved significantly since the country gained independence in 2002. Digital literacy is also improving, especially in urban areas where access to mobile phones and mobile internet is expanding. However, persistent challenges limit the uptake of digital tools (Table 2).

Table 2:
Basic literacy and digital literacy challenges and advancements in Timor-Leste

	Challenges	Key advancements
Basic literacy	• Persistent low literacy in rural areas and among older adults • Significant disparities between urban and rural literacy rates • Linguistic diversity complicates education delivery • High dropout rates in rural areas due to economic and logistical issues in accessing educational facilities • Teacher shortages, outdated curricula and limited educational resources	• Steady improvement in literacy since independence in 2002 • Adult literacy rate reached 70% by 2020[60] • Youth literacy (ages 15–24) is more than 85%[61]
Digital literacy	• Low-to-moderate digital literacy [62] • Urban-rural digital divide in access to technology and the internet • Limited digital content in local languages[63] • Reliance on foreign languages (Bahasa Indonesia, English) for online resources[64,65]	• Access to digital technologies expanding, especially in urban areas • Increasing use of mobile phones and mobile internet for news, social media and public services • Need for digital upskilling recognised in both the public and private sector

60 World Bank Data. Indicators.
61 Ibid.
62 UNCDF. (2023). Assessing Digital and Financial Literacy in Timor-Leste: A Survey on Knowledge, Skills and Access.
63 GSMA Mobile Connectivity Index. Timor-Leste: Index Score 2023. See Content and Services.
64 Love Frankie, The Asia Foundation and Oxfam. (2022). Digital Youth in Timor-Leste.
65 Timor-Leste's National Strategy for Digitalisation and ICT (Timor Digital 2032), stated an ambition to prioritise the roll-out of a national digital and ICT skills programme/scheme in 2024, with the aim of developing digital skills across the board, from policymakers and technical staff to civil society organisations and citizens. See Timor Digital 2032.

3.3
Policy and regulations

Enabling policies

Timor-Leste offers an enabling policy environment for both climate adaption and digitalisation. The national digital policy, Timor Digital (2032),[66] articulates a commitment to strengthen basic digital public infrastructure, including providing citizens with unique digital IDs. It also identifies as a strategic priority providing access to digital government services via numerous channels, including mobile phones and "one-stop shop" digital services at the Suco (village) level, with service desks that enable connections to the government, NGOs, development partners and markets, powered by solar energy in off-grid locations. In a country where individual and household access to smartphones and the internet are limited, this is an effective way to reach communities with digital solutions. Increased access to digital services will indirectly benefit climate adaptation strategies to manage natural hazards, agriculture and health by reaching more people and supporting citizens through online channels.

In addition to Timor Digital (2032), Timor-Leste has specific strategic priorities for climate adaptation and resilience in the National Adaptation Plan (2021) and National Climate Change Policy (2022). The National Climate Change Policy (2022)[67] identifies key climate-related challenges that include rising temperatures and sea levels and erratic rainfall, which lead to floods and droughts, as well as mitigation and adaptation strategies to deal with these challenges.

These policies are supplemented by Timor-Leste's Nationally Determined Contributions (2022–2030), which focus on reducing greenhouse gas emissions, and the Green Climate Fund (GCF) Country Programme (2022–2030), which prioritises renewable energy and sustainable infrastructure.

Collectively, these policies and initiatives provide a positive policy environment for climate adaptation and resilience in the country. However, the lack of a national climate change strategy and action plan is a critical gap. A plan is needed to operationalise the objectives of the National Climate Change Policy (2022) and the National Action Plan (2021) at municipal levels, given ongoing decentralisation in the country.[68] In addition, a roadmap for integrating climate tech in climate adaptation and resilience initiatives would help accelerate adaptation via digital tools.

66 Ibid.
67 See: Timor-Leste National Climate Change Policy (2022).
68 European Union. (January 2024). European Union releases 1 million Euros to Timor-Leste's Government to support Decentralisation.

Implementation challenges

Climate adaptation and resilience initiatives in Timor-Leste involve several government bodies with intersecting responsibilities, creating institutional complexity and implementation challenges. The State Secretariat for the Environment, under the Ministry of Economic Affairs, leads the coordination of national climate actions and engagement with the United Nations Framework Convention on Climate Change (UNFCCC). The Ministry of Agriculture and Fisheries also plays a key role, especially in adaptation measures related to food security and rural livelihoods. Technical expertise is provided by the Department for Climate Change and Energy Efficiency, while other agencies, such as the National Directorate for Climate Change (NDCC), support sectoral planning, including the development of the National Action Plan. Despite these institutional arrangements, climate governance is hampered by unclear mandates, overlapping roles and limited resources, limiting the coherence and effectiveness of climate policy implementation.[69]

Policy gaps

To advance digitalisation for sustainable development and climate resilience, robust data privacy and protection laws, along with strong cybersecurity measures, are essential. While Timor-Leste's Constitution (2002) guarantees every citizen the right to privacy, the absence of a data privacy and protection law is a significant gap in the country's digital transformation. Lack of cybersecurity measures is also a key challenge in Timor-Leste and a growing concern as the government advances e-government services. According to the International Telecommunication Union (ITU) Global Cybersecurity Index (GCI 2024), which measures the commitment of countries to cybersecurity across five pillars – legal, technical, organisational, capacity development and cooperation – Timor-Leste is categorised at a nascent stage.[70]

To address these gaps, the Advancing Timor-Leste's Autonomous Telecommunications Landscape (ATLATL) initiative, supported by USAID and implemented by DAI as a technical partner, drafted a data privacy and protection law in 2023, which is not yet implemented. Additionally, in collaboration with the Government of Timor-Leste, ATLATL developed a National Cybersecurity Strategy,[71] which has been officially adopted by the Council of Ministers.

69 UNDP. (November 2021). National Adaptation Plans in focus: Lessons from Timor-Leste.

70 In the Global Cybersecurity Index, 46 countries are categorised as Role-Modelling (T1), reflecting the highest level of cybersecurity development; 29 countries are listed as Advancing (T2); 49 as Establishing (T3), 56 as Evolving (T4); and 14 as Building (T5), including Timor-Leste. See: ITU. (2024). Global Cybersecurity Index 2024.

71 Digital Frontiers DAI. (2023). Success story: ATLATL – A TRUSTED TECHNICAL ENGAGEMENT: Spearheading Legislation for Timor-Leste's ICT Sector.

3.4
Financing for climate adaptation

Like many SIDS, Timor-Leste faces financing constraints for climate adaptation and resilience initiatives. With competing national priorities like healthcare, education and basic infrastructure development, climate adaptation vies for limited government resources in a tight fiscal environment. The country's heavy dependence on declining oil revenues further limits domestic financing capacity for climate adaptation and resilience.

Timor-Leste has partnered with numerous development organisations on climate-related projects, including the Asian Development Bank (ADB), United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP), Japan International Cooperation Agency (JICA) and the European Union (EU). However, total climate finance is not enough to meet climate adaptation needs.

Financing from the Green Climate Fund

As the world's largest dedicated climate fund, the Green Climate Fund (GCF) provides funding through grants, concessional debt, guarantees and equity instruments, leveraging blended finance mechanisms to attract private investment across LMICs.[72]

Since the GCF's first investment in Timor-Leste in 2019, four projects have been approved totalling USD 65.3 million.[73] While this demonstrates successful engagement with the GCF, Timor-Leste's approval rate and funding volume remain below regional averages, highlighting persistent access barriers that limit the country's ability to compete with institutionally stronger nations for available resources.

Challenges in accessing funding

Government agencies often lack technical expertise, including in project design, financial structuring and monitoring systems required to apply for international climate finance. Weak interministerial coordination further complicates project alignment with national climate priorities and creates inefficiencies in the preparation of project plans for funding applications. The country has applied to the GCF for capacity building support to improve its ability to apply for climate financing.[74]

In addition, Timor-Leste's mountainous terrain and dispersed communities increase both project implementation costs and the complexity of monitoring, making climate adaptation projects more expensive than comparable initiatives in countries with better infrastructure and geographic accessibility. These higher costs make Timor-Leste less competitive for internationally funded projects that prioritise cost-effectiveness.

Finally, low private sector capacity and minimal foreign direct investment (FDI) in climate-related sectors have limited the development of bankable projects and blended finance opportunities. The absence of appropriate incentive structures like tax incentives, risk guarantees or public-private partnerships (PPP) further deter private sector climate investment.

72 See: About GCF.
73 Green Climate Fund: Democratic Republic of Timor-Leste.
74 Green Climate Fund. (2024). Readiness Proposal: Timor-Leste.

3.5
Governance and institutional capacity

Public sector challenges

Timor-Leste faces significant challenges in terms of public sector capacity. While the country has made notable strides since independence in 2002, it still struggles with limited human resources, underdeveloped infrastructure and weak governance frameworks. Many government institutions face difficulties in fulfilling their mandates due to a lack of technical expertise and insufficient institutional coordination, which affect the delivery of essential public services.

These challenges also affect the implementation of climate adaptation and resilience projects. Timor-Leste's public sector would benefit from capacity building in climate risk assessments and in understanding the impacts of climate change at the local level, both of which would support data-based adaptation and resilience efforts. A major barrier is the lack of funding for education and training in climate resilience strategies and projects for government officials, which hinder the development of expertise necessary for climate-related initiatives.[75]

Another key issue is the lack of information from sucos and municipalities on the local impacts of climate change, which leaves government agencies poorly informed and exacerbates the challenges of planning and implementing appropriate climate adaptation and resilience measures.[76]

Private sector development

Private sector development is still in early stages. A review of public sector development led by the Australian government in 2018 identified several systemic barriers, including the absence of enabling policies for small businesses, poorly defined land rights that prevent land from being used as collateral for business financing, a shortage of skilled labour and limited access to markets, particularly in remote areas.[77] These challenges are especially pronounced in the information and communication technology (ICT) sector, a key enabler of digitalisation, where private sector growth is hindered by inadequate connectivity infrastructure, an unclear policy environment, a lack of business-friendly regulations, limited digital literacy and limited access to financing.[78] Low private sector development, in turn, limits the capacity of companies to fill the financial and technical capacity gaps to drive innovation in climate adaptation and resilience.

75 Ibid.
76 Ibid.
77 Department of Foreign Affairs and Trade. (2018). Review of Australia's contribution to private sector development in Timor-Leste.
78 In a landmark move to strengthen innovation and advance digitalisation, the Oecusse Digital Centre has recently been granted free trade zone status, in a move to foster innovation and promote e-commerce and incentivise online global trade. See: Business Insider. (25 December 2024). Oecusse Digital Centre Granted Free Trade Zone Status and Oecusse International Company Registry Officially Established.

04.
Anticipate, Adapt, Absorb: How climate tech can support adaptation and resilience in Timor-Leste

4.1
Extreme weather events and natural hazards

4.1.1 Timor-Leste's vulnerability to climate change

Situated between two tectonic plates and along the Pacific "Ring of Fire," Timor-Leste faces significant risks from earthquakes and tsunamis. Its tropical climate is also heavily influenced by the West Pacific Monsoon and the El Niño-Southern Oscillation (ENSO),[79] which can cause dramatic variations in annual rainfall – sometimes by as much as 50% – and alter the timing of peak rainfall.

This variability was evident during the November 2023 to May 2024 rainy season, when El Niño led to above-average temperatures and irregular rainfall. From October 2023 to January 2024, precipitation levels fell more than 30% below average and, by mid-February, drought conditions were detected in 10 of the country's 14 municipalities.[80] The resulting drought and heat led to crop failures, livestock deaths and water shortages, exacerbating livelihood challenges and increasing food insecurity, malnutrition and water, sanitation and hygiene (WASH) needs.

In early 2024, the Assessment Capacities Project (ACAPS), an international NGO that provides international humanitarian analysis, projected a 60% likelihood of La Niña developing in Timor-Leste between June and August 2024.[81] La Niña typically brings increased rainfall and a heightened risk of flash floods. The transition from El Niño to La Niña was expected to bring both dry conditions and extreme rainfall events simultaneously, alongside above-average temperatures. While increased rainfall would serve to alleviate drought, it would also increase the risk of landslides and flash floods, which would lead to more crop losses, contaminate water sources and further strain livelihoods and WASH infrastructure.[82]

In this already fragile context, climate change is intensifying Timor-Leste's vulnerability to extreme weather events, especially hydrometeorological hazards. Rising global temperatures are worsening climate variability, increasing the frequency and severity of extreme weather patterns. Changes in temperature are projected to further disrupt rainfall distribution, leading to heavier downpours during the wet season and prolonged dry spells in the dry season, exacerbating both flood and drought risks. Additionally, rising sea levels pose a significant threat to coastal communities by increasing the risk of inundation, damaging critical infrastructure and endangering agriculture, health and food security. 65% of Timor-Leste's population live in low-lying coastal areas and are exceptionally vulnerable to the impacts of climate change.

79 El Niño is the warming of sea surface temperature that occurs every few years, typically concentrated in the central-east equatorial Pacific. An El Niño is declared when sea temperatures in the tropical eastern Pacific rise 0.5°C above the long-term average. El Niño is felt strongly in the tropical eastern Pacific with warmer than average weather. See: UK Met Office. (n.d.). What are El Niño and La Niña?
80 ACAPS. (13 May 2024). Timor-Leste: Humanitarian impacts of El Niño-related drought and heat. Briefing Note.
81 Ibid.
82 Ibid.

4.1.2 Climate tech solutions

Category: Anticipate

Early warning systems

Early warning systems (EWS) are a critical adaptive measure for coping with the impacts of extreme weather events and reducing the risks of natural hazards. EWS provide advance notice of potential extreme weather events and natural disasters, allowing communities and authorities to prepare and minimise loss and damage. Research indicates that issuing an early warning even 24 hours in advance can reduce the impact of a natural hazard by up to 30%, highlighting the importance of timely alerts.[83]

Traditionally, EWS have relied primarily on meteorological data collected by national meteorology departments and have used conventional dissemination methods for alerts, such as loudspeakers, sirens, television and radio. However, due to the limited data available, the accuracy and granularity of the data and delays in obtaining it, these systems can fail to predict hazards with sufficient accuracy and enough in advance to reach people in time and prevent significant loss.

In 2022, UN Secretary-General António Guterres launched the Early Warnings for All (EW4All) initiative, which aims to ensure that everyone in the world is protected from hazardous weather, water or climate events through an EWS (Figure 8).[84,85] The GSMA is a key partner of the EW4ALL initiative.

Climate tech offers significant advantages over traditional EWS for detecting, preparing for and responding to extreme weather events and natural hazards. Key technologies and use cases are captured in Table 3 and categorised by the ease of adoption in Timor-Leste and similar contexts, based on the complexity of implementation and resources required (for an explanation of the full criteria, see Annex 1).

Figure 8:
The four pillars of the Early Warnings for All initiative

Source: Early Warnings for All

83 World Meteorological Organization: Early Warning System.
84 United Nations: Early Warnings for All.
85 The GSMA has catalysed the role of the mobile industry in EWS for several years and immediately took a leadership role in the Early Warnings for All initiative through the GSMA Mobile for Humanitarian Innovation programme, which is funded by the UK Foreign, Commonwealth & Development Office. The GSMA is part of the ITU-led Pillar 3: Warning dissemination and communication. See: GSMA. (2024). Mobile Enabled Early Warning Systems: The GSMA and the Early Warnings for All initiative.

Table 3:

Key climate tech use cases for early warning systems and ease of adoption in Timor-Leste

	Technology	Use case	Ease of adoption	Implementation considerations
	**Feature phones (SMS/Voice)**	SMS/voice alerts for extreme weather events; Emergency instructions; Citizen reporting on hazardous or disruptive conditions (blocked roads, flooding)	**High**	• Works with existing mobile infrastructure • Low technical barriers
	**Data collection platforms (e.g. for crowdsourced data such as OpenStreetMap,[86] Ushahidi[87])**	Citizen reporting of real-time hazard data (blocked roads, flood zones); Enhanced situational awareness at the community level	**Medium-High**	• Useful for engaging communities and integrating local knowledge in EWS • Requires periodic internet access to sync data • Can function offline for data collection
	**Smartphone apps**	Weather alerts Community evacuation planning Hazard reporting	**Medium**	• High smartphone penetration • Poor connectivity limits real-time features • Offline-first design essential • Data costs could be a barrier
	**IoT sensors**	Real-time monitoring of natural hazards Automatic alerts and warnings when thresholds exceeded	**Medium**	• Can be solar powered to overcome electricity issues • Requires local maintenance capacity • Moderate equipment costs
	**Remote sensing (satellite imagery analysis)**	Large-scale monitoring of droughts, floods, deforestation	**Medium**	• Free satellite data available • Requires GIS skills and institutional capacity • Limited by poor connectivity for data access • Government/institutional implementation
	**Digital data integration platforms**	Climate, geographic and demographic data integration for cross-sector decision-making	**Medium-Low**	• Valuable for interagency coordination • Requires stable internet and IT capacity • Institutional use primarily

86 OpenStreetMap is an open-source platform that enables the creation of detailed geographic data in areas with incomplete mapping. See: Open Street Map website.

87 Ushahidi is a platform that aims to empower people through citizen-generated data to develop solutions that strengthen their communities. See: Ushahidi website.

	Technology	Use case	Ease of adoption	Implementation considerations
	**Weather radar systems**	Meteorological hazard forecasting	**Medium-Low**	• High equipment and maintenance costs • Requires meteorological expertise • Complex technical requirements • Government-level implementation
	**GIS and Digital twins**	Hazard scenario simulation; Risk exposure mapping; Strategic planning tool	**Low**	• High strategic value • Requires trained personnel and institutional buy-in • Consistent connectivity requirements • Long-term capacity building needed
	**Drones/Unmanned aerial vehicles**	High-resolution imagery for hazard monitoring; Post-disaster damage assessment	**Low**	• Ideal for remote mountainous areas • High equipment costs • Regulatory considerations • Limited local maintenance capacity • Connectivity dependent for data transfer
	**AI-powered computer vision**	Camera-based detection of hazards such as landslides, shoreline erosion	**Low**	• Technically complex • Requires high-speed connectivity • Best piloted with external technical support • Very high data requirements
	**AI and Machine Learning**	Large dataset analysis for improved hazard forecasting (e.g. cyclone paths, drought onset)	**Low**	• Needs extensive data pipelines and computing resources • Long-term institutional capacity required • High cost

These technologies offer a data-driven approach to early warnings, significantly improving the timeliness, accuracy and inclusiveness of responses to climate-related hazards in vulnerable areas.

4.1.3 Climate tech initiatives for early warning systems in Timor-Leste

Climate tech is already being trialled in Timor-Leste for the monitoring of extreme weather events and natural hazards. For example, in 2020, the government launched an EWS in the capital, Dili, to enhance flood detection and improve disaster preparedness. In 2023, a short-term anticipatory mapping project was conducted using OpenStreetMap to identify areas prone to landslides and floods in some of the most vulnerable areas. Funded by the GCF, UNEP is currently supporting the development of a multi-hazard EWS that is expected to benefit more than a million people in Timor-Leste. These examples are detailed below.

Early warning systems for floods in Dili

In 2020, the Government of Timor-Leste, the global humanitarian organisation Mercy Corps[88] and Similie,[89] a tech startup based in Timor-Leste, launched an EWS for flood warnings in Dili. Under this initiative, 17 hydrometeorological stations were deployed to collect real-time data on rainfall, water levels in the river, temperature, soil moisture and other environmental variables. The data is transmitted to Similie's EWS platform for real-time data analysis, and when a parameter surpasses predefined thresholds, alerts are sent to government agencies that then disseminate warnings to at-risk communities in the capital.[90]

Through the ASEAN Blue Innovation Challenge (ABIC 2024),[91] Similie is now developing a mobile app to deliver early warnings directly to communities across Timor-Leste. Five hundred people have been enrolled to trial the service, with plans for nationwide expansion after successful completion of the pilot.

Anticipatory risk mapping

In 2023, the Red Cross Climate Centre, Timor-Leste Red Cross and the Humanitarian OpenStreetMap Team conducted a mapping activity of areas vulnerable to floods and landslides in Timor-Leste using OpenStreetMap (OSM).[92,93] Using GIS, a national multi-hazard assessment identified four priority locations to map. The teams then used Kobo Toolbox,[94] a global open-source data collection platform, and SketchMap, which digitalises paper maps, to add annotations from communities such as key infrastructure and historical flood events, to better assess the impacts. 1,760 buildings were documented in four pilot areas, and the data has been shared on the Humanitarian Data Exchange (HDX), an open platform for sharing data on humanitarian crises and emergency responses across humanitarian organisations.[95,96]

Multi-hazard early warning system

In one of four climate adaptation and resilience projects funded by the GCF in Timor-Leste, UNEP is developing a national multi-hazard early warning system (MHEWS) set for completion by 2027. As part of the project, which was initiated in 2022, UNEP is deploying eight automatic weather stations (AWS) in different municipalities, as well as doppler radar and ocean sensors to improve climate monitoring and forecasting for a range of hazards, including floods, heatwaves, cyclones and storm surges.

A national multi-hazard forecasting centre is also to be established.[97] One of the aims of the project is to integrate early warning information from multiple sectors, including agriculture, health and coastal management, to create a more comprehensive EWS. Once complete, the MHEWS could significantly improve climate adaptation and resilience to multiple natural hazards in Timor-Leste.

88 Learn more at: Mercy Corps Timor-Leste.
89 See: Similie website.
90 To date, the system has identified more than 20 flash flood events, benefitting more than 300,000 people. Dili's Early Warning System: From Setup to Alerts, see more here
91 UNDP. (October 2024). Catalogue of Winners: ASEAN Blue Innovation Challenge.
92 See: Open Street Map website.
93 Humanitarian OpenStreetMap. (n.d.). Anticipatory Mapping for Climate Resilience in Timor-Leste.
94 See: Kobo Toolbox website.
95 Humanitarian Data Exchange: Timor-Leste Anticipatory Mapping.
96 The Australian Red Cross and Red Cross Red Crescent Climate Centre are supporting CVTL in developing an Early Action Protocol (EAP) based on this anticipatory mapping. An EAP is an initiative by the Red Cross that aims to mitigate the impact of predicted events such as typhoons, floods or droughts by enabling the release of funding to execute pre-agreed early action before an extreme weather event or natural disaster. See: Netherlands Red Cross. (n.d.). Early Action Protocol Development.
97 UNEP. (11 August 2023). An early warning system for disasters takes shape in Timor-Leste.

4.1.4 Lessons from comparable contexts

As Timor-Leste develops an EWS for climate adaptation and resilience, the experiences of Pacific Island nations and comparable contexts that are further ahead in the development of these systems offer valuable lessons for leveraging climate tech effectively.

The following examples demonstrate how digital tools can be strategically deployed to overcome the geographic, infrastructure and resource constraints that Timor-Leste faces, while extending coverage to remote populations and building community ownership and buy-in.

Category: Anticipate

A multi-channel approach to the dissemination of early warnings

Women's Weather Watch: gender-responsive EWS in Pacific SIDS

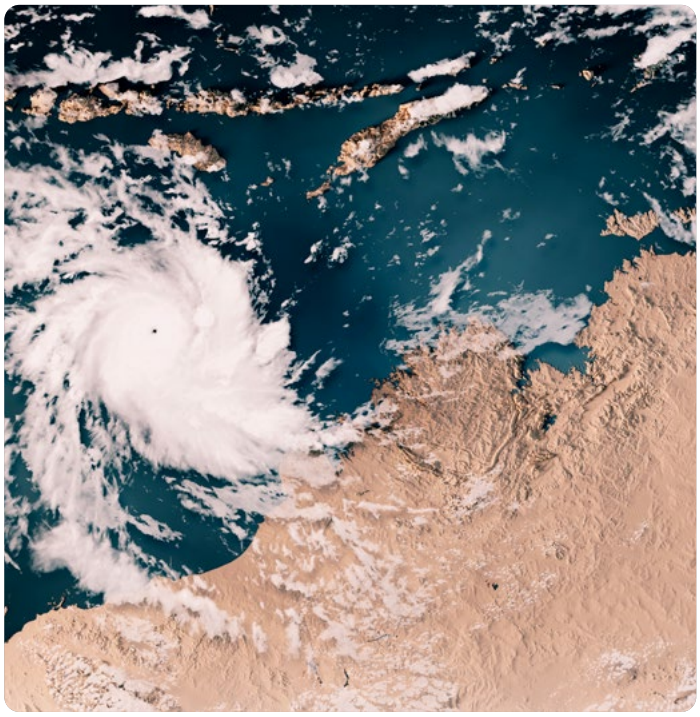
Women's Weather Watch (WWW) is a community-based EWS in the Pacific Islands, designed to ensure women's voices and needs are central to responses to extreme weather events and natural hazards. This initiative emerged under femLINKpacific, a non-profit media and policy network based in Fiji, following interviews with women affected by severe flooding in Fiji in 2004, which revealed that although women had played vital roles in the response, they had never been consulted about their experiences.[98]

WWW aims to strengthen EWS by empowering women to lead preparedness efforts in their communities. Women leaders in the network receive and communicate early warnings through SMS and other communication channels. The early warnings enable them to take critical preparedness actions, such as securing homes, storing food and water, relocating vulnerable individuals and disseminating warnings throughout their communities. The women also engage directly with national disaster management offices and meteorological services to communicate local conditions and needs.

The initiative expanded from Fiji to Papua New Guinea and Vanuatu, and has proven effective during events like Tropical Cyclone Harold in Vanuatu, where WWW enabled faster, more coordinated community responses. It promotes gender-responsive action by facilitating women's participation in climate and disaster risk reduction (DRR) dialogues and enabling women to organise and lead humanitarian responses.

With increasing connectivity and widespread access to mobile phones, WWW's communication tools have expanded beyond an original focus on community radio. While radio remains a vital channel, the system now incorporates multi-channel communication, including social media, bulk messaging apps and SMS alerts. This multi-channel approach allows for real-time, two-way communication: communities receive alerts and can also share updates. WWW also has a disaster impact assessment tool that can be accessed from a desktop or mobile device.[99]

Women Wetem Weta (WWW) is a disaster preparedness initiative and EWS in Vanuatu, designed to keep rural and remote communities informed during humanitarian crises. Launched in 2019, it was inspired by Fiji's Women's Weather Watch. The system enables a core network of women leaders to share real-time disaster information through bulk SMS messages in their local language, ensuring communities receive timely warnings of cyclones, tsunamis and floods.



98 FemLINK Pacific. (28 January 2019). Innovation Station: Women's Weather Watch, Fiji. ActionAid Australia.
99 UN Women. (2022). Inclusive and accessible multi-hazard early-warning systems.

Category: Anticipate

Using mobile phones to extend the reach of early warning systems

MACRES: a mobile-first approach in Tonga

The Kingdom of Tonga has been working to enhance its early warning dissemination systems following the 2022 volcanic eruption and tsunami, which caused widespread destruction and exposed critical gaps in reaching communities in time. While Tonga had already been using Facebook for early warning dissemination before 2022, the disaster highlighted the need for more effective and inclusive alert mechanisms.

With funding from the Climate Risk and Early Warning Systems (CREWS) Accelerated Support Window,[100] the Kingdom of Tonga developed the Mobile Applications Community and Response System (MACRES),[101] with the Tonga Meteorological Services and the World Meteorological Association (WMO), playing a key role. The mobile app is designed to deliver multi-hazard early warnings to improve disaster resilience. The app addresses gaps in the dissemination of alerts by delivering timely, accessible early warnings on mobile phones through visual and user-friendly features, ensuring that critical information reaches a broad audience, including persons with disabilities. The app also enables real-time hazard reporting and damage assessments from communities to national authorities, creating an information flow that strengthens the EWS.

In 2024, with funding from the World Bank under the EW4All initiative, Tonga partnered with Everbridge, a US-based critical event alert technology company,[102] to improve the dissemination of early warnings. Everbridge will deploy its cell broadcast technology,[103] allowing alerts to be sent directly to all smartphone users without the need for an internet connection or opt-in, ensuring wider reach during emergencies.[104,105]

100 A funding initiative supporting early warnings in SIDS and countries designated as least-developed countries (LDCs) by the UN based on official development assistance (ODA). CREWS projects are implemented by the United Nations Office for Disaster Risk Reduction (UNDRR), the World Bank Global Facility for Disaster Reduction and Recovery (GFDRR) and the World Meteorological Organization (WMO). Learn more here.

101 World Meteorological Organization. (13 October 2022). Tonga boosts early warnings through smartphones.

102 Everbridge (17 September 2024). Island Country of Tonga Partners with Everbridge to Enhance Multi-Hazard Early Warning Systems & Response.

103 Cell broadcast is a method of simultaneously sending alerts via mobile phones to multiple mobile phone users in a defined area, and are used for public emergency warnings. See: Parsons, O. and Hamilton, Z. (2023). Cell Broadcast for Early Warning Systems. A review of the technology and how to implement it. GSMA.

104 Ibid.

105 In 2024, Tonga also acquired new weather radar, which will help the TMS warn local communities of incoming severe weather so they can prepare. The radar technology provides detailed information on location and intensity of rainfall, thunderstorms and tropical cyclones that affect Tonga. This initiative is part of a range of activities planned under the Weather Ready Pacific Program across the Pacific Islands region.

Category: Anticipate

Lessons from more advanced multi-hazard early warning systems in similar contexts

A comprehensive multi-hazard early warning system: Vanuatu's Van-KIRAP[106]

Like Timor-Leste, Vanuatu experiences extreme climate variability and has suffered severe impacts from extreme weather events. Tropical Cyclone Pam in 2015, for example, caused damage equivalent to 64% of the country's GDP.[107] More recently, an earthquake in December 2024 claimed 14 lives.[108] Vanuatu's Van-KIRAP – initially a five-year project (2020–2025) that has been extended to 2027 and funded by the GCF[109] – and has been developed and implemented by a number of partners including the Vanuatu Meteorology and Geo-Hazards Department (VMGD) and the Secretariat of the Pacific Regional Environmental Program (SPREP), provides a highly relevant and more comprehensive model for a multi-hazard early warning system (MHEWS) in Timor-Leste.

Whereas Timor-Leste's MHEWS is still under development, Van-KIRAP is operational and more extensive in scope. It integrates a range of technologies, including AWS that transmit real-time data from remote, disconnected areas, helping to overcome the challenge of monitoring microclimates across Vanuatu's varied terrain. These are supported by automated rain gauges and a weather radar system that feeds into the national preparedness system.

A particularly relevant innovation is the integration of traditional ecological knowledge with modern tools, most notably through the ClimateWatch mobile app.[110] This app enables community members with smartphones to record observations of traditional weather indicator species, contributing valuable Indigenous knowledge to the prediction of extreme weather events and natural hazards, turning them into citizen scientists. In Timor-Leste, where tara bandu, the customary regulation or law established by communities at the village level to address social and environmental issues, especially for the sustainable use of resources, remain strong, this model offers a way to digitally capture and integrate traditional, community-based knowledge with modern, tech-enabled data.

Van-KIRAP also offers the Climate Futures Portal, which provides accessible climate projections to decision-makers in government, industry and communities. The platform provides tools to support planning in agriculture, infrastructure, fisheries, tourism and water management. In Timor-Leste, where institutional capacity is still being strengthened, such a tool could significantly enhance cross-sectoral decision-making and evidence-based planning.

From an implementation perspective, Van-KIRAP exemplifies best practice in inclusive governance. The project established multi-sectoral working groups – bringing together actors from meteorology, agriculture, fisheries, tourism, infrastructure and civil society – ensuring that climate information services are comprehensive. For Timor-Leste's MHEWS, creating similar cross-sectoral governance early in the project cycle would be beneficial, particularly given its focus on multiple sectors.

Additionally, while Timor-Leste's MHEWS currently focuses on hazard detection and alert dissemination, Van-KIRAP has gone further by embedding climate information services in sectoral decision-making. This makes it even more relevant – not only for emergency response, but also for long-term planning.

The project's use of interactive geospatial mapping tools and step-by-step hazard assessment guides has made complex data and processes accessible to non-experts. As Timor-Leste develops its MHEWS, adopting similar user-friendly digital interfaces could significantly increase the usefulness of the system.

Finally, Van-KIRAP demonstrates the value of investing in human capital alongside digital infrastructure. The project's extension phase is dedicated to ensuring that staff at the Vanuatu Meteorology and Geo-hazards Department receive extensive training to independently manage and maintain radar and monitoring equipment. This emphasis on sustainability is a crucial lesson for Timor-Leste if its MHEWS is to become an effective long-term EWS.

106 SPREP. (25 July 2024). Van-KIRAP a cornerstone for climate resilient development in Vanuatu.
107 See: Vanuatu Climate Change Finance Review.
108 Government of Vanuatu. (2024). Vanuatu National Statement on Climate and Tropical Cyclone Seasonal Outlook for 2024/2025 Season.
109 Van-KIRAP is implemented by the Secretariat of the Pacific Regional Environment (SPREP), the Vanuatu Meteorology and Geohazard Department (VMGD), the Commonwealth Scientific and Industrial Research Organisation (CSIRO), National Groundwater Information System Australia (NGIS) and Frontier SI, an Australian research and product development social enterprise. FrontierSI provides the connections and collaborative model for its network to access, develop and apply space and spatial research, development and innovation project outcomes into impactful solutions. See more here.
110 Vanuatu Meteorology & Geo-hazards Department: ClimateWatch App. Vanuatu.

Category: Anticipate

Developing community-based EWS

Given Timor-Leste's unique context of microclimates, remote communities, varied topography and vulnerability to multiple hazards, community-based early warning systems (CBEWS) can provide complementary capacity to national MHEWS systems. These localised systems enable communities to actively engage in risk identification, monitoring and response planning while building local ownership and sustainability.

Community-based systems generally incorporate high-tech, low-tech and traditional tools to ensure maximum reach and inclusion. They are inherently people-centred, more cost-effective and provide real-time alerts to reach populations that are extremely remote, dispersed and disconnected – communities that national systems may not be equally suited to reach.

Community-based landslide EWS

Low-cost landslide monitoring sensors, such as the Community Slope SAFE acoustic sensors developed by Loughborough University in the UK[111] and tested in Myanmar, demonstrate how tailored tech solutions can address specific local natural hazards and involve communities in the operation and maintenance of these systems. The sensors, designed specifically for low-resource settings, can "hear" developing landslides and provide visual and audio early warnings to communities. [112] Given Timor-Leste's mountainous terrain and high vulnerability to landslides, such a solution could provide life-saving alerts at the local level, complementing a national monitoring system.

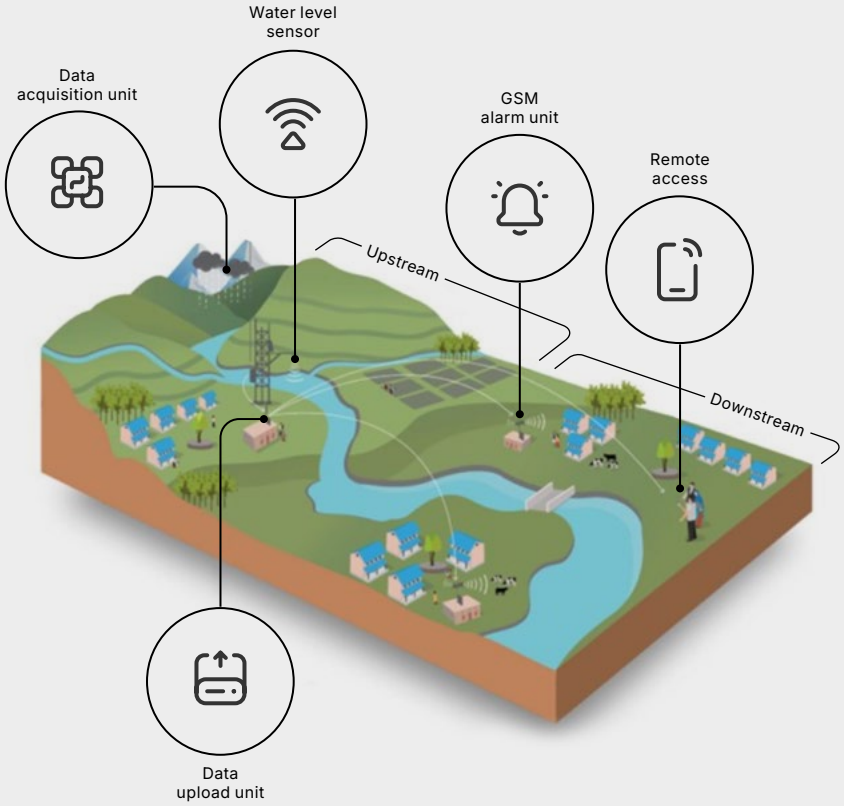
Community-based flood early warning systems

Community-based flood early warning systems (CBFEWS) have been in development in Nepal for more than a decade. In 2023, the International Centre for Integrated Mountain Development (ICIMOD) conducted a comprehensive flood risk assessment in Nepal's southern Madhesh Province, focusing on communities living along the flood-prone Lal Bakaiya river.[113] The region, like many in Timor-Leste, faces seasonal flooding that endangers lives, infrastructure and livelihoods.

ICIMOD engaged 13 municipalities in Rautahat District to assess vulnerabilities, conduct flood modelling and determine the need for a CBFEWS. It then developed a CBFEWS using connected rainfall sensors and river gauges that upload data in real time to a monitoring centre and can trigger automated alerts, as well as transmit the data in real time to at-risk downstream communities via mobile phone (Figure 9).

111 See Loughborough University website: Low-cost landslide early warning system.
112 Ibid.
113 Shakya, S. and Sanyal, S. (2025). In southern Nepal, 13 municipalities unite to fund Community-Based Flood Early Warning System. ICIMOD Blog.

Figure 9:
Community-based flood early warning system in Nepal



Source: ICIMOD[114]

A key part of developing the CBFEWS was building multi-stakeholder cooperation. Municipal leaders, local officials and community representatives jointly agreed to establish a shared fund for the maintenance and operation of the system. Each municipality pledged an annual contribution of approximately $750 to support caretakers, basic equipment maintenance and training for early warning dissemination and response.[115]

The Lal Bakaiya CBFEWS design is based closely on the four pillars of the EW4All initiative:

- **Risk knowledge:** Mapping flood-prone zones and community vulnerabilities
- **Monitoring and forecasting:** Installing river gauges and integrating rainfall data
- **Warning communication:** Establishing alert protocols using SMS, sirens and local volunteers
- **Preparedness and response:** Training community members and conducting simulation drills

The ICIMOD project also highlights the importance of ensuring sustainability, including local ownership, financial viability and institutional support, such as legal agreements between municipalities and capacity building for long-term governance.

Like Nepal, Timor-Leste experiences frequent flooding that affects remote and rural communities. Given its exposure to climate-related hazards, Timor-Leste could adapt this model by identifying high-risk rural areas, piloting CBFEWS in flood-prone sucos (villages) and fostering collaboration between municipal authorities, the Civil Protection Authority and community-based disaster management committees to build community-based systems.

Lessons from Nepal's experience include building sustainable local EWS through pooled financing and establishing clear governance frameworks, embedding low-tech and cost-effective solutions in resource-limited settings and involving the local community to manage and build trust in the system.

114 Ibid.
115 Ibid.

Box 1:

Monitoring coastal erosion using satellite data in Pacific SIDS

With a coastline of more than 700 km, Timor-Leste is highly vulnerable to coastal erosion, flooding and saltwater intrusion in freshwater sources.[116] The main reasons for this vulnerability are rising sea levels from glacier melt and stereodynamics – the combined effects of ocean warming and changing ocean currents driven by climate change – contributing to rising and increasingly variable sea levels.[117]

The Pacific Community (SPC) has launched a new tool, Digital Earth Pacific (DE Pacific), that analyses vast amounts of satellite imagery – ranging from decades-old Landsat data to near-weekly Sentinel data – using advanced AI algorithms to detect environmental changes and generate practical maps. These AI-driven change detection models help monitor shifts in land use, coastal erosion, cyclone impacts and other dynamics across Pacific Island countries and territories.[118] The tool is free and open digital public infrastructure that enables SPC member states to make more informed decisions. In Tuvalu, the DE Pacific coastline detection tool is using satellite imagery combined with sea level rise measurements to understand coastal erosion for data-driven policymaking.

DE Pacific works with governments and technical teams to develop tools and services tailored to specific national needs. While Timor-Leste is not a member of the SPC due to its closer proximity to ASEAN nations, it benefits from engagement, knowledge sharing and technical assistance from the SPC community on certain projects, and there may be an opportunity to work with DE Pacific on monitoring coastal erosion to formulate data-driven climate adaptation and resilience policies and launch coastal protection initiatives.

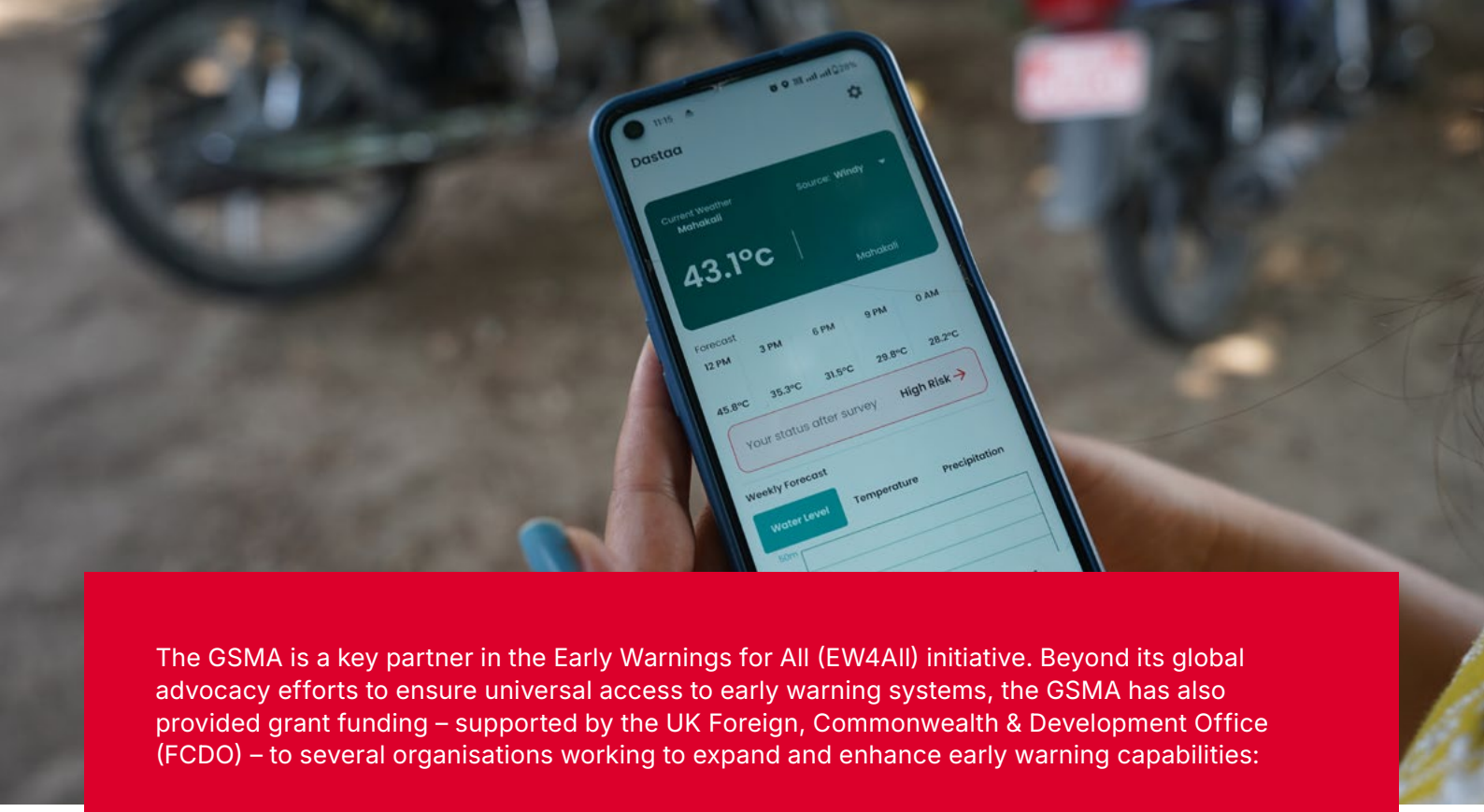
116 UN General Assembly. (1 August 2024). Remarks by H.E. Dionisio Babo Soares Permanent Representative of the Democratic Republic of Timor-Leste to the United Nations. 102nd Plenary Meeting on the Draft Resolution and Decision concerning Sea-Level Rise.
117 World Bank Climate Change Knowledge Portal: Timor-Leste – Sea Level Rise.
118 The Pacific Community (SPC). (n.d.). How SPC's Digital Earth Pacific harnesses Artificial Intelligence to revolutionise our understanding of the environment.

Advancing the use of climate tech for early warning systems in Timor-Leste: Key insights

- Timor-Leste's efforts to strengthen EWS for climate adaptation and resilience can draw valuable insights from the initiatives described in this chapter. In terms of climate tech deployment for EWS, the country can benefit from **multi-channel EWS** that blend traditional tools like sirens and community radio with digital channels such as SMS and chat apps, as these have proven effective in reaching diverse and remote communities.
- **Strong community engagement**, especially in local CBEWS, can help promote adoption, trust and offer long-term sustainability while also being cost-effective.
- Early warnings on digital channels must be delivered in **local languages and accessible formats** to ensure maximum inclusion, and **offline functionality** is essential in rural areas with limited or unreliable connectivity.
- Top-down MHEWS should involve **cross-sector stakeholders** and offer ways to integrate **local knowledge and involve local communities**.

Digital technologies alone will not create effective EWS. Success depends on building strong regional and national multi-stakeholder partnerships, sustainable funding mechanisms, local capacity building and community participation.

Timor-Leste's limited engagement with regional cooperation bodies, unlike Pacific SIDS that benefit from collective initiatives, makes it even more important to build these partnerships as it advances the use of climate tech for EWS. With impending entry into ASEAN, Timor-Leste may be better positioned to leverage regional cooperation to strengthen its early warning initiatives.



The GSMA is a key partner in the Early Warnings for All (EW4All) initiative. Beyond its global advocacy efforts to ensure universal access to early warning systems, the GSMA has also provided grant funding – supported by the UK Foreign, Commonwealth & Development Office (FCDO) – to several organisations working to expand and enhance early warning capabilities:

Action Aid: Grant to adapt and improve the national 'EWS 1294' system in Cambodia[119]

Buraq Integrated Solutions: Grant to strengthen mobile-enabled early warning systems for anticipatory action in Pakistan's northern mountain ranges[120]

Tearfund: Grant to support the provision of weather forecasting data and agricultural extension advice to farmers in Ethiopia, as well as parametric insurance[121]

NAXA: Grant to scale an anticipatory action platform in Nepal for floods, profiling the disaster risk of households in the pilot region and issuing cash assistance to impacted communities

People in Need: Grant to strengthen EWS by leveraging IoT and mobile tech for anticipatory action in the Philippines[122]

Rumsan Associates: Grant to support blockchain-powered anticipatory action and cash assistance in Nepal[123]

Trans-African Hydro-Meteorological Observatory (TAHMO): Grant to strengthen EWS in Ghana through multiple technologies[124]

119 GSMA. (n.d.). ActionAid Cambodia.
120 GSMA. (n.d.). Buraq Integrated Solutions.
121 GSMA. (n.d.). Tearfund.
122 GSMA. (n.d.). People in Need.
123 GSMA. (n.d.). Rumsan Associates.
124 GSMA. (n.d.). TAHMO.

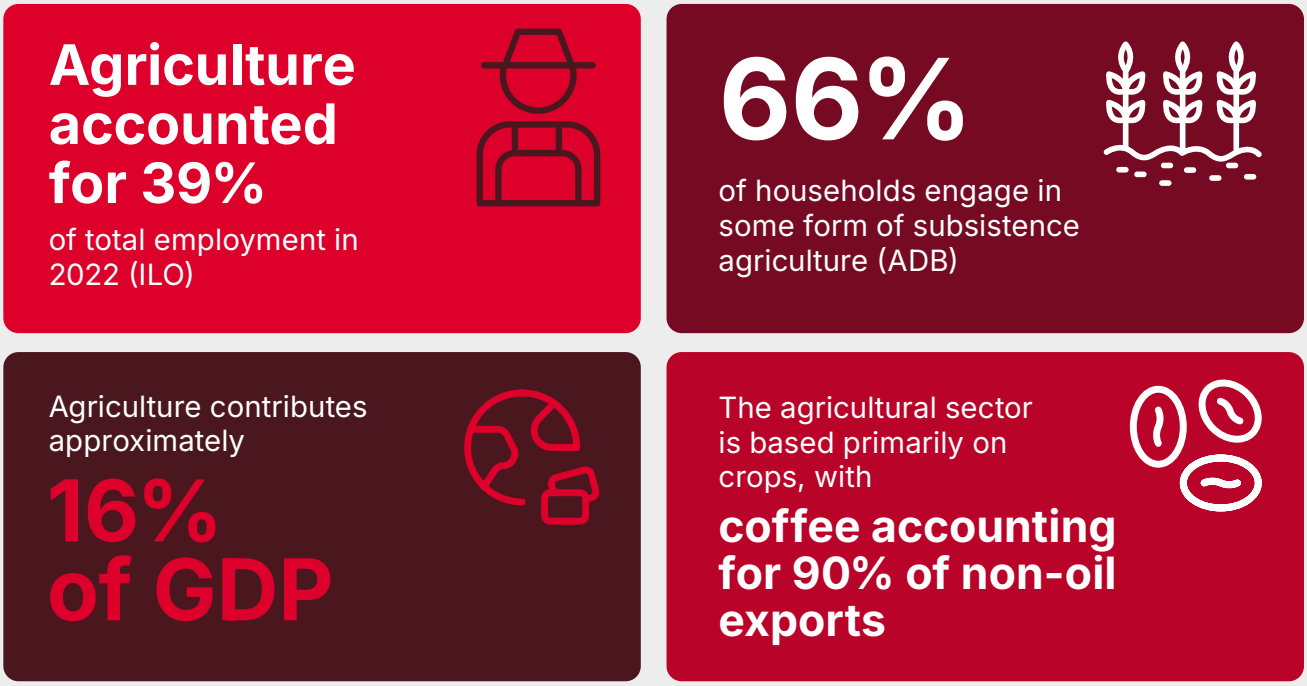
4.2
Agriculture and food security

4.2.1 The impact of climate change on agriculture and food security

Climate adaptation and resilience in agriculture encompass strategies and practices designed to better manage the adverse effects of climate change on agricultural systems and ensure food security. It requires adjustments in farming methods to cope with climate-related changes, including rising temperatures, shifting precipitation patterns and extreme weather events.

Agriculture is central to Timor-Leste, providing livelihoods and food and contributing to GDP (Figure 10). However, the country faces high food insecurity, with 60% of its food supply imported, including 45% of its staple crop, rice. While food insecurity is a widespread challenge in SIDS, Timor-Leste is particularly vulnerable. It ranks 104th out of 127 countries in the Global Hunger Index,[125] and its food production is expected to be among the most affected by climate-induced shifts in rainfall patterns in Southeast Asia.[126]

Figure 10:
Role of the agricultural sector in Timor-Leste



Sources: International Labour Organization (ILO) and Asian Development Bank[127]

125 Global Hunger Index. (2024). Timor-Leste.
126 World Bank Group and Asian Development Bank. (2021). Climate Risk Country Profile: Timor-Leste.
127 Iyengar, K. (29 February 2024). Addressing Timor-Leste's Food Security and Nutrition. Development Asia. See more here

Despite employing a significant proportion of the population, Timor-Leste's agricultural sector suffers from low productivity. Over the past decade, real GDP per capita in agriculture has declined by almost 20%, with major crops such as coffee, maize and rice experiencing significant reductions.[128] The amount of cultivated land has shrunk by 35% between 2001 and 2020, while reliance on rainfall for irrigation makes crop cultivation highly unpredictable.[129] Poor soil quality, steep mountainous terrain and post-harvest losses of 20% to 50%[130] due to inadequate storage and pest damage, further weaken the sector. Smallholder farmers also face severe capital constraints, limiting their ability to invest in productivity-enhancing equipment and inputs.

Climate change is compounding these challenges. Erratic rainfall, prolonged droughts and rising temperatures increasingly threaten food security and rural livelihoods. In October 2023, the World Food Programme (WFP) reported that 22% of the population faced food scarcity. The UN Central Emergency Response Fund (CERF) estimated that 44% of families were experiencing moderate to severe food insecurity, while 54% lacked adequate water access – rising to 70% in some areas.[131] As noted earlier, in early 2024, Timor-Leste experienced 30% less precipitation due to El Niño, with 10 of 14 municipalities showing signs of drought. The WFP warned in April 2024 that continued climate-related disruptions would further threaten agricultural production and exacerbate food insecurity.[132]

4.2.2 Climate tech for climate adaptation and resilience in agriculture and food security

Climate tech offers significant opportunities to strengthen climate adaptation and resilience in agriculture and food security across multiple dimensions, as captured in Table 4.

In Timor-Leste, high climate variability makes agriculture unpredictable and risky. Using simple and easy-to-adopt digital technologies, especially agricultural climate advisory, and moving to more complex and resource-intensive technologies over time while learning from pilot projects (for example, experimenting with IoT sensors to measure soil moisture), offer a critical pathway for building climate resilience while supporting rural livelihoods.

128 National Institute of Statistics. (February 2024). Agricultural GDP: Patterns and Trends.
129 Ibid. At 6.5 cubic meters per capita of internal renewable water resources in 2018, Timor-Leste ranks 63 out of 180, which is considerably lower than countries in a similar context, such as Indonesia, Myanmar and Laos, which had 7.5, 18.7 and 27 cubic meters per capita for the same period, respectively.
130 Government of Timor-Leste and WFP. (2019). Fill the Nutrient Gap – Timor-Leste.
131 UN CERF. (2024). Timor-Leste: Drought, 01 Jan 2024.
132 WFP. (18 April 2024). Timor-Leste facing high food insecurity, latest report warns.

Table 4:

Climate tech use cases to support climate adaptation and resilience in agriculture and food security and ease of adoption in Timor-Leste

Technology	Use case	Ease of adoption	Implementation considerations
Feature phones	SMS/IVR-based weather forecasts, market information and agricultural extension services Community-based data collection with farmers reporting crop conditions and pest outbreaks via SMS	**High**	• Uses existing mobile networks • Immediate value to farmers • Suitable for low literacy and digital skills • Integrates farmer knowledge and experience
Smartphones	Agricultural climate advisory to farmers on tailored apps Digital marketplaces where farmers can access crop prices and connect with buyers and input suppliers	**High-Medium**	• Moderate set-up costs • Digital marketplaces may require payment system integration
AI-powered crop disease detection	Smartphone camera-based analysis of crop diseases	**Medium**	• Requires smartphone access • Globally accessible tools for analysis at the local level (e.g. Plantix)[133]
Satellite-based crop monitoring	Enables tracking of agricultural productivity or impacts of extreme weather events	**Medium**	• Free satellite data available for analysis • Requires capacity building for analysis
IoT sensors	Smart farming (e.g. precision irrigation, storage monitoring)	**Low-Medium**	• High level of resources for individual farmers • Requires local technical support
Drone-based crop monitoring	Precision agriculture, pest detection	**Low**	• High equipment costs
AI and Machine learning	Forecast weather and crop outputs	**Low**	• Resource intensive
Digital financial services	Parametric insurance	**Medium**	• Payment system integration needed • Requires financial and, ideally, digital financial inclusion • Regulatory framework needed

133 Plantix is a globally accessible and free AI-enabled app for crop pest detection. See: Plantix website.

4.2.3 Climate tech initiatives for agriculture and food security in Timor-Leste

Despite the significant potential of climate tech, adoption in Timor-Leste's agricultural sector has been limited. There are some promising initiatives, including an online platform for monitoring food security and granular weather forecasting for farmers. These examples are detailed in this section.

Suco-Level Food Security Monitoring System (SMSANS)

SMSANS was a web app developed by the non-profit Catalpa International[134] in partnership with the Food and Agriculture Organization of the United Nations (FAO) and Timor-Leste's Ministry of Agriculture and Fisheries. This online platform collated data on food security from a network of village-based food security officers, producing monthly reports at the national and district levels.[135] The system monitored crop yields, pests, harvests, consumption, market prices and potential shortages, integrating this information with climate and economic data to provide policymakers with reliable assessments of food availability and early warnings of risks to food security at a granular level by Suco.[136,137]

While the data was valuable in understanding food security by region, the website stopped being maintained in 2022 due to a lack of government buy-in and funding.[138] This highlights a critical challenge: the need for sustained government commitment and funding for long-term maintenance and operation.

Tempu.tl weather forecasting platform

Tempu.tl, also developed by Catalpa, provides Timor-Leste's first online weather forecast service, with data sourced from satellites and other international forecasting systems.[139] Available in multiple languages, Tempu.tl offers accessible, village-level weather forecasts to assist farmers in planning agricultural activities and protecting crops and livestock. The platform has potential to help reduce risks to agricultural production from erratic weather patterns. Information can be accessed via Facebook, WhatsApp, as well as traditional information channels like newspapers and community radio to provide maximum reach.

While these initiatives are promising, Timor-Leste lags similar countries in the uptake of digital tools in agriculture in general, as well as specific initiatives to support climate adaptation and resilience in agriculture. The development of agricultural climate advisory is an especially notable opportunity for Timor-Leste to better support farmers.

134 Learn more about Catalpa here.
135 See Catalpa website: Toward Food Security in Timor-Leste.
136 Ibid.
137 FAO. (2016). Final Evaluation of the Project: Establishing a sustainable National Information and EWS (NIEWS) on Food Security in Timor-Leste.
138 Historical data is available through the government but is not being currently utilised (Source: Interview with Catalpa and Government of Timor-Leste).
139 Ibid.

4.2.4 Lessons from similar contexts

Several Pacific Island and other comparable countries have successfully implemented mobile-based agricultural climate advisory services that offer valuable insights for climate adaptation and resilience efforts in agriculture and food security in Timor-Leste.

Category: Adapt

The role of Digital Agricultural Advisory Services in supporting climate adaptation and resilience.

The AgriTouch app: empowering smallholder farmers with data in Samoa

The Pacific Island of Samoa is highly vulnerable to climate hazards and the impacts of climate change. Agriculture plays a crucial role in Samoan livelihoods, with the 2019 Agriculture Census indicating that 94.3% of households engaged in crop cultivation or the rearing of livestock. In 2020, agriculture contributed 8.3% of GDP, primarily through subsistence farming.[140]

A major climate adaptation challenge for smallholder farmers in LMICs is limited access to timely and reliable information. Traditionally, they rely on agricultural extension officers – government-appointed professionals who provide technical assistance and training. However, due to chronic underfunding, agricultural extension services are often understaffed and unable to meet farmers' needs. In many resource-constrained settings, extension workers themselves may require upskilling and capacity building to support farmers effectively.

In 2022, the Ministry of Agriculture and Fisheries (MAF), in collaboration with international partners including UNDP, UNESCO and the Indian High Commission to New Zealand, launched the AgriTouch app to provide Samoan farmers with easy access to essential agricultural information.[141]

The app aims to bridge knowledge gaps identified by farmers in consultations with MAF and its partners by offering real-time market insights, crop management guidance, details on ongoing agricultural projects, funding opportunities and a tool for farmers to track production and expenses. The app was developed locally by a Samoan innovator in close collaboration with farmers, which has helped ensure cultural relevance, appropriate user design and local ownership.

140 Market Development Facility. (2023). Samoa: Annual Report 2023.
141 Samoa Global News. (8 March 2022). Ministry of Agriculture and Fisheries Launch AgriTouch App. Govt Secretariat Press Release.

FARMIS: mobile-based agricultural advisory service in Papua New Guinea

Papua New Guinea shares several characteristics with Timor-Leste, including mountainous terrain, dispersed rural communities, limited digital infrastructure and an agricultural sector dominated by smallholder farmers and dependent on traditional practices.

FARMIS[142] is a digital agricultural information service that uses multiple technologies, including AI, to deliver solutions for smallholder famers in Papua New Guinea. FARMIS transforms agricultural extension services via a free mobile app that provides farmers with access to crop advisory, weather advisory, market information, farm input availability and a forum to connect with experts and other farmers. The app was launched in 2019 by Papua New Guinea's Department of Agriculture and Livestock.[143] By integrating climate information, market information, technical information and social networking features, FARMIS supports farmers in decision-making across several domains.

OSCAR: digital agricultural climate advisory in Vanuatu

OSCAR (tailOred System of Climate Services for AgRiculture) was launched in Vanuatu in 2023, providing a digital agricultural advisory tool that helps farmers make informed decisions to improve crop resilience based on local climate conditions.[144]

Developed through the Van-KIRAP project, Vanuatu is the first Pacific SIDS to implement OSCAR, through a collaboration between the Vanuatu Meteorology and Geo-hazard Department, Department of Agriculture and Rural Development (DARD) and the APEC Climate Center (APCC), and maintained by the government.

The system generates localised forecasts by processing data from satellite imagery, ground-based weather stations and historical climate patterns – a significant improvement over traditional services that relied on regional weather data that might not reflect microclimatic conditions – and produces agricultural meteorological bulletins.

The mobile-first platform allows farmers to access real-time weather data, weekly forecasts and seasonal predictions (3–6 months) directly from their smartphones. OSCAR also provides DARD extension officers with real-time access to comprehensive weather and climate information to support both commercial and subsistence farmers.

Beyond more immediate farming decisions, OSCAR measures how climate change is affecting crop yields throughout the country, providing crucial data for long-term agricultural planning and climate adaptation and resilience strategies to support food security.

142 Learn more about FARMIS here.
143 GSMA. (2019). Landscaping New Opportunities for Digital Agriculture in Papua New Guinea.
144 SPREP. (16 August 2023). OSCAR launched at Sixth Pacific Met Council Meeting.

Category: Absorb

Box 2: How digital financial services can support climate adaptation and resilience in agriculture

Access to financial services is essential for helping smallholder farmers adapt to climate change. With access to credit, savings and insurance, farmers can better prepare for and recover from climate shocks like floods, droughts and shifting weather patterns.

Credit enables farmers to invest in climate adaptation and resilience strategies that would otherwise be unaffordable, such as drought-resistant seeds, improvements in irrigation or crop diversification, while weather index insurance helps cushion losses from extreme events, allowing farmers to rebuild without falling into debt.

Savings offer a vital safety net, yet many rural communities still lack access to secure and formal savings tools. Digital financial services, such as mobile banking, are making it easier to save, access emergency funds and receive aid quickly during crises and to recover from shocks.

Parametric insurance in Pacific SIDS

Through the Pacific Insurance and Climate Adaptation Programme (PICAP), led by the United Nations Capital Development Fund (UNCDF) and UNDP, parametric climate insurance has been trialled in SIDS such as Fiji, Vanuatu, Samoa and the Solomon Islands.[145] Unlike traditional insurance that relies on damage assessments after an extreme weather event, parametric insurance payouts are triggered automatically when specific thresholds (e.g. rainfall or wind speed) are reached, ensuring funds reach vulnerable people quickly. The programme targets vulnerable groups, including women, youth and small businesses in agriculture, fisheries and tourism, who suffer most from natural hazards such as cyclones and floods.

Following a feasibility study supported by the Commonwealth Secretariat, Fiji rolled out parametric microinsurance with strong results. In 2023, after extreme rainfall, 1,013 farmers received payouts totalling FJD 201,000 (USD 88,000) within two weeks of the event. Payments were delivered via either bank accounts or e-wallets, reaching some of the country's most vulnerable groups such as women, who were 40% of recipients, and persons with disabilities (24% of recipients).

Encouraged by Fiji's success, private insurers are now expanding parametric products to other Pacific SIDS. The Fijian government sees the model as a practical tool to build long-term resilience in sectors vulnerable to climate change.

Feasibility for Timor-Leste

Given the high risk of natural hazards and extreme weather events in Timor-Leste, parametric climate insurance has significant potential to strengthen climate adaptation and resilience among vulnerable groups such as smallholder farmers and rural households.

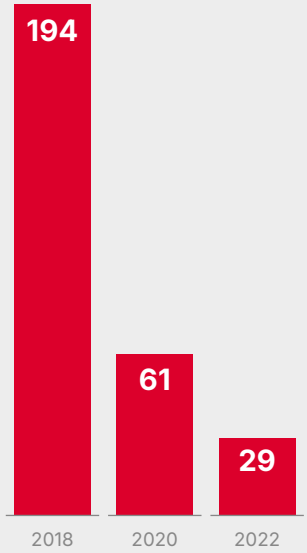
Financial and digital financial inclusion are growing in the country. As of 2022, 64% of adults in Timor-Leste had access to a bank account[146] and mobile money uptake has been increasing rapidly. For example, the e-wallet MOSAN, offered by mobile network operator (MNO) Telemor, has approximately 200,000 subscribers. Financial access service points have also been increasing (Figure 11).

145 Pullanikkatil, D. et al. (24 September 2024). Parametric Insurance: A lifeline for Fiji's climate challenges. The Commonwealth.
146 Central Bank of Timor-Leste. (2022). Getting Ready for the Next Digital Breakthrough: Financial Inclusion Report 2022.

Figure 11:
Financial inclusion in Timor-Leste

Unserved SUCOS

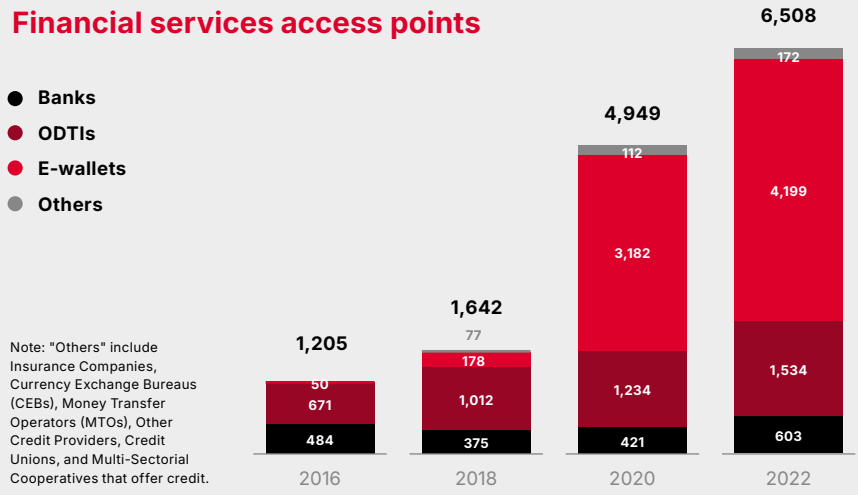
Since 2018, the number of unserved sucos has declined due to increased financial services access points and their geographic distribution.



Timorese adults are using more financial services compared to 2020. Women use more financial services than men, except for e-wallet services.

	Banks	ODTIs	E-wallets
Total adult population	64%	6%	22%
Female	65%	10%	18%
Male	62%	2%	27%

Financial services access points



Note: "Others" include Insurance Companies, Currency Exchange Bureaus (CEBs), Money Transfer Operators (MTOs), Other Credit Providers, Credit Unions, and Multi-Sectorial Cooperatives that offer credit.

Source: Central Bank of Timor-Leste (2022)

Timor-Leste has also made progress in building a digital payments ecosystem. For example, R-TIMOR is the electronic interbank settlement system, and the central bank (BTCL) has implemented the national switch, P24. The system provides the infrastructure to connect major financial service providers, the Ministry of Finance and indirect participants, offering a secure platform for different financial services to exchange information and perform transactions.[147]

However, there are several challenges that would need to be addressed for parametric insurance to succeed in the country. Despite improvements in financial access points, actual usage of financial products remains limited. Only 8% of bank account holders have accessed credit and only 22% of the adult population is registered as e-wallet users, with approximately 10%–15% actively using the service.

Current mobile money services are also restricted by the amounts that can be held in e-wallets and the types of products and services they can deliver, making it more difficult to offer more complex financial products like insurance.

Low levels of digital and financial literacy – reflected in a national average score of just 20.47 out of 52 on the UNCDF Digital and Financial Literacy Index [148] – pose additional barriers. Many rural residents remain unfamiliar with mobile money and a preference for cash persists.

Strengthening digital financial inclusion in Timor-Leste and expanding the financial products that can be offered via digital financial services, would help strengthen the climate resilience and adaptation capacity of vulnerable households and smallholder farmers, and could pave the way for parametric insurance to be trialled in the short to medium term.

147 Ibid.
148 UNCDF. (2023). Assessing Digital and Financial Literacy in Timor-Leste: A Survey on Knowledge, Skills and Access.

Implementing climate tech for climate adaptation and resilience in agriculture and food security in Timor-Leste: Key insights

The examples from comparable contexts demonstrate that agricultural climate advisory could be a high-impact opportunity to support Timorese farmers to cope with the impacts of climate change, improving productivity and minimising losses.

Given Timor-Leste's underdeveloped private sector, resource-constrained agricultural households, and limited digital infrastructure, commercialisation of climate advisory services could face significant challenges. In this context, government-led digital agricultural climate advisory services that provide foundational information are likely to offer a more viable starting point, to address gaps where private providers may struggle to establish sustainable business models, while ensuring essential climate information reaches farmers.

Multi-stakeholder collaboration on financing and technical capacity, mobile-based service delivery, and integration with existing extension services, are other factors that have also been key to the successful development and delivery of solutions to enhance climate adaptation and resilience in SIDS.

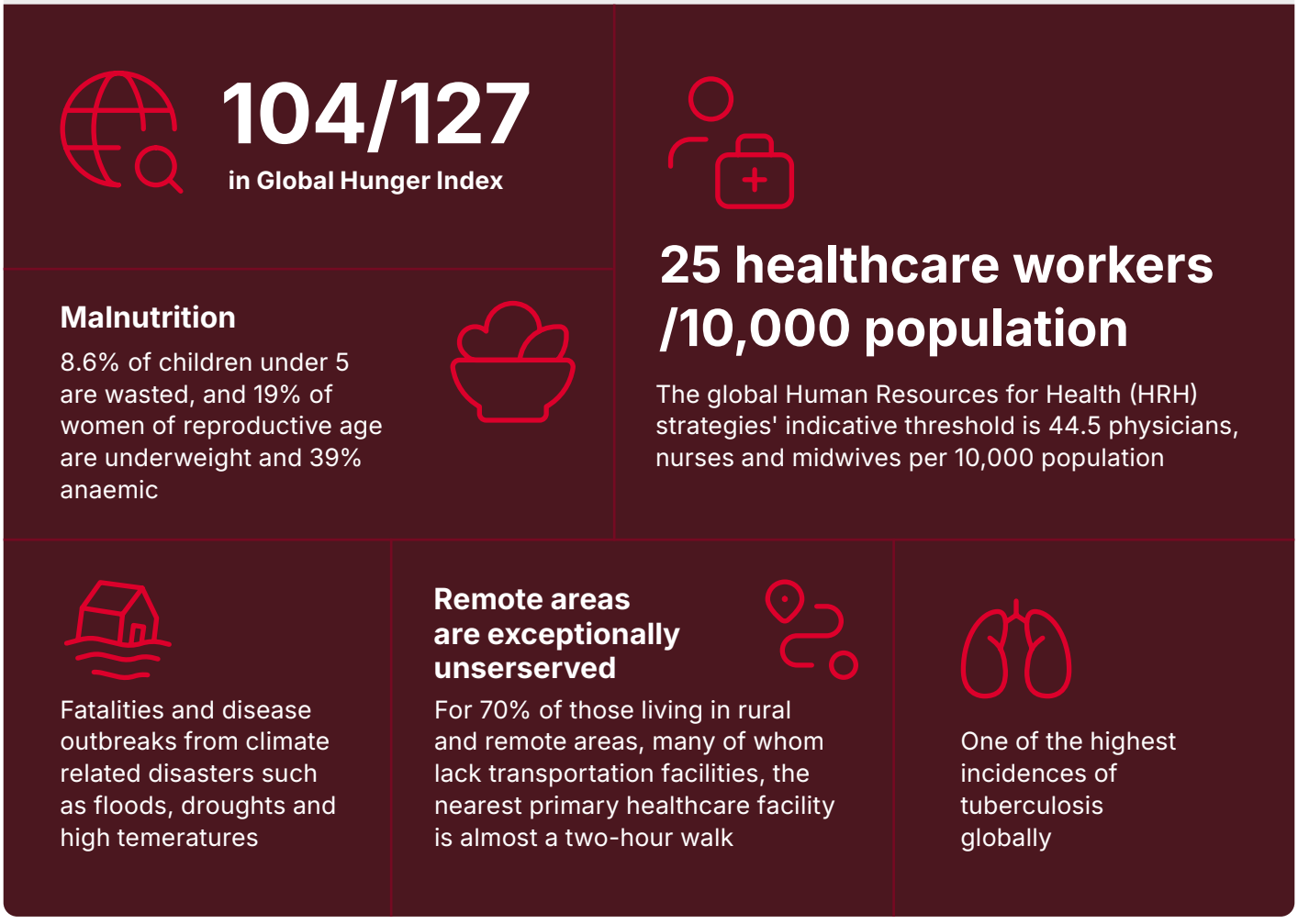
4.3
Public health

Climate adaptation and resilience in the healthcare system involves strategies and measures to strengthen healthcare services to cope with the impacts of climate change.

4.3.1 Climate-related healthcare challenges in Timor-Leste

Timor-Leste faces significant healthcare challenges that are compounded by high vulnerability to climate change, inadequate healthcare infrastructure and limited service delivery capacity. While the country provides free healthcare at the point of care and has one of the lowest out-of-pocket healthcare expenditures, access to medical services remains a critical concern, particularly for remote populations.[149]

Figure 12:
Key healthcare challenges in Timor-Leste[150]



Sources: Global Hunger Index 2024, World Health Organisation[151,152]

149 Universal Health Coverage Partnership. (22 March 2024). Timor-Leste: Saving lives through critical care in remote mountainous regions.
150 WHO and UNFCCC. Climate and Health Country Profile 2015: Timor-Leste.
151 Universal Health Coverage Partnership. (22 March 2024). Timor-Leste: Saving lives through critical care in remote mountainous regions.
152 WHO. Regional Office for South-East Asia. (2015). WHO Country Cooperation Strategy 2015–2019: Timor-Leste.

Key healthcare challenges linked to climate change include:

- **Vector-borne and waterborne diseases:** Extreme weather events, such as floods, contribute to outbreaks of vector-borne and waterborne diseases such as dengue fever and malaria by altering vector distribution and worsening sanitation. Dengue fever remains a serious threat in Timor-Leste, with a high number of cases and fatalities, particularly among children. Poor sanitation and limited access to clean water increase the risk of diarrheal diseases and typhoid fever.
- **Freshwater scarcity and heat-related illnesses:** Frequent droughts limit access to safe drinking water while rising temperatures increase the prevalence of heat-related illnesses. Despite improvements in water access, many communities still lack clean water.
- **Food security and malnutrition:** Climate shocks, including droughts and erratic weather, disrupt agriculture and exacerbate food insecurity. This worsens malnutrition, particularly among children and pregnant women, increasing health risks.
- **Tuberculosis (TB) incidence:** Malnutrition, worsened by climate change, contributes to Timor-Leste's high TB burden. Changing environmental conditions, such as temperature and humidity fluctuations, increase susceptibility to the disease.

These interconnected challenges highlight the urgent need for healthcare services that are prepared to respond to the growing impacts of climate change.

4.3.2 Climate tech for climate resilience and adaptation in public health

Climate tech can significantly enhance the efficiency and reach of healthcare interventions, especially in response to stresses caused by climate change. Table 5 captures key technologies and use cases for climate adaptation in public health, ranked by ease of adoption in Timor-Leste.

Table 5:

Key climate tech use cases for climate adaptation and resilience in public healthcare and ease of adoption in Timor-Leste

Technology	Use case	Ease of adoption	Implementation considerations
Feature phones	Disease outbreak notifications and warnings Access to basic health information	**High**	• Immediate reach • Builds on existing infrastructure and resources
Digital health records (offline-first)	Digital patient tracking and vaccination records by community health workers	**High**	• DHIS2 system being implemented
Smartphones	Disease surveillance via community health workers reporting cases via mobile devices Access to health information and services	**High**	• Enhances existing surveillance and access
Telemedicine	Remote consultations via basic video calls due to lack of access from natural hazards or broader lack of healthcare services	**Medium-Low**	• Requires reliable connectivity • Requires higher smartphone penetration
Digital platforms for supply chain monitoring and cold chain vaccine monitoring	Digital tracking and management of supplies of medication and tracking of vaccine storage temperature	**Medium**	• Critical for medication supply chain management • Critical for vaccine programmes • Moderate resource needs
GIS	Mapping climate risks to health infrastructure	**Medium**	• Supports emergency planning • Requires GIS skills
AI and ML	Analysing multiple data sources to predict epidemics	**Low**	• Resource intensive

Timor-Leste's National Adaptation Plan (2021) prioritises the development of a climate-resilient healthcare system to address the increasing health risks posed by climate change. Key objectives include reducing the burden of vector-borne diseases, mitigating the impact of heat and air pollution-related illnesses and strengthening the adaptive capacity of the healthcare sector.

However, Timor-Leste faces significant challenges in implementing digital healthcare solutions. One major obstacle is the absence of a digitalised national identity system, which is crucial for streamlining health records and building a more efficient, digitalised public health system. Additionally, the country is developing electronic health records (EHRs), but most healthcare data is still recorded in paper format.

To better address these challenges, Timor-Leste is aiming to leverage digital health tools for disease surveillance, resource management and diagnostics. This is indicated in Timor-Leste's Digital Health Blueprint, launched in September 2024 and developed in collaboration with the WHO.[153] The document outlines a five-year action plan for implementing digital health solutions to strengthen the national healthcare system and improve the universal healthcare service.

4.3.3 Climate tech for healthcare in Timor-Leste

Timor-Leste has begun laying the foundation for a digitally enabled public health system through a series of impactful initiatives. These efforts are focused on TB management, integrated disease surveillance and pharmaceutical supply chain monitoring. They demonstrate the country's growing capacity to adopt digital health solutions that could eventually support broader climate adaptation and resilience in healthcare.

TB management through AI-enabled diagnostics

In 2023, Timor-Leste reported 6,171 cases of TB, the second highest in Southeast Asia. In response, the government, with the support of partners such as the WHO and Global Fund, launched a One-Stop Mobile Diagnostic Van equipped with AI-integrated digital X-rays and electronic medical record systems. This mobile solution improves access to advanced diagnostics and strengthens surveillance. With intensified efforts, Timor-Leste has achieved a 91% success rate in TB treatment and recovery, showcasing the power of targeted digital health interventions.[154]

Integrated electronic surveillance system for communicable diseases

District Health Information Software 2 (DHIS2) is an open-source public health software for integrated disease surveillance. Initially developed at the University of Oslo, it is now being used in more than 30 countries in partnership with a global network to provide a locally owned digital healthcare record system.[155]

In 2023, the Ministry of Health of Timor-Leste, in collaboration with the WHO, launched the Integrated Case-Based Electronic Surveillance System for communicable diseases, including TB, HIV and malaria. Built on the DHIS2 platform, this digital system replaces traditional paper-based data recording, improving efficiency, accuracy and accessibility in healthcare data management. The system is designed to ease the administrative workload of healthcare workers while strengthening disease surveillance. For TB, it offers tools for patient tracking, enabling proactive contact tracing and follow-ups, as well as geolocation features to identify patient residences for targeted anti-mosquito measures and other public health interventions.[156]

A key feature of the system is its interactive dashboard with advanced analytics, providing real-time insights for health authorities. Additionally, the system includes a user-friendly mobile app that supports both online and offline data collection – an essential capability for healthcare workers operating in remote areas with unreliable network connectivity.

153 Tatoli. (23 January 2025). WHO and MoH hold consultation on Digital Health Blueprint.
154 Government of Timor-Leste and World Health Organization. (2024). Timor-Leste Digital Health Blueprint.
155 DHIS2. (n.d.). Overview: Supporting strong health systems with DHIS2.
156 WHO. (22 November 2023). Timor-Leste launches a digital platform for TB, HIV and Malaria surveillance. The mobile app is yet to be operationalised (Source: Interview with WHO).

mSupply for supply chain management of medicines

The mSupply mobile app, developed by the mSupply Foundation with support from the Australian government via UNFPA, has significantly improved inventory management in Timor-Leste's healthcare system.[157] By enabling real-time tracking of medical supplies across key institutions such as the Timor-Leste Medical and Pharmaceutical Supply Agency (SAMES)[158] and the National Hospital Guido Valadares (HNGV), the platform streamlines procurement, storage, ordering and distribution to healthcare facilities.

Ensuring the availability of essential medicines during communicable disease outbreaks is crucial for timely treatment, preventing the progression of disease and limiting its spread. mSupply plays a vital role in disease management by supporting the supply chain for medications, including those targeting vector-borne and respiratory diseases, which are exacerbated by climate change.

These initiatives highlight Timor-Leste's growing capacity to integrate digital solutions in healthcare for climate adaptation. While most are still in the early stages and not mature enough for a comprehensive impact assessment, the foundation has been laid for future progress.

In terms of the digitalisation of healthcare for climate adaptation and resilience, high-impact climate tech initiatives include predictive analytics and disease monitoring and surveillance, but these require a stronger underlying digital health system, including electronic health records, and a more advanced DHIS2 system.

Meanwhile, information on the prevention and management of climate-related diseases via mobile phones using SMS or smartphone apps, offers a viable way to increase health awareness among both community health workers and communities. Health EWS could also help with preparedness and response measures in situations of heat stress or flooding, for example. Initiatives from similar contexts, featured in the next section, illustrate ways that digital tools can support climate adaptation and resilience in public health in Timor-Leste.

157 UNFPA. (7 July 2023). Upscaling distribution of health supplies in Timor-Leste through mSupply digital system.
158 National Institute for Pharmaceutical and Medical Products.

4.3.4 Lessons from comparable contexts

Category: Anticipate

Early Warning, Alert and Response System (EWARS) for disease surveillance in Fiji

Implementing an EWARS is a priority for Timor-Leste, as reflected in the Climate-Resilient and Environmentally-Sustainable Health Care Facilities in Timor-Leste policy and strategy document (2024), which aims to integrate EWARS in the healthcare system for the monitoring and surveillance of climate-sensitive disease outbreaks and for emergency response.

In a notable example of an early warning and disease surveillance system, the WHO has developed and deployed "EWARS in a box" in Fiji after Cyclone Winston in 2016, to help Fiji track disease outbreaks in disaster-hit areas. EWARS in a box is a cost-effective portable electronic system for data collection and real-time disease monitoring in situations of natural disasters and conflicts. [159] The box contains all the equipment needed to establish surveillance and response activities, particularly in difficult and remote field settings without reliable internet or electricity. The box contains 60 mobile phones, laptops and a local server to collect, report and manage disease data. A solar generator and solar chargers allow the phones and laptops to function without 24-hour electricity. A single kit costs approximately $15,000 and can support surveillance for 50 fixed or mobile clinics serving roughly 500,000 people.[160]

Health authorities use EWARS during public health emergencies to strengthen and support the national disease surveillance system. The WHO works with Ministries of Health and health sector partners to train local health workers to use the system.[161]

The strength of EWARS is as a stand-alone intervention in times of crisis without the need for a digitally advanced public health system – vital in a context like Timor-Leste that is still in the early stages of digitalisation.

159 Sheel, M. et al. (18 January 2019). Evaluation of the early warning, alert and response system after Cyclone Winston, Fiji, 2016. Bulletin of the World Health Organization.
160 See WHO website. Early Warning, Alert and Response System (EWARS).
161 Ibid.

Category: Anticipate and Adapt

Integrated digital health information system (HIS) in Samoa

Tamanu is an open-source electronic medical record (EMR) system tailored for low-resource settings, which was adopted in Samoa in 2019.[162]

Before 2019, Samoa's health facilities relied largely on paper and Excel-based records, even though the country had engaged with the WHO to explore electronic health systems since 2013. The urgency for a comprehensive digital health information system (HIS) emerged during a measles outbreak in 2019. This crisis indicated an urgent need for a scalable, mobile system capable of real-time data transfer to manage patient tracking, vaccine monitoring and control outbreaks. To support this transformation, Samoa introduced a digital health policy that laid the groundwork for the design and deployment of Tamanu.

By 2021, Samoa had implemented Tamanu with the support of the SPC, WHO and New Zealand's Ministry of Foreign Affairs and Trade, linking hospitals and healthcare facilities and enabling data entry in the field. The system could share information across the health network within minutes, significantly enhancing response times and operational efficiency.[163]

A critical step was addressing Samoa's lack of GIS maps. The Ministry of Health mobilised government officials to create basic road maps and integrated census data from the Bureau of Statistics, facilitated through data-sharing agreements. These efforts enabled the creation of comprehensive electronic health records for the population. Each patient was assigned a unique identification number that was linked to an identification document (ID) for verification during health visits. Importantly, Tamanu was integrated in health emergency preparedness plans and non-communicable disease monitoring. Real-time data from Tamanu supports outbreak tracking (e.g. dengue fever) and climate-related morbidity trends, and its offline-first design has made it functional even during natural hazards.

During the COVID 19 pandemic, the system was further expanded, enabling vaccination registrations and facilitating the tracking of disease spread. The system also supported digital platforms like Google Forms for self-reporting and laboratory systems for recording COVID test results. By then, district-level mapping allowed vaccination coverage to be visualised by village, supporting targeted interventions. A large-scale training initiative prepared 400 health officers and 200 government officials to operate the system effectively. In 2021, the Ministry of Health integrated mSupply to track medical stocks at facilities.

Tamanu is therefore adaptable to various needs. Timor-Leste is engaged with Beyond Essential Systems, the company that developed Tamanu as a free, open-source platform for digital health records on mobile phones and desktops in low-resource settings, via its support centre in Fiji. Adopting Tamanu and integrating it with early warning systems and climate-sensitive disease surveillance platforms, as Samoa has done, offers a viable pathway for Timor-Leste to adopt digital health tools to strengthen its healthcare system while embedding climate adaptation and resilience.

162 See MIT SOLVE website: Equitable Health Systems – Tamanu.
163 Government of Samoa. (2021). Annual Report: Financial Year 2020/21.

Category: Anticipate and Adapt

Integrating climate and health in national planning: ClimateSmart Indonesia

Indonesia has made significant strides in advancing its digital healthcare platform, SATUSEHAT.[164] In 2023, the Institute for Health Modelling and Climate Solutions (IMACS), KORIKA, the Mohammed bin Zayed University of Artificial Intelligence and the Government of Indonesia launched the ClimateSmart Indonesia Initiative (CSI) to address the gap in monitoring and managing climate-related diseases. Through this initiative, the partners aimed to implement a climate information system for health.[165] The project is also supported by global partners, including Reaching the Last Mile Fund (RLM),[166] which was established in 2017 by the President of the United Arab Emirates, the Bill & Melinda Gates Foundation and the Patrick J. McGovern Foundation.[167]

The objective is to establish an integrated climate health system for climate-related diseases by combining health data from sources like SATUSEHAT with real-time climate information from meteorological sources, especially the Meteorology, Climatology and Geophysical Agency (BMKG).

Through this collaboration, ClimateSmart Indonesia partners will:

- Enhance disease prediction models to develop more effective response strategies
- Equip policymakers and health professionals with actionable insights using AI and meteorological data
- Optimise resource allocation and emergency response efforts, ensuring better protection of Indonesia's most vulnerable populations

While Indonesia has a more digitally mature healthcare system, a pilot version of this model could be trialled in one or two climate-vulnerable municipalities in Timor-Leste, especially in areas already adopting DHIS2 or electronic health records.

Separately, Indonesia launched an EWARS system in response to the WHO mandating that all member countries have an early warning system to report infectious disease outbreaks. At the end of 2015, the Indonesia Ministry of Health launched the EWARS website to facilitate data processing and reporting to detect disease early and respond as soon as possible.

EWARS reports on 23 diseases. Each disease has its reporting and alert protocols, and the records must be updated weekly. The accuracy and completeness of the weekly report is significant in detecting diseases that have potential for an outbreak. In a recent monitoring and evaluation exercise of the system in Papua, a particularly remote and unconnected province of Indonesia, most respondents reported that EWARS is important and useful in improving early detection of outbreaks. The system has led to increased coordination in disease management at the provincial level.

However, respondents noted that the limited number of districts involved in the system affected representation, and some stated that only about 30%–35% of districts in each regency (government level below the provincial level) were involved and trained in EWARS reporting. Barriers to complete reporting and response to alerts included limited human and funding resources for surveillance, lack of epidemiological training and technical limitations imposed by limited internet and mobile communication infrastructure in this remote region.

While the first example highlights the opportunities of climate tech when the right partnerships, resources and expertise are available, the second is a reminder of the key enablers needed to maintain even low-tech initiatives in remote, disconnected and under-resourced communities, as many in Timor-Leste are. Sufficient financing, connectivity and investment in technical upskilling are key to success.

164 See: SATUSEHAT website.
165 Blueprint for Climate and Health Data Integtation.
166 See: The End Fund website.
167 Tanahair. (5 May 2025). Indonesia launches ClimateSmart to tackle climate-driven disease risks with AI.

Using climate tech to build climate adaptation and resilience in public healthcare in Timor-Leste: Key insights

To realise the full potential of climate tech for climate adaptation and resilience in public health, Timor-Leste will need to strengthen foundational systems, such as electronic health records and DHIS2. Given that they are still nascent, there is an opportunity to integrate climate information and build an integrated system from the start.

Timor-Leste can also prioritise institutional coordination with its meteorological agency, the health ministry and local disaster agencies from the outset, building a more resilient healthcare system.

Meanwhile, high-impact opportunities lie in:

- **Expanding community access to health information** through SMS and smartphone applications in user-friendly ways.
- **Strengthening community-based health early warning systems**, using mobile phones to communicate during suspected outbreaks to improve and reduce the speed of management. These must be designed for low-bandwidth environments and offer offline-first mobile apps and SMS-based alert systems for remote regions, to overcome lack of access in mountainous terrain and connectivity challenges.

Finally, long-term partnerships and local capacity building and ownership are essential for sustainability, and solutions must be tailored to Timor-Leste's cultural context for adoption.

To build technical expertise and strengthen its system, Timor-Leste could participate more actively in regional Pacific and Asian climate-health peer-to-peer learning opportunities.

05.
Considerations for scaling climate tech

Climate tech offers numerous opportunities to strengthen climate resilience and adaptation in Timor-Leste, but solutions must be tailored to its unique geographic, cultural and economic context.

Geographically, the country's rugged and mountainous terrain creates highly localised microclimates that vary dramatically over short distances. As a result, national-level climate data is often insufficient and needs to be complemented with granular information, and solutions must be adapted to respond to specific topographic and climatic conditions.

Moreover, the country's insular geography and exposure to climate-related hazards means that climate tech initiatives must prioritise risk categories most relevant to Timor-Leste. Many of the most climate-vulnerable communities also happen to be the most physically remote, often lacking reliable digital infrastructure, so any climate tech solution must be designed for accessibility and operability in isolated areas.

Culturally, Timor-Leste is home to a highly diverse population that speaks multiple languages, including Tetum, Portuguese and numerous local dialects. Climate tech tools must accommodate this linguistic diversity and consider varying literacy levels to ensure inclusivity and widespread usability.

Furthermore, traditional knowledge systems remain deeply embedded in daily life. Rather than replacing these practices, successful climate technologies should be designed to complement and enhance them. This also means ensuring that digital tools reinforce, rather than undermine, existing community cooperation models and traditional governance structures such as Tara Bandu, which remain central to how decisions are made in rural areas.

With a significant proportion of the population living under the poverty line, affordability is a central consideration. The most impactful tools will be those that enhance livelihoods. Equally important are tools that are engineered for use in environments with limited internet access and minimal technical support.

The following are some key considerations in scaling climate tech for climate adaptation and resilience in Timor-Leste.

Climate tech solutions require a mobile-first approach, integrating legacy tech (e.g. USSD/SMS/IVR) with offline functionality.

Given Timor-Leste's connectivity constraints and limited infrastructure, climate tech solutions must prioritise mobile-first design principles. With a significant urban-rural divide in ownership of smartphones between urban and rural regions, solutions should be designed for smartphones as well as for feature phones.

- Offline functionality is critical in Timor-Leste's mountainous terrain where connectivity is intermittent. Solutions like DHIS2's offline mobile app and EWARS in a box demonstrate how essential climate-health services can function without constant connectivity.
- Given the high penetration of mobile phones, SMS-based early warnings, agricultural advisories and health alerts can form the backbone of communications to rural and remote communities.
- Starting with simple SMS and voice services, smartphone apps and web portals can be added as connectivity, access and affordability of the internet improves.
- Mobile interfaces should support Tetum and Portuguese at minimum, with audio options for low-literacy populations.

While the connectivity landscape could change rapidly, implementation should consider current limitations while anticipating improved connectivity.

Timor-Leste should adopt a forward-looking approach to climate tech deployment, ensuring that use cases are aligned with current limitations, while laying a scalable foundation for future digital infrastructure growth. Given the current connectivity constraints:

- Combine multiple connectivity sources, including satellite, terrestrial radio links and mobile networks to ensure the continuity of critical services.
- Prioritise investments in connectivity improvements in municipalities most vulnerable to the impacts of climate change.
- Coordinate public and private investments in digital infrastructure to ensure underserved, climate-vulnerable regions are prioritised in upcoming submarine cable and satellite connectivity expansion.
- Ensure climate tech solutions can integrate with improved national digital infrastructure as the implementation of Timor Digital 2032 advances, instead of becoming redundant.

Timor-Leste could increase financial investment in climate adaptation and resilience initiatives through diversified and sustainable funding strategies.

Timor-Leste's current climate finance does not meet its climate adaptation and resilience needs, requiring strategic resource mobilisation. This includes diversifying funding sources and identifying sustainable financing models.

This includes:

- Building on existing investments to reduce costs rather than creating parallel infrastructure, where possible, such as enhancing DHIS2 and the MHEWS under development.
- Deploying blended finance mechanisms, for example, combining donor grants with private sector investment and government budget allocations.
- Leveraging opportunities such as the CREWS funding for EWS, offering free basic services such as weather and climate advisory and health information, while generating revenue from more advanced agricultural advisory and health services.
- Focusing heavy investment on proven, scalable and sustainable solutions in the long run and de-risking investment with smaller investments for pilots and trials of proof of concept for untested innovations.

Technical upskilling and public sector capacity building are essential to the long-term sustainability of digital climate adaptation and resilience projects, and essential to develop future national capacity to prepare for intensifying climate shocks.

The successful implementation of numerous digital projects captured in this report demonstrate growing capacity, but scaling climate tech requires sustained technical development and upskilling.

This includes:

- Training government officials to take a multi-sectoral approach to climate adaptation and resilience, learning from the multi-sectoral approaches being adopted in comparable contexts.
- Developing local expertise in data generation and analysis, including skills such as GIS mapping, capturing and integrating key sources of data for decision-making on online platforms, climate modelling and health surveillance analytics, to be self-reliant in driving data-informed decision-making in the long run.
- Ensuring local technicians are trained to independently maintain and upgrade any digital systems that are implemented, and accounting for this in project costs and timelines.
- Developing partnerships with local universities for research collaboration and technical training.
- Actively fostering regional knowledge exchange with Pacific Island SIDS and ASEAN countries such as Indonesia, Nepal and Myanmar to tap into technical expertise, share best practices and strengthen peer learning networks.
- Establishing dedicated climate tech career pathways within relevant ministries, supported by ongoing professional development partnerships with regional institutions.

Sustainable climate tech adoption requires genuine community inclusion in climate tech initiatives, integrating Timor-Leste's strong traditional governance and knowledge systems and using participatory design approaches, as well as building trust with communities.

For climate tech adoption in Timor-Leste to be sustainable and impactful, initiatives must be rooted in community inclusion. This includes:

- Building climate tech solutions that integrate traditional knowledge with modern scientific knowledge, such as Vanuatu's ClimateWatch app, to ensure they are relevant and acceptable to local communities.
- Solution providers working closely with communities and suco (village) governance structures to build and promote climate tech initiatives, rather than creating alternative government structures that are incompatible with traditional decision-making processes.
- Project design planning for implementation phases that progressively transfer technical management from external partners to community leaders and local government officials.
- Engaging communities in solution design from inception, following models where CBEWS and agricultural advisory services have emerged from local needs assessments.
- Ensuring communities understand the role of deployed technologies, who controls data and how it will be used, while providing value through tangible benefits.

Timor-Leste's limited private sector development requires targeted approaches to stimulate climate tech innovation while building on existing strengths.

To unlock the potential of climate technology for adaptation and resilience in Timor-Leste, the government and other partners should take a proactive role in stimulating private sector innovation by building on existing initiatives, connecting local entrepreneurs with regional climate tech leaders and creating an enabling environment through regulatory sandboxes, government procurement and co-investment mechanisms. Specific actions include:

- Building on the lessons of existing initiatives, such as Catalpa's and Similie's flood EWS.
- Connecting entrepreneurs in Timor-Leste with successful climate tech initiatives in Pacific SIDS and ASEAN for mentorship and technical collaboration.
- Using government procurement and service contracts to create market demand for local climate tech solutions.
- Creating regulatory sandboxes that allow experimentation in innovation, for example, in digital financial services that can play a key role in building the climate resilience of households.
- Establishing government-backed guarantees and co-investment funds to reduce private sector risk in climate tech development.
- Connecting private sector innovators with university research and international technical cooperation to build local capabilities.
- Focusing initial private sector development on areas with demonstrated need, for example, agricultural extension or emergency communications.

Annex

Ease of adoption assessment criteria for climate tech use cases in Timor-Leste and similar contexts

High ease of adoption:

- Works with basic mobile networks (2G/3G)
- Low set-up cost and minimal ongoing expenses
- Can operate offline or with intermittent connectivity
- Requires minimal technical expertise for operation
- Provides immediate, visible value to users
- Can be maintained by local communities/staff

Medium ease of adoption:

- Requires reliable mobile internet but not broadband
- Moderate costs
- Some technical training needed but achievable locally
- Partial offline functionality
- Value realised in the medium term

Low ease of adoption:

- Requires high-speed internet and stable power
- High costs and ongoing technical support
- Always-online requirement
- Needs specialised expertise for operation
- Complex integration requirements

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G-SIG Timor-Leste

General Directorate for Electricity, Water, and Sanitation (DG REAS)

Institute of Technology and Communication (TIC)

International Federation of Red Cross (IFRC)

Konservasaun Flora no Fauna (KFF)

Korea International Cooperation Agency (KOICA)

Menzies School of Health Research, Australia

Mercy Corps

Ministry of Health

Ministry of Social Solidarity and Inclusion (MSSI)

Ministry of Tourism and Environment

Ministry of Transport and Communication

National Communications Authority

National Designated Entity (NDE) for Climate Technology

National Directorate of Climate Change (NDCC)

National Directorate of Meteorology and Geophysics (DNMG)

Oxfam International

Ra'es Hadomi Timor Oan (RHTO)

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Telemor

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United Nations Disaster Risk Reduction (UNDRR) Timor-Leste

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With One Seed

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World Vision

WorldFish

Key informants from other SIDS

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IT Galax, Fiji

Skyeye Pacific Limited, Samoa

South Pacific Regional Environment Programme (SPREP)

UNCDF Pacific Region

UNCDF Fiji

Key stakeholder mapping

Organisation

Public sector

Agriculture and Land Use Geographic Information System (ALGIS), Ministry of Agriculture and Fisheries

Civil Protection Authority

Ministry of Health

Ministry of Social Solidarity and Inclusion (MSSI)

Ministry of Tourism and Environment

Ministry of Transport and Communication

National Designated Entity (NDE) for Climate Technology Centre and Network

National Directorate of Climate Change

National Directorate of Meteorology and Geophysics (DNMG)

National Institute for Pharmacy and Medical Products (INFPM)

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Private sector

Ecosecurities

Simile

Starlink Services

Telemor Mosan

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Food and Agriculture Organization of the United Nations (FAO)

Green Climate Fund (GCF)

International Federation of Red Cross (IFRC)

Mercy Corps

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UK Foreign, Commonwealth & Development Office (UK FCDO)

UNICEF

United Nations Development Programme (UNDP) Timor-Leste

United Nations Disaster Risk Reduction (UNDRR) Timor-Leste

Water Aid

World Health Organization, Timor-Leste

NGOs and civil society organisations

Australian Aid

Australian Partnership for Human Development (PHD)

Care International

Catalpa International

G-SIG Timor-Leste

Local Conference of Youth Timor-Leste

mSupply Foundation

Plan International

Timor-Leste Disability Association (ADTL)

Village Disaster and Climate Management Councils

World Vision

WorldFish

Mobile network operators

Telemor

Telkomcel

Timor Telecom

Academia

Menzies School of Health Research, Australia

University of Timor-Leste (UNTL)

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